Mathematics Motivation and its Relationship with Mathematics Performance

Evidence from the National Assessment for Educational Progress-High School Longitudinal Study of 2019 Overlap Sample

AIR - NAEP Working paper 2021-03

Jizhi Zhang
George Bohrnstedt
Bitnara Jasmine Park
Sakiko Ikoma
Burhan Ogut
Markus Broer

JULY 2021

The research contained in this working paper was commissioned by the National Center for Education Statistics (NCES). It was conducted by the American Institutes for Research (AIR) in the framework of the Education Statistics Services Institute Network (ESSIN) Task Order 14: Assessment Division Support (Contract No. ED-IES-12-D-0002/0004) which supports NCES with expert advice and technical assistance on issues related to the National Assessment of Educational Progress (NAEP). AIR is responsible for any error that this report may contain. Mention of trade names, commercial products, or organizations does not imply endorsement by the U.S. Government.

This page was intentionally left blank.

Mathematics Motivation and its Relationship with Mathematics Performance

Evidence from the National Assessment for Educational Progress-High School Longitudinal Study of 2019 Overlap Sample

AIR - NAEP Working paper 2021-03

JULY 2021

Authors:
Jizhi Zhang, George Bohrnstedt, Bitnara Jasmine Park, Sakiko Ikoma, Burhan Ogut, and Markus Broer

American Institutes for Research®
1400 Crystal Drive, 10th Floor
Arlington, VA 22202-3289
202.403.5000 | **AIR.ORG**

AIR

Established in 1946, with headquarters in Arlington, VA, the American Institutes for Research (AIR) is a nonpartisan, not-for-profit organization that conducts behavioral and social science research and delivers technical assistance both domestically and internationally in the areas of health, education, and workforce productivity. For more information, visit www.air.org.

NCES

The National Center for Education Statistics (NCES) is the primary federal entity for collecting and analyzing data related to education in the U.S. and other nations. NCES is located within the U.S. Department of Education and the Institute of Education Sciences. NCES fulfills a Congressional mandate to collect, collate, analyze, and report complete statistics on the condition of American education; conduct and publish reports; and review and report on education activities internationally.

ESSIN

The Education Statistics Services Institute Network (ESSIN) is a network of companies that provide the National Center for Education Statistics (NCES) with expert advice and technical assistance, for example in areas such as statistical methodology; research, analysis and reporting; and Survey development. This AIR-NAEP working paper is based on research conducted under the Research, Analysis and Psychometric Support sub-component of ESSIN Task Order 14 for which AIR is the prime contractor.

William Tirre, a Program Director in the NCES Assessment Division, oversees the Research, Analysis and Psychometric Support sub-component of ESSIN Task Order 14.

Suggested citation:

Zhang, J., Bohrnstedt, G., Park, B. J., Ikoma, S., Ogut, B., and Broer, M. (2021). *Mathematics Motivation and the Relationship with Student Performance: Evidence from the HSLS Overlap Sample*.
[AIR-NAEP Working Paper #2021-03]. Washington, DC: American Institutes for Research.

For inquiries, contact:

Jizhi Zhang, Principal Researcher
Email: jizhizhang@air.org

Markus Broer, Project Director for Research under ESSIN Task 14
Email: mbroer@air.org

Mary Ann Fox, AIR Vice President and Project Director of ESSIN Task 14
Email: mafox@air.org

Executive Summary

The United States faces a major challenge in attracting, preparing, employing, and retaining a qualified workforce to fill STEM jobs. It is therefore crucial to motivate more high school students to take an interest in STEM areas and to sustain that interest and advance through high school in progressively more advanced courses that would prepare them for choosing STEM study majors in college (and eventually enter STEM careers). In addition, research consistently shows that there are gender as well as racial/ethnic disparities in STEM educational and career choices (Anderson & Kim, 2006; Herrera & Hurtado, 2011; Schultz et al., 2011). Specifically, female students are less likely to obtain a STEM degree than are male students, and Black and Hispanic students are less likely to obtain a STEM degree than are White students. Despite many efforts at change, the percentages of Black and Hispanic students who choose STEM majors in college and pursue STEM careers are lower than the percentages of White and Asian students who do so (Snyder, De Brey, & Dillow, 2016; Snyder & Hoffman, 2001; Snyder & Tan, 2006). Furthermore, Black and Hispanic students are less likely to complete both undergraduate and professional degrees than White and Asian students (Myers & Pavel, 2011).

This study uses the overlap sample of about 3,500 students who participated both in the High School Longitudinal Study of 2009 (HSLS:09) and the 2013 Grade 12 National Assessment of Educational Progress (NAEP) mathematics assessment to investigate how mathematics motivation (mathematics identity, mathematics self-efficacy, and mathematics interest) at grade 9 and 11 related to grade 12 NAEP mathematics performance, simultaneously taking into account grade 9 mathematics achievement, family and school background factors, and grade 11 educational expectations and high school mathematics coursetaking. In addition, multiple group SEM analyses were conducted to determine whether the relationships examined above vary by gender and race/ethnicity groups.

The overall SEM models reveal that mathematics motivation grade 11 was statistically significantly associated with grade 12 NAEP mathematics achievement, particularly mathematics identity among three indices. The other variables significantly related to grade 12 NAEP mathematics achievement were grade 11 educational expectations and the highest level of difficulty of mathematics courses taken through the end of grade 11. Some of the student and school contextual variables also displayed significant relationships with students' grade 12 NAEP mathematics achievement, like race/ethnicity, student grade 9 Algebra achievement, and student SES.

Although grade 11 mathematics self-efficacy did not show a significant relationship with grade 12 NAEP performance when controlling for grade 11 mathematics identity, the SEM results showed that mathematics self-efficacy at grade 9 appears to play an important role in the model because of its relationship to mathematics identity at grade 11. Having an interest in mathematics at grade 9 did not play the same kind of important intervening role on mathematics identity at grade 11.

The multiple group SEM results also indicated that the proposed mathematics motivation framework fit the data quite well regardless of gender or race/ethnicity. Some interesting differences identified in the multiple group SEM models across gender and race/ethnicity groups are highlighted below.

- Grade 11 mathematics identity was significantly associated with grade 12 mathematics NAEP performance for White and Hispanic students, but not for Black students.

- White students with higher educational expectations at grade 9 were more likely to take more difficult mathematics courses at grade 11. However, this relationship did not exist for Hispanic students. In addition, the relationship was significantly negative for Black students. That is, while counterintuitive, the higher Black students' grade 9 educational expectations were, the less likely they were to take difficult mathematics courses.

- Female students with higher mathematics self-efficacy at grade 9 tended to have higher educational expectations at grade 11. However, this relationship did not exist for male students.

There are several directions in which further research can go. For example, when the data from the Second Follow up are available, it will be possible to examine the role of mathematics motivation in grade 11 in college-level STEM students' performance in STEM courses, and whether they have declared a STEM major. These additional studies will contribute to an understanding of the role that mathematics motivation plays in choosing STEM majors and eventually in whether one chooses a STEM career.

Contents

List of Tables

List of Figures

Background

The number of jobs in the science, technology, engineering, and mathematics (STEM) sector is projected to grow at a faster rate than that of non-STEM jobs during the current decade (Carnevale, Smith, & Strohl, 2013). For example, the projected growth rates for biomedical engineers, medical scientists, and systems software developers are 62 percent, 36 percent, and 32 percent from 2010 to 2020, respectively. In contrast, the overall growth rate for all occupations is 14 percent from 2010 to 2020. The United States will need about 1 million more STEM professionals by 2020 than are currently projected to graduate in order to meet growing workforce demands. Attracting, preparing, employing, and retaining a qualified workforce to fill these STEM jobs is a major challenge. In addition, research consistently shows that there are gender as well as racial/ethnic disparities in STEM educational and career choices (Anderson & Kim, 2006; Herrera & Hurtado, 2011; Schultz et al., 2011). Specifically, Black and Hispanic students are less likely to obtain a STEM degree than are White students, and female students are less likely to obtain a STEM degree than are male students.

Some 69 percent of 2013–14 STEM degree recipients were male (Snyder, Brey, & Sally, 2016). The underrepresentation of women in STEM fields has been fairly persistent over the past decade, even though women have comprised the majority of postsecondary students since the 1980s.Beede et al. (2011) reported that women held less than 25 percent of STEM jobs in 2009, even though women account for almost half of the workforce. Between 2001 and 2009, the percentage of women in STEM occupations held constant at 24 percent, while the percentage of women in the total college-educated workforce increased from 46 to 49 percent. According to more recent data, Corbett and Hill (2015) reported that women held only 12 percent of engineering jobs and 26 percent of computer and mathematical jobs in 2013.

There is not only a gender gap in STEM, but also a racial/ethnic one. Despite many efforts at change, the percentages of Black and Hispanic students who choose STEM majors in college and pursue STEM careers are lower than the percentages of White and Asian students who do so (Snyder, De Brey, & Sally, 2016; Snyder & Hoffman, 2001; Snyder & Tan, 2006). Furthermore, Black and Hispanic students are less likely to complete both undergraduate and professional degrees than White and Asian students (Myers & Pavel, 2011).

In recent years, there has been a call for more intensive, theory-based research on the underlying psychological processes that affect underrepresented female and minority students' commitment and success in STEM fields (Wang, 2013; Wang & Degol, 2013). It is vital to better understand the links between motivational beliefs, educational expectations, coursetaking difficulty level, and other contextual factors as they relate to achievement in STEM fields, and whether these relationships vary based on students' race/ethnicity and gender. Answering these questions could lead to better-designed programs to encourage more high school students—especially female and minority students—to take STEM courses and eventually choose STEM careers (Wang, 2013).

The design of the present study is based on the belief that a deeper understanding of the psychological processes underlying student decision-making and performance in STEM fields is key to building better STEM support programs, from high school on up. The purpose of this study is to examine how a set of motivational beliefs (including having a mathematics identity, a sense of self-efficacy for doing mathematics, and an interest in mathematics) and educational expectations relate to STEM coursetaking in high school and how these factors in turn relate to mathematics achievement. Also of importance is whether these factors operate the same for Black and Hispanic students as for White students, what their relationship is to achievement gaps, and whether the relationship to the gaps vary by gender. In addition, this study investigates the trajectories of high school students' mathematics motivation from grade 9 to grade 11, to provide a developmental perspective on mathematics motivation and its relationship with mathematics achievement.

This study focuses on achievement in grade 12 in what arguably is the most important of the STEM subject areas—mathematics (Cribbs, Hazari, Sonnert, & Sadler, 2015). Research shows that high school mathematics achievement is not only an important predictor of attendance at 4-year colleges and universities (Adelman, 2006), but also success in the other STEM fields of science, technology, and engineering (Rose & Betts, 2001).

Much of the research on STEM participation and achievement is limited to cross-sectional designs and single-institution datasets (Wang, 2013). The current study uses a national longitudinal dataset to investigate the changes in students' mathematics motivation across the high school years and how they relate to mathematics achievement in grade 12. The use of a longitudinal design allows for a better understanding of the role of motivational beliefs as they develop in their relationship to mathematics coursetaking and mathematics achievement. The data source is the overlap sample of students who participated in the High School Longitudinal Study of 2009 (HSLS:09) and who also took the 2013 Grade 12 National Assessment of Educational Progress (NAEP) Mathematics Assessment. (The data are discussed in greater detail below.) The study addresses the following three sets of research questions:

1. What was the overall achievement in the 2013 Grade 12 NAEP Mathematics Assessment for White, Black, and Hispanic students? What were the achievement gaps in the 2013 Grade 12 NAEP Mathematics Assessment between Black and White students, and Hispanic and White students? Did achievement and race/ethnicity achievement gaps vary by gender and other contextual variables?

2. What were the levels of student mathematics motivation at grade 9 and grade 11? Were there any differences in student mathematics motivation across gender and racial/ethnic groups?

3. What was the relationship between grade 12 NAEP mathematics performance and mathematics motivation, including educational expectations, taking into account grade 9 mathematics achievement, family and school background factors, and high school mathematics coursetaking such as taking advanced, regular, or basic courses? Did these relationships differ by gender and race/ethnicity?

Conceptual Model

This section presents a comprehensive conceptual framework to understand high school students' mathematics performance and racial/ethnic achievement gaps through the lens of achievement motivation. First, this section discusses how motivational constructs (mathematics identity, self-efficacy, and interest) derived from two different theoretical perspectives are hypothesized to relate to students' academic behavior (e.g., taking mathematics courses) and academic achievement. Second, this section discusses how students' educational expectations are hypothesized to relate to academic achievement. Third, this section examines the literature on gender and racial/ethnic differences in motivation and their relationships to mathematics achievement. Fourth, this section discusses how family and school factors are hypothesized to influence students' mathematics motivation and mathematics achievement. Finally, these hypotheses are integrated into a conceptual model that depicts the trajectories of students' mathematics motivation across high school and their relationships with mathematics achievement—relationships which will be evaluated by investigating a national longitudinal dataset using Structural Equation Modelling (SEM) techniques (Bollen, 1989).

Motivation

Motivation can be thought of as the drive or energy expended in pursuit of a goal (mathematics achievement in this study). It can either be extrinsic (based on actual or perceived rewards or punishments) or intrinsic (based on internalized beliefs and values about the importance of achieving the goal) (Deci, 1975). More generally, motivation has been defined as "the process whereby goal-directed activity is instigated and sustained" (Pintrich & Schunk, 2002, p. 5). Because one cannot observe this internal, latent process, a theoretical framework is necessary for measuring motivational beliefs. And as noted above, "Due to the latency of psychological constructs, the construct motivation can be conceptualized in different ways, with different theories focusing on different psychological processes" (Lameva & Chonteva, 2013, p. 4).

Contemporary literature on achievement motivation focuses heavily on the relations of individual's beliefs, values, and goals on behaviors (Eccles &Wigfield, 2002). Modern motivational theories are grounded in a socio-cognitive perspective, focusing on understanding students' cognitive process of whether they choose to engage in learning tasks and how persistent they can be while working on those tasks. More specifically, motivational theories address two questions: (1) Can I do the task? And (2) why am I doing the task? One way to conceptualize whether one can do well on and why I am carrying out a task is through identity theory. *Do I see myself as a person with the ability to carry out a task for a given purpose?* For example, in the domain of mathematics, I would ask whether I see myself as a student who is good in mathematics and if the answer is in the affirmative, I would then seek to demonstrate this by taking increasingly more advanced mathematics courses or engaging in other mathematics activities (e.g., joining a mathematics club or participating in mathematics competitions). But in addition to ability, contemporary motivation theory suggests consideration of at least two other constructs: self-efficacy and interest (Eccles et al., 1983).

Mathematics Identity

In educational settings, having an academic identity has long been considered an important part of students' academic success and persistence (Marsh, 1990; 1993; Marsh, Bryne, & Shavelson, 1988). More recently, researchers have studied the impact of content-specific identities (e.g., mathematics identity, science identity) on academic performance, including how these identities relate to minority and female students' academic performance and choices in STEM-related fields (Chemers, Zurbriggen, Syed, Goza, & Bearman, 2011; Stets, Brenner, Burke, & Serpe, 2017; Syed, Azmitia, & Cooper, 2011).

This study takes a symbolic interactionist perspective, in which identities are a function of the meanings that people attach to the roles that they play—student, father, priest, and so on (Stryker & Burke, 2000). The self is seen as composed of a hierarchy of identities where the more prominent or salient the identity, the higher it is in the hierarchy (McCall & Simmons, 1978; Stryker, 1968). Following Stone (1995/1962), identities are established when significant others use the same words to describe someone as that person uses for themselves. Thus to be *identified*, claims made for oneself must be legitimated and supported by significant others. For example, a student's mathematics identity is based not only on their own perceived mathematics capabilities and accomplishments, but this perception must also be supported by others. That is, one not only sees oneself as being "a math person," but one is also identified by significant others (e.g., teachers, parents, friends) as "a math person."

How parents, teachers, and friends view someone in relation to mathematics has an impact on that person's perceptions of their own mathematics competence (Bleeker & Jacobs, 2004). For example, Wenger (1998) found that one's perception of his or her mathematics identity was impacted by others in the community. This in turn influenced one's participation within that community. Furthermore, others may see skills and abilities in someone that they themselves do not initially see. But because of others' support, they are led to make identity claims for themselves. That is, identity development is a reciprocal process.

Not surprisingly, research shows that students' academic identity plays a significant role in their academic achievement and learning behavior. Eccles and Barber (1999) found that underrepresented minorities with a strong academic identity had greater persistence to degree completion compared to those with strong social identities (e.g., based on race/ethnicity or gender). Chemers et al. (2011) sampled 665 undergraduate and graduate students and found that having a science identity significantly predicted students' commitment to science careers. Even more importantly, Stets et al. (2016) found that having a science identity was positively associated with the students' likelihood of entering a science occupation. Not only does a mathematics identity grow out of one's previous accomplishments in mathematics and the recognition from others for those accomplishments, but it also links to feeling efficacious about doing mathematics and a deep interest in mathematics, both as an antecedent and consequence of having a mathematics identity. These in turn lead to additional mathematics pursuits in the form of the number and difficulty of mathematics courses taken and eventually to decisions about whether to pursue a college degree and whether to major in mathematics or some other STEM field.

As noted above, a students' identity is closely associated with other motivational constructs such as mathematics self-efficacy and having an interest in mathematics.

Mathematics Self-Efficacy

Bandura (1994) defined self-efficacy as:

> "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. Self-efficacy beliefs determine how people feel, think, motivate themselves, and behave. Such beliefs produce these diverse effects through four major processes. They include cognitive, motivational, affective, and selection processes" (p. 71).

Zimmerman (2000) summarized that (1) Self-efficacy measures focus on performance capabilities rather than personal qualities, such as physical or psychological capabilities; (2) Self-efficacy beliefs are multidimensional and differ on the basis of the domain of functioning. For example, self-efficacy beliefs about performing on a mathematics test may differ from beliefs about performance on a reading test; (3) Self-efficacy beliefs depend on a mastery criterion of performance rather than on normative or other criteria. For example, students evaluate how well they are at solving an arithmetic problem, not how well they expect to do on the problem compared with other students; (4) Self-efficacy beliefs specifically refer to future performance and are assessed before students perform the relevant activities.

In Eccles's expectancy-value theory, self-efficacy beliefs are referred to as competence-related beliefs and these are of two types: ability beliefs and expectancy beliefs (Eccles et al.,1983). *Ability beliefs* are defined as individuals' perceptions of their *current* competence, particularly in a specific domain such as mathematics or science. These beliefs reflect evaluations not only of their own ability, but how their ability compares to others. *Expectancy beliefs* refer to how one thinks he or she will do on *future* tasks, either in the immediate or longer-term future. Thus, self-efficacy beliefs are of two types, one of which refers to present competence (ability beliefs) and the other to future performance (expectancy beliefs) (Wigfield & Eccles, 2000). Expectancy-value theorists hypothesize that expectancies for future performance are influenced by ability beliefs, the perceived difficulty of different tasks, individual goals, and previous experiences. For example, individuals' beliefs about their mathematics ability comes from many years of experiences with mathematics and reflect their own evaluation of their current skills in mathematics. Individuals' expectancies refer to how they think they will do in the future (e.g., in an upcoming mathematics course), and they base their expectancies of success primarily on their beliefs about their ability in math. As important as these two constructs are theoretically, empirical research has shown that they cannot easily be distinguished from each other (Eccles & Wigfield, 1995; Eccles, Wigfield, Harold, & Blumenfeld, 1993). Eccles and Wigfield (2002) concluded that, "[a]pparently, even though these constructs can be theoretically distinguished from each other, in real-world achievement situations they are highly related and empirically indistinguishable" (p. 119).

The formulation of self-efficacy by expectancy-value, with its emphasis on ability and expectancy beliefs, fits conformably with Bandura's self-efficacy theory, given its emphasis on persons' beliefs about their capabilities to generate performances that have influence over events that impact their lives.

A role-specific identity (e.g., a science identity) is important for motivating role-specific behaviors that can further reinforce that identity. Self-efficacy is increased by self-verification of an identity in that it leads to a sense of control over the role-related environment (Stets & Burke, 2000). But that sense of control also motivates behaviors that provide the opportunity to verify identities. Ervin and Stryker (2001) also postulated that self-efficacy is both an antecedent of as well as a consequence of role-related identity behaviors. Brenner, Serpe, and Styker (2017) examined the reciprocal relationship between role-specific self-efficacy, identity prominence, and identity salience using four waves of data from a longitudinal study of underrepresented college students in STEM fields. Identity prominence is seen as the affective component of identity; that is, it is the subjective value assigned to an identity (McCall & Simmons, 1978). By contrast, identity salience is defined as the probability that a given identity will be enacted in a particular situation or setting (Stryker, 1968, 2004). Brenner et al. (2017) found that science self-efficacy was related to identity prominence, which in turn was related to identity salience. While the direct relationships of prominence and salience back to role-specific self-efficacy over time were statistically significant, both relationships were weak.

Extensive research also indicates that students with lower mathematics self-efficacy or lower perceived competence in mathematics perform less well on mathematics tests compared to students with higher mathematics self-efficacy (Eccles, 2009; Valian, 2007; Wigfield, Eccles, Davis-Kean, Roeser, & Scheifele, 2006; Zimmerman & Kitsantas, 1997, 1999). In addition, students with higher perceived competence in mathematics are more likely to enroll in advanced mathematics courses, participate in mathematics clubs, and choose a quantitative college major (Dweck, 2008). Self-efficacy has also been considered as the essential motivational construct to understand student's academic achievement and behaviors (Zimmerman, 2000).

While it appears to be necessary, higher mathematics self-efficacy is likely insufficient to predict students' mathematics course choices and mathematics achievement (Joyce & Farenga, 2000; Shapka, 2009; Wang, 2013). Believing one can do mathematics does not necessarily mean that a student will choose to work on mathematics or enjoy mathematics. Besides having a mathematics identity and a sense of efficacy in doing mathematics, a student needs to also demonstrate an interest in and other positive subjective values toward mathematics.

Mathematics Interest

Having an interest in mathematics (hereafter referred to as "mathematics interest") is also an important motivational construct. Hidi and Renninger (2006) define interest as a learners' predisposition to engage and reengage specific disciplinary content (e.g., mathematics, science) over time as well as the psychological state that accompanies this engagement. Under the framework of the expectancy-value theory, mathematics interest emphasizes the enjoyment of mathematics; in this regard, the construct is similar to intrinsic motivation in self-determination theory (Ryan & Deci, 2000; Schiefele, 2001). When students intrinsically value mathematics, they are more likely to deeply engage in mathematics activities and be more resilient in the face of difficulty while doing mathematics thinking. Atwater, Wiggins, and Gardner (1995) found that students with greater interest in mathematics tended to enroll in more mathematics courses and earn higher grades in mathematics than those with less interest in it.

Theoretical work shows important connections between self-efficacy and interest. According to Eccles's expectancy-value theory and Bandura's self-efficacy theory, self-efficacy beliefs should influence interest beliefs. Wigfield (1994) proposed a developmental view on the relationship between self-efficacy beliefs and interest beliefs. He thought that young children are likely to view self-efficacy and interest beliefs as being independent of each other. Over time, particularly in the achievement domain, children begin to attach more value to activities in which they do well. Eventually, self-efficacy beliefs and interest become positively related to one another. Furthermore, Simpkins et al. (2006) found that students' mathematics self-efficacy and valuing mathematics were positively correlated with achievement—students with a higher degree of mathematics efficacy who also highly valued mathematics were more likely to do well in mathematics than those without these characteristics.

Finally, as noted above, the symbolic interactionist perspective sees oneself as comprised of a hierarchy of one's various identities all operating within social structures (Stryker, 1968, 1980). As such, one would hypothesize that mathematics identities, a sense of efficacy in doing mathematics, and having an interest in mathematics operate reciprocally over time. In this formulation, students who repeatedly do well in mathematics get more support from significant others (e.g., teachers, parents, and other students), which leads to a sense of efficacy in being able to do mathematics, which in turn leads to an interest in it, which leads to the development of a mathematics identity. This identity then grows stronger and occupies a more salient place in their identity hierarchy as they continue to do well in mathematics and are reinforced for doing so by others. Having a mathematics identity, feeling efficacious about doing mathematics, and an interest in doing mathematics are hypothesized to *motivate one to take successively more difficult mathematics courses and aspire to perform well in those courses*. But if performance does not meet some objective criterion for proficiency in mathematics (e.g., a B or better in coursework), the expectation is that over time motivation will suffer—feelings of efficacy, interest, and identity will diminish. Performance is important because it reflects the reinforcement (positive or negative) of the persons who are viewed to be the most important significant others in judging mathematics abilities and skills—mathematics teachers. Finally, the trajectories are not expected to necessarily be linear; they can take twists and turns, but this study hypothesizes that for all three components of motivation to remain positive or to grow depends upon trajectories that continue to be positive in direction for all three. The opposite would be true for the lack of a mathematics identity as well as efficacy and interest.

To summarize, the three components of mathematics motivation—mathematics identity, self-efficacy, and interest—are posited as reciprocally related to one another and all appear to play important roles in influencing students' mathematics-related behaviors and achievement. And mathematics achievement is seen as either reinforcing or diminishing all three components over time, depending upon whether trajectories of mathematics performance are positive or negative.

This study focuses on students' mathematics identity, their interest in mathematics, and their sense of efficacy in doing mathematics. This study hypothesizes that students who do well in mathematics early in their high school careers are likely to identify themselves as "math persons," feel confident about their mathematical ability, and expect to be successful in mathematics. These characteristics in turn are hypothesized to lead to taking more and more challenging mathematics courses while in high school—courses that require increasingly deeper cognitive-level processing. These behaviors in turn are hypothesized to be associated with mathematics achievement.

Educational Expectations and Achievement

In addition to the three motivation variables noted above, adolescents' expectations about their future educational attainment are important as well because they influence academic choices, decisions, behaviors, and activities, which in turn affect academic achievement (Nurmi, 2004).[1] High school seniors' educational aspirations as part of the Wisconsin Longitudinal Study of 1957 were the best single predictor of educational outcomes seven years later (Gasson, Haller, & Sewell, 1972; Sewell, Haller, & Ohlendorf, 1970; Sewell & Shah, 1968). Ou and Reynolds (2008) investigated the relationship between student educational expectations and education attainment among 1,286 low-income, minority students who grew up in an urban area. The study found that students' expectations was one of the strongest predictors of educational attainment.

In addition, researchers suggest that students' educational expectations influence their academic-related decisions and activities, such as taking a higher-level mathematics course in high school, thus shaping their academic achievement and ultimate educational attainment. Beal and Crockett (2010) conducted a longitudinal study of 317 adolescents and found that the subjects' educational expectations significantly predicted their educational achievement and attainment by mediating the adolescents' participation in extracurricular activities.

Social Contexts, Motivation, and Achievement

Students' motivational beliefs also develop under the influence of various social contexts, including family and school. Therefore, a better understanding of students' motivational beliefs as they relate to mathematics performance requires having knowledge of family and school contexts as well.

Data from the Wisconsin Longitudinal Study showed a significant relationship between students' educational aspirations and their parents' educational attainment (Sewell & Shah, 1968). Other studies found that students with high socioeconomic status (SES) were more likely to have higher mathematics test scores (Coley, 2002; Gregory & Weinstein, 2004) and to participate in and finish advanced mathematics classes (Sciarra, 2010) than were students with low SES. Parents with higher levels of education and higher earnings are able to provide greater learning opportunities and a more academic environment at home than parents with lower levels of education and lower earnings. Castambis (2005) found that parents with high SES had a better understanding of the educational system—for example, how to communicate with teachers and

[1] Bozick, Alexander, Entwisle, Dauber, & Kerr (2010) used data from the Wisconsin Longitudinal Study to show that stable educational expectations across individuals' school careers are important predictors not only of school performance but also long-term status attainment.

discuss their children's mathematics track—than did low SES parents (Useem, 1992). Overall, family income and parents' education have been shown to relate to students' mathematics motivation and achievement as well as to the mathematics achievement gaps between minority students and White students.

School context is also an important factor in understanding student achievement. Freiberg (1999) argued that school influences student achievement through student attachment, commitment, involvement, and, most importantly, through schools' resources and academic climate. Perry and McConney (2010) found that school SES was significantly associated with students' academic achievement. The relationship was similar for all students regardless of their level of SES. Rumberger and Parlardy (2005) used the National Education Longitudinal Survey of 1988 (NELS:88) to examine individual and school effects on achievement growth between grade 8 and grade 12 in mathematics, science, reading, and history. They found that school-level SES had as much impact on students' achievement as the students' individual-level SES did, after controlling for other background factors.

Gender, Motivation, and Academic Achievement

Gender plays a significant role in shaping individuals' achievement motivation, and thus influences individuals' achievement behaviors (e.g., taking a mathematics course) and outcomes. Historically, men were more likely than women to go to college and enter high-paying occupations. During the last three decades, the status of women in postsecondary education and the workplace changed substantially. Women have been obtaining more college degrees than men (Snyder, De Brey, & Dillow, 2016; Snyder & Hoffman, 2001; Snyder & Tan, 2006). Gender gaps in mathematics and science achievement have decreased (Freeman, 2004). However, gender differences in STEM education and occupations still exist. Overall, more female high school students were enrolled in advanced mathematics and science classes than their male peers, but they were less likely than male students to report liking these courses. Beede et al. (2011) reported that women held fewer than 25 percent of STEM jobs in 2009, despite comprising close to half of the workforce. Furthermore, 2015 Integrated Postsecondary Education Data System (IPEDS) data showed that that 69 percent of those with STEM degrees were male (437,000 million male recipients compared to 199,000 female recipients).

Understanding motivational differences related to the gender gaps in mathematics performance is one of the goals of this study.

Within the last few decades, researchers have also noted gender differences in students' self-efficacy beliefs. For example, Eccles et al. (1993) found gender differences in students' ability beliefs and expectancies for success as early as early elementary school. In accordance with traditional gender norms and stereotypes, boys had more positive competence beliefs for mathematics than girls did—even though boys and girls performed equally well in mathematics.

Research has indicated that both boys' and girls' overall self-efficacy beliefs decline over the course of schooling (Wigfield & Eccles, 2000; Wigfield, Eccles, Yoon, & Harold, 1997). However, boys and girls display different change patterns across different achievement domains. Girls' self-efficacy toward mathematics in the elementary and middle school years declines at a slower rate than boys' self-efficacy does, leading to a smaller mathematics achievement gap as students enter higher grade levels.

Eccles et al. (1993), using a longitudinal design that followed students from second to fifth grade, also found that students in lower grades had higher levels of competence and subjective task values beliefs compared to students in higher grades. Across grades, boys had more positive competence beliefs and subjective values for mathematics than did girls, a finding in accordance with traditional gender stereotypes.

Race/Ethnicity, Motivation, and Academic Achievement

In the contemporary United States, educational achievement gaps between White students and their Black and Hispanic peers contribute to racial/ethnic economic inequality (Jencks & Phillips, 1998). The most recent data from the National Assessment of Educational Progress (NAEP) shows achievement gaps between White students and Black and Hispanic students. In 2015, White students performed about 0.88 and 0.62 standard deviations higher than Black and Hispanic students, respectively, in grade 12 mathematics assessments. In addition, Black and Hispanic students are consistently underrepresented in STEM degree programs and occupations, worsening economic inequality across racial/ethnic groups (Anderson & Kim, 2006; Herrera & Hurtado, 2011; Schultz et al., 2011).

Why do minority students, particularly Black and Hispanic students, tend to achieve at lower levels and participate less in STEM degree programs and occupations than White students? Scholars have offered a number of possible answers, pointing to factors ranging from inequalities in students' social class backgrounds, to differences in cultural orientations toward schooling, to various inequalities between and within schools themselves (Downey, 2008; Rothstein, 2004). Motivation becomes an important possible factor to interpret the differences in academic behaviors and achievement between White and minority students. Research has shown that Black and Hispanic students are less likely to see themselves as "a math person" or as someone fitting into the STEM profession, probably because minority students are not typically exposed to Black and Hispanic role models working in STEM careers (Seymour & Hewitt, 1997). Also, Black and Hispanic students are more inclined to suffer from negative stereotypes about their mathematics achievement than students of other races/ethnicities are (Steele, 2011). This causes Black and Hispanic students to be more likely to doubt their mathematical competence, which can lead to a disengagement from mathematics tasks and activities.

Lewis and Connell (2005) found that Black students' mathematics coursetaking decisions were predicted by both their interest in mathematics and their beliefs about the utility of mathematics. Azmitia, Syed, and Radmacher (2008) pointed out that minority students were more likely to struggle with having an academic identity, even beyond mathematics. Andersen and Ward (2014) found that high-ability White ninth-graders valued mathematics more than their high-ability Black and Hispanic peers did, indicating that Black and Hispanic students might have lacked support for their value beliefs about the utility of mathematics.

Summary of Relationships between Motivation, Achievement, and Social Context

Overall, the research literature suggests that students' mathematics motivation helps explain their choice of mathematics tasks, persistence on these tasks, the power to accomplish these tasks, and their performance on them. The literature also consistently demonstrates that students with high mathematics self-efficacy who also have a high subjective value about mathematics are more likely to engage in learning mathematics and persist in learning it when confronted with challenges, resulting in higher mathematics achievement. Gender and race/ethnicity play important roles in shaping individuals' motivation. Female, Black, and Hispanic students suffer from negative stereotypes about their ability to achieve in mathematics, which then affects their ability to learn mathematics, to form a positive mathematics identity, and to do well on mathematics assessments.

Hypothesized Conceptual Model

This study's hypothesized conceptual model (see Figure 1) takes a comprehensive perspective in investigating the relationships among mathematics performance, mathematics motivation, educational expectations, and mathematics coursetaking[2] as students move from grade 9 to grade 12. The conceptual model depicts a series of sequential paths, representing evidence-based hypotheses about how students' mathematics motivation and educational expectations in their freshman year of high school relate to mathematics motivation, educational expectations, and mathematics coursetaking in grade 11, and how these in turn—along with school-level contextual variables—relate to mathematics achievement in grade 12.

The existing literature highlights the relationship among the role of students' mathematics motivation in shaping student academic decisions and schooling outcomes (Eccles & Wigfield, 2002; Liem, Lau, & Nie, 2008; Syed, Azmitia, & Cooper, 2011; Zimmerman, 2000), the role of students' educational expectations in impacting students' academic achievement (Beal & Crockett, 2010; Nurmi, 2004; Ou & Reynolds, 2008), and the role of social context including both family and school background as reflected in students' determinations and interpretations of family and school experiences (Perry & McConney, 2010; Rumberger & Parlardy, 2005), and how these impact student academic achievement. However, there is limited research about how each factor influences and is influenced by other factors when all are taken into consideration across time.

This study postulates a sequential path-analytic framework to describe the relationships among mathematics motivation, educational expectations, and high school coursetaking difficulty between grades 9 and 11. While even a longitudinal design does not allow one to draw firm causal inferences, it can confirm whether the findings are consistent with the conceptual model and the hypotheses embodied within it.

[2] The variable of math coursetaking refers to the difficulty level of math courses taken.

Turning now to the paths in the conceptual model, first, this study hypothesizes that:

1. Students' mathematics motivation, educational expectations, and algebra achievement at grade 9 (the beginning of high school) are related to their socio-demographics as well as the demographics of the school they attend.

2. Mathematics motivation and educational expectations develop from grade 9 to grade 11. In other words, mathematics motivation constructs as well as educational expectations are positively related among themselves and to each other over time.

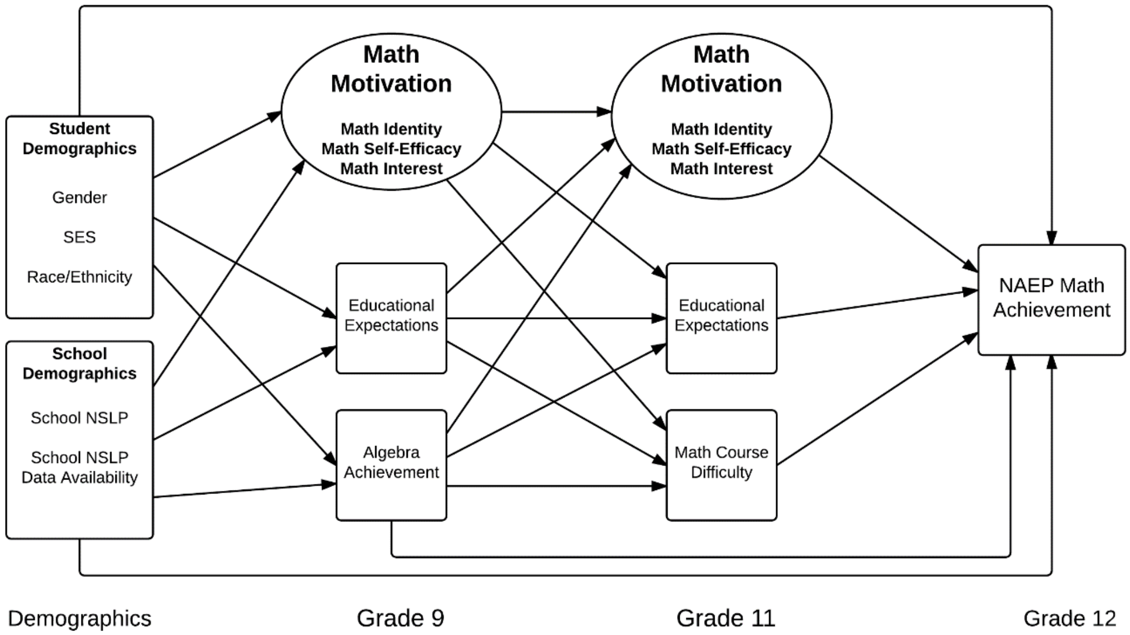
3. Grade 9 algebra achievement is a precursor to mathematics motivation and educational expectations at grade 11. The assumption here, drawn from the research literature, is that positive mathematics performance results reinforces and further develops a mathematics identity, an increased sense of efficacy in doing mathematics, and an increased interest in the subject.

4. Mathematics motivation, educational expectations, and algebra achievement at grade 9 are hypothesized to have an impact on students' mathematics coursetaking at grade 11. The assumption is that students who have done well in mathematics in the past, have a mathematics identity, who feel efficacious about doing mathematics, who are interested in mathematics, and have high educational expectations are more likely to take additional and more challenging mathematics courses in the future.

5. Grade 12 NAEP mathematics achievement is associated with grade 11 mathematics motivation, educational expectations, and mathematics coursetaking difficulty level after controlling for student socio-demographics and school SES.

It is these five interrelated hypotheses that form the conceptual framework. Results will be examined overall and separately by gender and major racial/ethnic groups. This approach will shed light on whether the conceptual framework operates similarly across student subpopulations, including female students, Black students, and Hispanic students. Finally, the proposed model delineates the developmental continuum of mathematics motivation and educational expectations across high school, which contributes to the understanding of developmental patterns for mathematics motivation.

Figure 1. Conceptual path model for mathematics motivation and mathematics achievement



NOTE: Mathematics motivation measurement models were analyzed before the path models were conducted. For the final path models, mathematics motivation at grade 9 and 11 were observed variables.

Methods

Data Source and Sample

This study uses the special overlap sample of approximately 3,480 students who participated in the High School Longitudinal Study of 2009 (HSLS:09) and took the 2013 Grade 12 National Assessment of Educational Progress (NAEP) Mathematics Assessment. The HSLS:09 base year took place in the 2009–10 school year, with a randomly selected sample of fall-term grade 9 graders. Students took an algebra assessment and a survey online in their schools. The first follow-up of HSLS took place in the spring of 2012, when most participants were in the spring of their 11th grade.

The NAEP-HSLS overlap sample permits an understanding of the NAEP scores in the context of students' psychological characteristics, family background, and school background, because HSLS included parent, student, and school surveys. The student survey collected a set of psychological variables on students' interests, identities, motivations, and aspirations around math, science, and engineering that were not included in the NAEP contextual questionnaires. The school survey collected data on school demographics and the school and teacher surveys measured school climate. The NAEP-HSLS overlap sample provides an opportunity to examine NAEP achievement with more family and school background variables[3] than are available from

[3] Family SES is an important background variable collected in the HSLS base year. However, about one quarter of base-year SES values are imputed.

the NAEP contextual questionnaires. In addition, HSLS contains multiple waves of data, which makes it possible to investigate these relationships longitudinally.

This study focuses on students' mathematics motivation and its relationship with mathematics achievement. Student mathematics motivation data were collected in a HSLS student questionnaire. Fifteen students who did not answer any mathematics motivation questions for grade 9 and grade 11 were excluded from the final analytic sample. In addition, about 230 students who did not have baseline mathematics achievement data were also removed from the final analytic sample. As a result, the final analytic sample was composed of 3,230 students who participated in both the HSLS and NAEP Grade 12 Mathematics Assessment. Table 1 presents the distribution of the final analytic sample by sex, race/ethnicity, and school eligibility for free or reduced-price lunch.

Table 1. Basic demographic characteristics for the final analytic sample, by gender, race/ethnicity, and NSLP eligibility

Student demographic characteristics	Final analytic sample			
	Unweighted number of students	Unweighted percentage	Weighted percentage[1]	
			Percentage	Standard error
Total	3230	100	100	†
Sex				
Male	1640	51	51	1.85
Female	1590	49	49	1.85
Race/ethnicity				
White	1980	61	69	2.76
Black	340	10	11	2.12
Hispanic	450	14	13	2.30
Asian/Pacific Islander	390	12	6	0.58
American Indian/Alaska Native	20	<1	1	0.65
Other	50	2	1	0.22
NSLP eligibility[2]				
Eligible	1120	35	37	1.96
Not eligible	2110	65	63	1.96

†Not applicable.
[1]Weighted using grade 12 NAEP survey weight.
[2]No information available category is not shown.
NOTE: NSLP=National School Lunch Program. Detail may not sum to totals because of rounding.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Tables 2-a and 2-b display the comparison of this final analytic sample to the original NAEP-HSLS overlap sample, and the HSLS and NAEP populations. The results show that the final analytic sample was similar to the original overlap sample in terms of basic demographic characteristics. Compared to the HSLS and NAEP populations, the final analytic sample had a higher percentage of White students. The final analytic sample also had a lower percentage of students who were eligible for the National School Lunch Program (NSLP). But the NAEP mathematics performance of the final analytic sample was similar to that of the original NAEP-HSLS overlap sample, and full NAEP and HSLS populations. As expected, the standard errors of the final analytic sample and the original NAEP-HSLS overlap sample were larger in all cases in comparison to those in the NAEP sample.

Table 2-a. Comparison of the final analytic sample with the NAEP-HSLS overlap sample, the 2013 NAEP grade 12 operations population and the HSLS population, by student subgroups

Student demographic characteristics	Original NAEP and HSLS overlap sample		Final analytic sample		NAEP population		HSLS population	
	Percentage	Standard error	Percentage	Standard error	Percentage	Standard error	Percentage	Standard error
Total	100	†	100	†	100	†	100	†
Gender								
Male	51	1.71	51	1.85	50	0.48	50	0.67
Female	49	1.71	49	1.85	50	0.48	50	0.67
Race/ethnicity								
White	69	2.88	69	2.76	58	0.70	52	1.14
Black	111	2.02	11	2.12	14	0.47	14	0.88
Hispanic	133	2.33	13	2.30	20	0.49	22	0.97
Asian/Pacific Islander	6	0.59	6	0.58	6	0.31	4	0.39
American Indian/Alaska Native	1	0.61	1	0.65	1	0.12	1	0.18
Other	1	0.21	1	0.22	2	0.12	7	0.34
NSLP eligibility[1]								
Eligible	36	1.86	37	1.96	39	0.70	†	†
Not eligible	64	1.87	63	1.96	60	0.71	†	†

† Not applicable.
[1]"No information available" category not shown.
NOTE: Grade 12 NAEP survey weight was used in the analysis.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table 2-b. Mathematics achievement comparison of the final analytic sample with the NAEP-HSLS overlap sample on the 2013 NAEP grade 12 assessment, by operational population student subgroups

Student demographic characteristics	Original NAEP and HSLS overlap sample			Final analytic sample		NAEP overall population	
	Average scale score (unweighted)	Average scale score (weighted)	Standard error	Average scale score (weighted)	Standard error	Average scale score	Standard error
Overall score	156.87	155.24	2.02	155.20	2.09	153.46	0.54
Gender							
Male	158.51	156.09	3.02	156.28	3.18	154.91	0.63
Female	155.17	154.35	1.46	154.08	1.48	151.99	0.61
Race/ethnicity							
White	160.27	159.58	2.18	159.56	2.30	161.52	0.59
Black	134.64	131.49	2.93	131.14	2.92	131.82	0.79
Hispanic	144.44	144.50	3.81	145.03	3.97	140.52	0.77
Asian/Pacific Islander	173.25	170.20	3.10	170.99	3.13	172.14	1.27
American Indian/Alaska Native	147.55	152.05	6.39	155.04	6.46	141.95	3.25
Other	159.34	157.15	5.97	156.80	6.02	155.12	1.68

NOTE: Grade 12 NAEP survey weight was used in the analysis. For the grade 12 mathematics assessment, the scale ranges from 0 to 300.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Variables

This section summarizes exogenous and endogenous variables that were used in the current study based on the hypothesized conceptual framework.

Exogenous Variables

The study used two sets of exogenous variables: (1) student demographics and (2) school background variables.

Student demographic variables included gender, race/ethnicity, and socioeconomic status (SES). Sex[4] and race/ethnicity were collected both by HSLS and NAEP. This study used NAEP data since the endogenous variable of greatest interest is NAEP mathematics performance. The SES measure is a composite created using the following items collected from the NAEP contextual questionnaire[5]: NSLP eligibility; parental education level; number of books in the home; whether there's a computer in the home; whether the family has access to the Internet; whether the family has its own clothes dryer; whether the family has a dishwasher; whether the family has more than one bathroom; and whether the student has their own bedroom. This composite was scored on a range from 0 to 16.[6] The internal consistency reliability of the measure is 0.62 as measured by Cronbach's alpha (Cronbach, 1951).

[4] HSLS:09 did not ask about gender but rather about sex. Sex was determined from school records and confirmed by the parent. Gender, as different from biological sex, was only asked of the student in the Second Follow-up in 2016.
[5] The details about the SES composite can be found at the technical memo of SES index.
[6] See Appendix A for the exact scoring used to create the SES index.

School background variables included the percentage of students who were racial/ethnic minorities (broken out separately for Asian, Black, and Hispanic students) and the percentage of students eligible for NSLP. Moreover, a high percentage of school-level NSLP data was missing, necessitating a dichotomous variable indicating whether or not this data was available.

Endogenous Variables

2013 Mathematics Grade 12 NAEP Assessment Scores—Plausible Values

NAEP reports an overall score for mathematics, which is a composite of five subscales: (a) number properties and operations; (b) measurement; (c) geometry; (d) data analysis, statistics, and probability; and (e) algebra. The overall score of the 2013 Grade 12 NAEP Mathematics Assessment (scale scores) was the outcome variable for the current study. NAEP scale scores are reported as "plausible values" because, by the NAEP assessment design, students are administered only a small subset of the total pool of assessment items, not representing the whole assessment domain.[7] Multiple imputation procedures are then used to produce a set of twenty "plausible values" (e.g., plausible scores) for each student taking the mathematics assessment. In generating the plausible values, NAEP uses a "conditioning model" that includes all the variables from the various contextual questionnaires NAEP collects along with the responses of students to the particular portion of the assessment items that they are assigned. The proper analysis of NAEP data requires that the variables included in the analysis are also included in the conditioning model. This requirement posed a problem for the analyses in this study given that many of the variables came from the HSLS questionnaires. In order to test whether the use of NAEP plausible values that have not been conditioned previously with the contextual variables from the HSLS might have led to biased results, models that included all the variables in the final analyses as the independent variables and NAEP performance as the dependent variable were run in two ways: using plausible values not conditioned with the contextual variables from HSLS and direct estimation where these variables are included.[8] Results revealed that using the NAEP plausible values not conditioned on variables from the HSLS contextual student questionnaire produced biased results. Therefore, a new set of plausible values conditioning on all variables used in the current study (both those from NAEP and those from HSLS) was produced. The technique used to generate the new set of plausible values is discussed in Appendix B.

Mathematics Achievement

Another important endogenous variable was students' mathematics achievement, as measured by an assessment of algebra reasoning administered to the HSLS sample in the fall of 2009, when the students were in grade 9. The algebra assessment covered six topics: The language of algebra; proportional relationships and change; linear equations, inequalities, and functions; nonlinear equations, inequalities, and functions; systems of equations; and sequences and recursive relationships.[9] It is closely based on the NAEP frameworks as they pertain to Algebra.

---

[7] For more information, see NAEP technical documentation on the web: http://nces.ed.gov/nationsreportcard/tdw/analysis.

8 Direct estimation refers to using raw NAEP scores instead of NAEP plausible values to conduct analysis by using AM software.

[9] More information about the algebra assessment can be found at: http://nces.ed.gov/surveys/hsls09/pdf/2011328_1.pdf.

Motivation and Educational Expectations

Student mathematics motivation was measured both at grade 9 and grade 11, with items assessing mathematics identity, self-efficacy, and interest. The exploratory and confirmatory factor analyses presented in the following section discuss in more detail the construction of the three mathematics motivation indices.

Student educational expectations were also surveyed both at grade 9 and grade 11. Students were asked "As things stand now, how far in school do you think you will get?" The options for this question ranged from "Less than high school" to "Complete a Ph.D., M.D., law degree, or other high-level professional degree."[10]

Mathematics Course Difficulty at Grade 11

The grade 11 follow-up asked students to indicate which mathematics courses they were currently taking. These courses were grouped into six categories from least advanced to most advanced. For example, a pre-algebra course was assigned a 1 whereas an Advanced Placement calculus course was assigned a 6. Each student was assigned a value between 1 and 6 based on the most advanced course he or she had taken at the time of the HSLS follow-up in grade 11. See Appendix C for a list of mathematics courses and the corresponding difficulty level.

Missing Data and Imputation

This section discusses the techniques used to handle missing data for mathematics motivation and the imputation methods for creating a new set of NAEP plausible values conditioned on HSLS contextual variables to be used in this study.

Mathematics Motivation Variables

Eleven items drawn from the HSLS student questionnaire related to mathematics motivation were included in the analysis of both the baseline and follow-up years (grades 9 and 11). The percentage of missing responses for the motivation items ranged from 1.2 to 16.9 percent across all 11 items (7.1 to 16.9 percent for the base year with an average of 8.5 percent, and 1.2 to 13.9 percent for the follow-up year with an average of 2.9 percent). Although the proportion of the missing data was not high, multiple imputation (Asparouhov & Muthén, 2010) was performed using the Mplus default method (i.e., the variance-covariance model), because the motivation items were the focus of the study. The multiple imputation excluded 15 students who did not respond to any of the 11 items at either baseline or follow up. Missing values for the 11 motivation items at both points in time were imputed using student item responses, where available, as well as four variables used as conditioning variables: gender, race/ethnicity, socio-economic status index, and baseline algebra achievement score. Using this procedure, five imputed datasets were generated. Any subsequent analyses involving student responses to the motivation items were conducted using the "type=imputation" command in Mplus. When this command is specified, parameter estimates are averaged over the five imputed datasets, and standard errors are calculated based on the average of the standard errors over the set of analyses

[10] "I don't know" option was coded as 0.

and the between-analysis parameter estimate variation (see Mplus manual version 7). Detailed information about the analytic procedures performed to answer each research question is provided in the following section.

To ensure the quality of the imputed datasets, the correlations among the imputed motivation items were compared between the imputed data and the data without any imputation. Additionally, the mean and standard deviations of mathematics motivation indices and the correlations among the indices were compared between the imputed data and the data without any imputation. The differences were minimal in the vast majority of cases, suggesting that the imputed datasets are of high quality.

NAEP Plausible Values

To get an unbiased estimate of the relationship between NAEP mathematics performance and mathematics motivation, the NAEP plausible values for this study were conditioned using all the background variables from the NAEP questionnaires as well as the measures of motivation, educational expectations, and coursetaking difficulty variables from the HSLS student questionnaire. The details of the procedure used are discussed in Appendix B.

For this study, five equivalent datasets were created after using multiple imputation techniques to handle missing data. After imputation of the new NAEP plausible values conditioned on both NAEP and HSLS variables, each of the five datasets had 20 NAEP plausible values. That is, a total of 100 datasets were created for the final analyses.

When the "Imputation" command is specified in MPlus, parameter estimates are averaged over the five imputed datasets, and standard errors are calculated based on the average of the standard errors over the set of analyses and the variations between analyses parameter estimates.

In addition, Mplus accommodates complex survey design features such as survey weights. All the analyses used NAEP student-level weights (as opposed to HSLS student level weights), because the focus of this study was to understand NAEP mathematics achievement within the context of student mathematics motivation.

Analyses

This section first covers the exploratory and confirmatory factor analyses carried out to determine the underlying factor structure of the motivation items, the results of which were used for the construction of the mathematics motivation indices. Second, this section includes an outline of the analysis methods used to examine the study's three major research questions.

The Factor Structure of Mathematics Motivation

The underlying structure of mathematics motivation items were examined by conducting exploratory factor analyses (EFA), allowing factors to correlate.[11] EFA was conducted for the grade 9 (base year) and grade 11 (follow-up year) variables separately. As Appendices D1 and D2 show, both the analyses suggested nearly identical underlying factor structures, with a

[11] Geomin oblique robust weighted least squares estimator was used.

three-factor structure fitting the data the best without items cross-loading on multiple factors except for one item. The three factors seemed best described as mathematics identity (three items), mathematics self-efficacy (four items), and mathematics interest (three items). Based on EFA results, confirmatory factor analyses (CFA) (Jöreskog, 1969) were conducted with a three-factor structure for grades 9 and 11 separately, excluding one item which cross-loaded on both the mathematics identity and interest factors.

Results from the CFA confirmed the three-factor structure for both grades 9 and 11. Appendix E shows the model fit indices, standardized factor loadings, and factor correlations. The proposed measurement model had a good fit based on Hu and Bentler's (1999) recommendations: For grade 9 a Root mean square error of approximation (RMSEA) = 0.03; comparative fit index (CFI) = 0.99; Tucker-Lewis index (TLI) = 0.98 and for grade 11 RMSEA = 0.05; CFI = 0.99; TLI = 0.98. Standardized factor loadings ranged from 0.82 to 0.96 for grade 9 mathematics identity, 0.83 to 0.92 for grade 9 mathematics self-efficacy, and 0.73 to 0.90 for grade 9 mathematics interest. For grade 11, standardized factor loadings ranged from 0.87 to 0.95 for mathematics identity, from 0.80 to 0.94 for mathematics self-efficacy, and from 0.65 to 0.97 for mathematics interest. These standardized factor loadings indicate that the items were strongly associated with each of the three latent mathematics motivation factors. The inter-factor correlations among the three factors ranged from 0.66 to 0.71 for grade 9 and from 0.66 to 0.70 for grade 11, indicating a fair degree of relatedness among the three factors.

Building Mathematics Motivation Indices

Based on the CFA results, three mathematics motivation indices were constructed by averaging item scores for each index. All three indices for both grades 9 and 11 show acceptable values for internal consistency reliability (Cronbach, 1951). For the mathematics identity index, Cronbach's alphas were 0.74 and 0.82 for grades 9 and 11, respectively. For mathematics self-efficacy, they were 0.89 and 0.90 for grades 9 and 11, respectively. For mathematics interest, they were 0.77 and 0.79 for grades 9 and 11, respectively. Table 3 lists the items for the three mathematics motivation indices.

Table 3. Constructed mathematics motivation indices from the High School Longitudinal Study (HSLS:09): Grade 9 (base year) and grade 11 (first follow-up year)

Mathematics motivation index	HSLS mathematics motivation survey questions	Response options
Mathematics identity	You see yourself as a mathematics person	0=Strongly disagree; 1=Disagree; 2=Agree; 3=Strongly agree
	Others see you as a mathematics person	
	You really enjoy mathematics	0=No; 3=Yes
Mathematics self-efficacy	You are confident that you can do an excellent job on tests in this course	0=Strongly disagree; 1=Disagree; 2=Agree; 3=Strongly agree
	You are certain that you can understand the most difficult material presented in the textbook used in this course	
	You are certain that you can master the skills being taught in this course	
	You are confident that you can do an excellent job on assignments in this course	
Mathematics interest	You are enjoying this class very much	0=Strongly disagree; 1=Disagree; 2=Agree; 3=Strongly agree
	You think this class is a waste of your time (reverse coded)	
	You think this class is boring (reverse coded)	

NOTE: For grade 9, questions for mathematics self-efficacy and mathematics interest were only administered to students who were taking a mathematics course for that semester. However, all students, regardless of whether they took a mathematics course or not, filled out questionnaires for mathematics self-efficacy and mathematics interest at grade 11. For students who did not take any mathematic course at grade 11, the items of mathematics self-efficacy and mathematics interest focused on students' opinions on general math classes.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table 4 presents the detailed correlations among mathematics motivation indices. The correlations among the three indices at both grades 9 and 11 were moderately high, ranging from 0.54 (self-efficacy and interest) to 0.60 (identity and self-efficacy). When examining the stability of the indices between grades 9 and 11 (shown in italics in the table), having a mathematics identity was considerably more stable (0.56) over time than either mathematics self-efficacy (0.34) or interest (0.37). Correlations among the mathematics motivation variables are displayed in Appendix F.

Table 4. Correlations among the mathematics motivation indices and NAEP mathematics performance

	Grade 9			Grade 11			Grade 12
	Mathematics Identity	Mathematics Self-efficacy	Mathematics Interest	Mathematics Identity	Mathematics Self-efficacy	Mathematics Interest	NAEP plausible values
Grade 9 Mathematics Identity	1.00						0.42
Grade 9 Mathematics Self-efficacy	0.60	1.00					0.30
Grade 9 Mathematics Interest	0.55	0.54	1.00				0.16
Grade 11 Mathematics Identity	*0.56*	0.42	0.32	1.00			0.53
Grade 11 Mathematics Self-efficacy	0.33	*0.34*	0.20	0.60	1.00		0.33
Grade 11 Mathematics Interest	0.34	0.28	*0.37*	0.58	0.54	1.00	0.29

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Some *caution must be used in comparing grade 9 and grade 11 mathematics motivation indices of self-efficacy and interest* since there were some design inconsistencies for these two measures between grade 9 and grade 11. For grade 9, questions for mathematics self-efficacy and interest were only administered to students who were taking a mathematics course that semester. However, all grade 11 students filled out questionnaires for mathematics self-efficacy and mathematics interest, regardless of whether they were currently enrolled in a mathematics course or not. There were 360 students who did not take any mathematics course in grade 11. Investigations were conducted to examine whether including those 360 students would lead to any bias for our statistical analyses. No significant biases were detected.

Analysis Methods Corresponding to the Research Questions

For research question 1 (*What was the overall achievement in the 2013 Grade 12 NAEP Mathematics Assessment for White, Black, and Hispanic students? What were the achievement gaps in the 2013 Grade 12 NAEP Mathematics Assessment between Black and White students, and Hispanic and White students?)*, descriptive statistics were calculated for performance on NAEP grade 12 mathematics overall and by racial/ethnic groups to provide a summary of mathematics achievement and the achievement gaps between White and Black students and White and Hispanic students. In addition, sequential multiple regression analyses were used to investigate whether achievement gaps can be explained by students' gender, SES, mathematics motivation, and base year mathematics achievement.

For research question 2 (*What were the levels of student mathematics motivation at grade 9 and grade 11? Were there any differences in student mathematics motivation across gender and racial/ethnic groups?),* descriptive statistics for the mathematics motivation indices were calculated by gender and racial/ethnic groups for grade 9 (base year) and grade 11 (follow-up year) to provide a general picture of student mathematics motivation for the various subgroups at both grades. In addition, this study investigates the zero-order relationships among these variables. Two steps were conducted: (1) examination of the correlations between the student social psychological variables (i.e., student mathematics motivation and student educational expectations) at grade 9 (base year) and the NAEP grade 12 mathematics scale scores, and (2) examination of the correlations using the same indicators listed above but using data from grade 11 (follow-up year).

For research question 3 (*What was the relationship between grade 12 NAEP mathematics performance and mathematics motivation, including educational expectations, taking into account grade 9 mathematics achievement, family and school background factors, and high school mathematics coursetaking such as taking advanced, regular, or basic courses? Did these relationships differ by gender and race/ethnicity?*), structural equational modeling (Bollen, 1989, 1993) was used to examine the relationships among mathematics motivation at grade 9 and 11, educational expectations, mathematics course difficulty, the other contextual variables, and grade 12 NAEP mathematics achievement.

A set of 11 structural equations were defined based on the conceptual model shown above. The first five equations represent the posited relationships of the exogenous variables (student, family, and school backgrounds) to the five endogenous variables measured at grade 9 (mathematics identity, mathematics self-efficacy, mathematics interest, educational expectations, and mathematics achievement). More specifically, the exogenous variables were gender, SES, race/ethnicity (Black, Hispanic, Asian/Pacific Islander, and Other were each dummy coded), percentage of students eligible for free or reduced-price lunch at the school, and NSLP data availability.[12] Since the structures of the equations are identical, only the first equation is displayed below.[13]

$$Y_1 = \alpha_1 + \gamma_1 Female + \gamma_2 Black + \gamma_3 Hispanic + \gamma_4 Asian + \gamma_5 Other + \gamma_6 SES + \gamma_7 SchoolFRL + \gamma_8 SchoolFRLmissing + \varepsilon_1 \quad (1)$$

Where Y_1 represents 9th grade mathematics identity, α_1 is the intercept, γ_1 to γ_8 are the path coefficients for female, Black, Hispanic, Asian, Other race/ethnic group, SES, percentage of students eligible for free or reduced-price lunch at the school, and NSLP data availability, respectively, and ε_1 is the disturbance term. The student demographic variables are dummy-coded so that White and male students are the omitted categories for race/ethnicity and gender, respectively. The next four equations are of the same form except that the endogenous variables are grade 9 mathematics self-efficacy (Y_2), grade 9 mathematics interest (Y_3), grade 9 educational expectations (Y_4), and grade 9 mathematics achievement (Y_5). Because the five endogenous variables at grade 9 share a common set of exogenous variables and no contemporaneous causality is assumed among the five endogenous variables included at grade 9, their disturbance terms, the ε_i, are allowed to freely correlate with each other.

The second set of equations (the sixth to the tenth equations) examines the three grade 11 mathematics motivation indices ($Y_{6–8}$), grade 11 educational expectations (Y_9), and grade 11 mathematics course difficulty level (Y_{10}) as a function of the five grade 9 endogenous variables. The hypothesis is that the effects of the exogenous variables are totally mediated through the five grade 9 endogenous variables. Similar to the grade 9 endogenous variables, the disturbance terms of the grade 11endogenous variables (i.e., grade 11 mathematics motivations, grade 11 educational expectations, and grade 11 mathematics course difficulty level) are allowed to freely correlate with one another since no contemporaneous causality is assumed among them. The sixth equation is displayed below.[14]

$$Y_6 = \alpha_6 + \beta_1 Grade9mathidentity + \beta_2 Grade9mathselfefficacy + \beta_3 Grade9mathinterest + \beta_4 Grade9educationalexpectations + \beta_5 Grade9Algebraachievement + \varepsilon_6 \quad (2)$$

where Y_6 represents grade 11 mathematics identity, α_6 is the intercept, and β_1 to β_5 are the path coefficients for grade 9 mathematics identity, grade 9 mathematics self-efficacy, grade 9 mathematics interest, grade 9 educational expectations, and grade 9 algebra achievement, respectively.

---

[12] Previous analyses had shown that NSLP data availability was a significant predictor and therefore was retained in the model.
[13] The other four equations are the same except that the endogenous variables would be grade 9 mathematics self-efficacy, grade 9 mathematics interest, grade 9 educational expectations, and grade 9 mathematics achievement.
[14] The other four regression equations are the same except that the endogenous variables would be grade 11 mathematics self-efficacy, grade 11 mathematics interest, grade 11 educational expectations, and grade 11 math course difficulty.

The final regression equation examines the relationship of grade 12 NAEP mathematics performance to grade 11 mathematics motivation, grade 11 educational expectations, grade 11 mathematics course difficulty, and grade 9 algebra achievement, while controlling for the eight student and school background (exogenous) variables. The eleventh equation is:

$$Y_{11} = \alpha_{11} + \beta_{26}\mathit{Grade11mathidentity} + \beta_{27}\mathit{Grade11mathselfefficacy} + \beta_{28}\mathit{Grade11mathinterest} + \beta_{29}\mathit{Grade11educationalexpectations} + \beta_{30}\mathit{Grade11mathcoursedifficulty} + \beta_{31}\mathit{Grade9mathachievement} + \gamma_{41}\mathit{Female} + \gamma_{42}\mathit{Black} + \gamma_{43}\mathit{Hispanic} + \gamma_{44}\mathit{Asian} + \gamma_{45}\mathit{Other} + \gamma_{46}\mathit{SES} + \gamma_{47}\mathit{SchoolFRL} + \gamma_{48}\mathit{SchoolFRLmissing} + \varepsilon_{11} \quad (3)$$

where Y_{11} represents the grade 12 NAEP mathematics score, α_{11} is the intercept, β_{26} to β_{30} are the path coefficients for grade 11 mathematics identity, grade 11 mathematics self-efficacy, grade 11 mathematics interest, grade 11 educational expectations, and grade 11 mathematics course difficulty, and β_{31} is the path coefficient for grade 9 algebra achievement. The path coefficient for female, Black, Hispanic, Asian, Other race/ethnic group, SES, percentage of students eligible for free or reduced-price lunch at the school, and NSLP data availability are captured by γ_{41} to γ_{48} respectively, and ε_{11} is the disturbance term. This disturbance term is assumed to be uncorrelated with any of the other ten disturbance terms in the model.

Following Byrne (1998), this study used the following fit indices to evaluate overall model fit: Chi-square (χ^2), CFI, TLI, and RMSEA.

Finally, following the full-sample SEM analysis, multiple-group SEM analyses was conducted to examine whether the hypothesized model was consistent across major subgroups, specifically between male and female students, as well as between White, Black, and Hispanic students.

For example, in the gender-based multiple-group analysis, a baseline model was first fitted simultaneously for male and female students where the structural coefficients were freely estimated across the male and female groups. Then, another multiple-group model was estimated where the coefficients were constrained to be equal for male and female students. Next, structural invariance was examined based on the chi-square difference test, which compared the two models (i.e., where the coefficients are freely estimated vs. constrained between male and female). If the chi-square test does not show a significant difference between the two models, it is evidence of structural invariance between the male and female models. By contrast, when the chi-square test is significant it indicates structural non-invariance. As discussed below, the test was not able to show structural invariance for any of the subgroup models when constraining all of the parameters to be equal. The next strategy was to see whether acceptable fits could be constructed by freeing up a subset of the structural coefficients one at a time using the modification indices to determine the order in which to do so. This strategy led to a defensible fit for each of the subgroup comparisons. That is, the final models reported here are hybrid models where some of the parameters were constrained between subgroups and others were freely estimated across groups.

Results

Research Question 1

What was the overall achievement in the 2013 Grade 12 NAEP Mathematics Assessment for White, Black, and Hispanic students? What were the achievement gaps in the 2013 Grade 12 NAEP Mathematics Assessment between Black and White students, and Hispanic and White students? Did achievement and race/ethnicity achievement gaps vary by gender and other contextual variables?

Descriptive statistics are presented in Table 4 to provide a general summary of students' mathematics achievement and achievement gaps measured by the 2013 Grade 12 National Assessment of Educational Progress (NAEP) Mathematics Assessment. As seen from Table 5, the weighted average grade 12 NAEP mathematics score was 155. The average scale scores for male and female students were 156 and 154, respectively—a non-statistically significant difference. In other words, there was no evidence of a male-female achievement gap.

Table 5. Grade 12 NAEP mathematics achievement, by sex and race/ethnicity: 2013

	Final analytic sample	
Sex and race/ethnicity	Weighted average scale score	Standard error
Overall score	155.20	2.09
Gender		
Male	156.28	3.18
Female	154.08	1.48
Race/ethnicity		
White	159.56	2.30
Black	131.14*	2.92
Hispanic	145.03*	3.97
Asian/Pacific Islander	170.99*	3.13
American Indian/Alaska Native	155.04	6.46
Other	156.80	6.02

*Indicates the mean of the subgroup was significantly different from that of White students at $p < 0.05$ level.
NOTE: The NAEP average scale scores were calculated using the imputed NAEP plausible values.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

However, significant achievement gaps were observed when comparing average scale scores across racial/ethnic groups. The average scale scores for White, Black, and Hispanic students were 160, 131, and 145, respectively. That is, there was a 29-point gap between White and Black students (approximately 0.85 S.D. units) and a 15-point gap between White and Hispanic students (approximately 0.44 S.D. units) (Table 5). Both the White-Black and White-Hispanic gaps were statistically significant.

In order to investigate whether the racial/ethnic achievement gaps could be explained by students' gender, socioeconomic status (SES), mathematics motivation, and base year mathematics achievement, a series of sequential regression analyses were conducted. The first model included only race/ethnicity dummy variables and represent the observed achievement gaps, which were 26 points (approximately 0.76 S.D.)[15] between White and Black students, and 15 points (approximately 0.44 S.D.) between White and Hispanic students. This result can also be seen in the Stage 1 results shown in Table 6-a.

The second stage controlled for student gender, SES, school level percentage of students eligible for NSLP, and National School Lunch Program (NSLP) data availability. The Stage 2 model explained about half of the White-Black achievement gap (13 out of 26 points). The remaining gap was still statistically significant ($p < 0.05$). In contrast, the achievement gap between White and Hispanic students (less than 2 points) at Stage 2 was no longer statistically significant. All the control variables added at Stage 2 were significantly related to grade 12 NAEP mathematics performance. At Stage 2, approximately 26 percent of the variance in the grade 12 NAEP mathematics achievement score was explained compared to 12 percent at Stage 1 (i.e., the *R*-square increased from 0.12 to 0.26 at stage 2.)

At Stage 3, grade 9 mathematics achievement, grades 9 and 11 educational expectations, and grade 11 mathematics course difficulty were added as additional control variables. In this model, the achievement gap between White and Black students decreased from 13 to 10 points. However, the gap remained significant. Surprisingly, the addition of these control variables *increased* the White-Hispanic achievement gap to a statistically significant 6 points. A large increase of *R*-square was observed from Stage 2 to Stage 3 (from 0.27 to 0.74).

At Stage 4, the six mathematics motivation indices (three from grade 9 and three from grade 11) were added to the regression analysis. Adding these variables left both the White-Black and the White-Hispanic achievement gaps virtually unchanged from the Stage 3 regression results. Among the mathematics motivation variables, only mathematics identity at grade 11 was significantly related to the grade 12 NAEP mathematics score. Neither of the other mathematics motivation indices were significantly related to NAEP mathematics performance for either the base or the follow-up years. Of the non-socio-demographic variables, mathematics achievement and educational expectations at grade 9 and the mathematics courses taken at grade 11, were significantly related to grade 12 mathematics achievement. Among the socio-demographic variables, gender, SES, school level percentage of students eligible for NSLP, and NSLP data availability were all statistically significant. That school-level NSLP data was unavailable yet was still significantly related to achievement probably means that these schools had relatively high percentages of students below or near the poverty line. The *R*-square slightly increased from 0.74 to 0.79 from the Stage 3 to the Stage 4 regression.

Grade 9 mathematics performance exhibited the strongest relationship with grade 12 NAEP performance, net of the other variables in the regression, followed by school-level eligibility for NSLP (negatively related) (Table 6-b). Having a mathematics identity exhibited the next strongest relationship to NAEP mathematics performance and was the only statistically significant motivational variable. Although statistically significant, the difficulty of the mathematics courses taken at grade 11 was less strongly related to grade 12 NAEP mathematics performance than having a mathematics identity, showing the importance of this variable for grade 12 mathematics achievement. Among the race/ethnicity variables, being Black, Hispanic, or Other were all negatively related to grade 12 mathematics performance, net of the other

---

[15] The sequential regression analysis was conducted using STATA and the outcome measure was one NAEP plausible value. The descriptive analysis was conducted using SAS PROC SURVEYMEANS.

variables in the model. Among the other socio-demographic variables, being female was negatively related and SES positively related to mathematics achievement in the Stage 4 model.

In summary, achievement gaps were found for White students compared to Black and Hispanic students but not between males and females. The regression analyses showed that controlling for student- and school-level SES and gender completely accounted for the White-Hispanic gap but for only about half the White-Black gap (a 13-point gap remained). Adding baseline mathematics achievement, the difficulty of mathematics courses taken through grade 11, and educational expectations at grades 9 and 11 to the model reduced the White-Black gap by another 3 points, but unexpectedly increased the White-Hispanic gap to 6 points. In the final model, in which the motivational variables at grades 9 and 11 were added, the White-Black and White-Hispanic gaps increased by about a half point, and among the motivation variables only grade 11 mathematics identity was statistically significantly related to grade 12 NAEP mathematics achievement.

Table 6-a. Unstandardized coefficients: Sequential regression analysis

Coefficients	Stage 1: Race/ethnicity only		Stage 2: Race/ethnicity + Demographics		Stage 3: Race/ethnicity + Demographics + Academic variables		Stage 4: Race/ethnicity + Demographics + Academic variables + Math motivation variables	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Intercept	159.92*	1.47	152.36*	5.07	134.96*	4.65	128.62*	4.96
Race/ethnicity								
Black	−25.82*	2.91	−13.32*	3.04	−10.42*	2.27	−11.14*	2.21
Hispanic	−14.93*	3.67	−1.77	3.71	−5.59*	2.48	−6.17*	2.35
Asian/Pacific Islander	12.51*	3.19	12.24*	2.86	−1.39	2.12	−2.10	2.07
Other	−4.15	5.73	−4.04	5.75	−7.47	4.82	−9.77*	4.67
Gender			−4.63*	2.16	−5.31*	1.55	−3.36*	1.49
SES			2.02*	0.30	0.25	0.24	0.45*	0.23
School NSLP			−3.20*	0.52	−2.04*	0.38	−2.07*	0.37
School NSLP data availability			−27.16*	5.06	−18.75*	3.62	−18.37*	3.49
Grade 9 mathematics achievement					25.11*	1.32	22.24*	1.24
Grade 9 educational expectations					1.51*	0.29	1.40*	0.28
Grade 11 educational expectations					0.91*	0.34	0.49	0.32
Grade 11 mathematics course difficulty					3.82*	0.83	3.09*	0.81
Grade 9 mathematics identity							1.70	1.39
Grade 11 mathematics identity							4.93*	1.21
Grade 9 mathematics self-efficacy							0.76	1.50
Grade 11 mathematics self-efficacy							0.93	1.33
Grade 9 mathematics interest							−2.06	1.22
Grade 11 mathematics interest							1.46	1.32
R-square	0.12		0.26		0.74		0.79	

* $p < 0.05$.
† Not applicable.
NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table 6-b. Standardized coefficients: Sequential regression analysis

Coefficients	Stage 1: Race/ethnicity only		Stage 2: Race/ethnicity + Demographics		Stage 3: Race/ethnicity + Demographics + Academic variables		Stage 4: Race/ethnicity + Demographics + Academic variables + Math motivation variables	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Race/ethnicity								
Black	−0.92*	0.10	−0.48*	0.11	−0.37*	0.08	−0.40*	0.08
Hispanic	−0.53*	0.13	−0.06	0.13	−0.20*	0.09	−0.22*	0.08
Asian/Pacific Islander	0.45*	0.11	0.44*	0.10	−0.05	0.08	−0.08	0.07
Other	−0.15	0.20	−0.14	0.21	−0.27	0.17	−0.35*	0.17
Gender			−0.17*	0.08	−0.19*	0.06	−0.12*	0.05
SES			0.07*	0.01	0.01	0.01	0.02*	0.01
School NSLP			−0.11*	0.02	−0.07*	0.01	−0.07*	0.01
School NSLP data availability			−0.97*	0.17	−0.67*	0.13	−0.65*	0.12
Grade 9 mathematics achievement					0.90*	0.04	0.79*	0.04
Grade 9 educational expectations					0.05*	0.01	0.05*	0.01
Grade 11 educational expectations					0.03*	0.01	0.02	0.01
Grade 11 mathematics course difficulty					0.14*	0.03	0.11*	0.03
Grade 9 mathematics identity							0.06	0.05
Grade 11 mathematics identity							0.18*	0.04
Grade 9 mathematics self-efficacy							0.03	0.05
Grade 11 mathematics self-efficacy							0.03	0.05
Grade 9 mathematics interest							−0.07	0.04
Grade 11 mathematics interest							0.05	0.05
R-Square	0.12		0.26		0.74		0.79	

* $p < 0.05$.
NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group. The standardized coefficients for dummy coded variables (Black, Hispanic, Asian/Pacific Islander, Other, Gender, and School NSLP data availability) were based on STDY standardization.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment

Research Question 2

What were the levels of student mathematics motivation at grade 9 and grade 11? Were there any differences in student mathematics motivation across gender and racial/ethnic groups?

Table 7-a presents means and standard errors for each of the mathematics motivation indices by gender and race/ethnicity[16] for both grade 9 (base year) and grade 11 (follow-up year). For each mathematics motivation index, the score ranged from 0 to 3, with 0 indicating the lowest level of motivation and 3 indicating the highest level (see Table 3 for level description).

Mathematics motivation at grade 9 (base year)

For grade 9 students, the overall means for mathematics identity, self-efficacy, and interest were 1.16, 1.91, and 1.85, respectively. Male students had higher mathematics identity scores (mean = 1.24) and mathematics self-efficacy scores (mean = 2.01) than female students (1.07 and 1.81, respectively). When comparing the mathematics motivation index scores of White and Black students at grade 9, Black students reported feeling more efficacious about doing mathematics and reported having a higher interest in mathematics than White students. In contrast, there were no measurable mean differences between White and Hispanic students on any of the three mathematics motivation indices at grade 9. However, Asian/Pacific Islander and Other students reported higher scores on mathematics identity than White students at grade 9, and Asian/Pacific Islander students also scored higher than White students on both mathematics self-efficacy and interest at grade 9.

Mathematics motivation at grade 11 (follow-up year)

For grade 11 students, the overall means for mathematics identity, self-efficacy, and interest were 1.24, 1.74, and 1.62, respectively. Similar to grade 9 results, grade 11 male students reported a higher mathematics identity (mean = 1.35) and efficacy in doing mathematics (mean = 1.84) than female students (1.13 and 1.65, respectively). However, there were no significant differences on any of the three mathematics motivation indices when comparing White and Black students at grade 11. Following the pattern at grade 9, there were no significant differences between White and Hispanic students on any of three mathematics motivation measures at grade 11. As was found at grade 9, Asian/Pacific Islander students scored higher than White students on mathematics self-efficacy and interest.

[16] For analyses of mathematics motivation and SEM analysis, some of the categories were collapsed for those categories that have small unweighted sample size. Specifically, category "Others" includes "American Indian/Alaska Native" and "Other."

Table 7-a. Mathematics motivation by gender and race/ethnicity for grade 9 (base year) and grade 11 (follow-up year)

Gender and race/ethnicity	Mathematics identity		Mathematics self-efficacy		Mathematics interest	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
Grade 9 (base year)						
Overall	1.16	0.03	1.91	0.03	1.85	0.03
Gender						
Male (reference group)	1.24	0.05	2.01	0.04	1.87	0.05
Female	1.07*	0.04	1.81*	0.04	1.83	0.04
Race/ethnicity						
White (reference group)	1.11	0.04	1.86	0.03	1.78	0.04
Black	1.21	0.08	2.05*	0.05	2.04*	0.07
Hispanic	1.17	0.09	1.94	0.08	1.94	0.09
Asian/Pacific Islander	1.42*	0.06	2.10*	0.06	2.07*	0.06
Others[1]	1.57*	0.19	2.14	0.15	1.89	0.16
Grade 11 (follow-up year)						
Overall	1.24	0.04	1.74	0.03	1.62	0.03
Gender						
Male (Reference group)	1.35	0.06	1.84	0.04	1.61	0.05
Female	1.13*	0.06	1.65*	0.04	1.63	0.04
Race/ethnicity						
White (Reference group)	1.20	0.05	1.72	0.04	1.56	0.04
Black	1.20	0.09	1.76	0.06	1.68	0.07
Hispanic	1.30	0.10	1.77	0.07	1.71	0.09
Asian/Pacific Islander	1.59*	0.08	1.85*	0.05	1.86*	0.05
Others[1]	1.53	0.25	2.01	0.18	1.89*	0.14

* Indicates the mean of the subgroup was significantly different from that of the reference group, at $p < 0.05$.
[1]Includes the original categories for “American Indian/Alaska Native” and “Other.”
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Mathematics motivation from grade 9 to grade 11

Overall, students’ mathematics self-efficacy and interest significantly decreased from grade 9 to grade 11; however, the degree to which students reported having a mathematics identity significantly increased from grade 9 to grade 11 (Table 7-b). The same pattern was observed for male and female students, as well as for White, Hispanic, and Asian/Pacific Islander students. However, the degree to which students reported having a mathematics identity for Black students did not significantly increase from grade 9 to grade 11.

Table 7-b. Mathematics motivation from grade 9 to grade 11, by gender and race/ethnicity

Gender and race/ethnicity	Mathematics identity					Mathematics self-efficacy					Mathematics interest				
	Mean					Mean					Mean				
	Grade		Difference	S.E.	p value	Grade		Difference	S.E.	p value	Grade		Difference	S.E.	p value
	9	11				9	11				9	11			
Overall	1.16	1.24	−0.08	0.03	<0.01	1.91	1.74	0.17	0.03	<0.01	1.85	1.62	0.23	0.03	<0.01
Gender															
Male	1.24	1.35	−0.11	0.05	<0.01	2.01	1.84	0.17	0.04	<0.01	1.87	1.61	0.26	0.05	<0.01
Female	1.07	1.13	−0.06	0.04	0.01	1.81	1.65	0.16	0.04	<0.01	1.83	1.63	0.20	0.04	<0.01
Race/ethnicity															
White	1.11	1.20	−0.09	0.04	<0.01	1.86	1.72	0.14	0.03	<0.01	1.78	1.56	0.22	0.04	<0.01
Black	1.21	1.20	0.01	0.08	0.77	2.05	1.76	0.29	0.05	<0.01	2.04	1.68	0.36	0.07	<0.01
Hispanic	1.17	1.30	−0.13	0.09	<0.01	1.94	1.77	0.17	0.08	<0.01	1.94	1.71	0.23	0.09	<0.01
Asian/Pacific Islander	1.42	1.59	−0.17	0.06	<0.01	2.10	1.85	0.25	0.06	<0.01	2.07	1.86	0.21	0.06	<0.01
Others[1]	1.57	1.53	0.04	0.19	0.79	2.14	2.01	0.13	0.15	0.08	1.89	1.89	<0.01	0.16	1.00

[1]Includes the original categories for “American Indian/Alaska Native” and “Other.”

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Research Question 3

What was the relationship between grade 12 NAEP mathematics performance and mathematics motivation (and educational expectations), taking into account grade 9 mathematics achievement, family and school background factors, and difficulty of high school mathematics course taken (e.g., taking advanced, regular, or basic courses)? Did these relationships differ by gender and race/ethnicity?

Overall

Results from the SEM analysis indicate that the data fit the model well. The root mean square error of approximation (RMSEA) was 0.03, the comparative fit index (CFI) was 0.96, and the Tucker-Lewis index (TLI) was 0.86, indicating a good model fit, although the TLI was slightly lower than the 0.90 criterion that is sometimes recommended (Hu & Bentler, 1999). Although all the coefficients reported below were estimated in a single model, results are presented in three tables for purposes of readability.

Relationships between the five endogenous variables measured at grade 9 and the preexisting variables

Table 8-a presents standardized and unstandardized coefficient estimates and standard errors for relationships between the grade 9 endogenous variables and the exogenous variables.[17]

Mathematics Identity (Grade 9) (Y1)

As seen from the standardized coefficients in Table 8-a, a mathematics identity in grade 9 was most associated with being of an Other race/ethnicity (0.51), followed by being Asian/Pacific Islander (0.40), being female (−0.23), and SES (0.08) where those with a higher SES were more likely to report having a mathematics identity.[18]

Mathematics Self-Efficacy (Grade 9) (Y2)

Feeling efficacious about learning mathematics at grade 9 is also related to being a female (−0.34), having high SES (0.11), and being Black (0.40) or Asian/Pacific Islander (0.41) compared to being White.

---

[17] All the results reported in this section are based on standardized coefficients.

[18] All the coefficients in Table 8-a took into account (control for) the variables shown in Eq. (1) in the Methods section. Thus, although the discussion does not explicitly indicate that the results take into account the other variables in Eq.(1), that is the intent. The same is true for the discussion of results from Eq. (2) in Table 8-b and Eq.(3) in Table 8-c.

Mathematics Interest (Grade 9) (Y3)

Black (0.41) and Asian/Pacific Islander (0.43) students reported higher mathematics interest than White students at grade 9. Students attending schools with higher percentages of students eligible for free or reduced-price lunch expressed more interest in mathematics than did students in schools with lower percentages of students eligible for free or reduced-price lunch (0.13).

Educational Expectations (Grade 9) (Y4)

Students with high educational expectations at grade 9 were also likely to be of higher SES (0.24). Black (0.51) and Asian/Pacific Islander (0.23) students reported higher educational expectations than White students.

Algebra Achievement (Grade 9) (Y5)

Higher SES was associated with higher mathematics achievement at grade 9, with a one standard deviation increase in SES associated with a quarter standard deviation higher NAEP mathematics performance. Being Black was associated with lower mathematics achievement scores compared to being White (−0.31), while being Asian/Pacific Islander was associated with higher scores than being White (0.58). Students attending schools with reported data on percentage of students at the school who are NSLP eligible also scored lower on average on the grade 9 algebra test (−0.37) as did those at schools where the eligibility for NSLP was missing.

The correlations among the disturbance terms of the endogenous variables at grade 9 are shown in Appendix F.

Table 8-a. Unstandardized and standardized structural coefficients associated with the grade 9 endogenous variables

Segment 1: Demographic variables and grade 9 key variables	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 9 mathematics identity (Y_1)				
Gender	−0.18*	0.06	−0.23*	0.08
SES	0.02*	0.01	0.08*	0.04
Race/ethnicity: Black	0.16	0.09	0.20	0.12
Race/ethnicity: Hispanic	0.11	0.11	0.13	0.14
Race/ethnicity: Asian/Pacific Islander	0.32*	0.07	0.40*	0.09
Race/ethnicity: Other	0.41*	0.19	0.51*	0.23
School NSLP	0.01	0.02	0.03	0.05
School NSLP data availability	−0.09	0.14	−0.11	0.17
Grade 9 mathematics self-efficacy (Y_2)				
Gender	−0.22*	0.05	−0.34*	0.08
SES	0.02*	0.01	0.11*	0.03
Race/ethnicity: Black	0.26*	0.07	0.40*	0.10
Race/ethnicity: Hispanic	0.14	0.09	0.22	0.14
Race/ethnicity: Asian/Pacific Islander	0.26*	0.06	0.41*	0.10
Race/ethnicity: Other	0.24	0.14	0.38	0.22
School NSLP	0.01	0.01	0.03	0.04
School NSLP data availability	−0.05	0.09	−0.08	0.15
Grade 9 mathematics interest (Y_3)				
Gender	−0.05	0.06	−0.07	0.09
SES	0.01	0.01	0.06	0.04
Race/ethnicity: Black	0.29*	0.09	0.41*	0.12
Race/ethnicity: Hispanic	0.13	0.10	0.18	0.14
Race/ethnicity: Asian/Pacific Islander	0.30*	0.07	0.43*	0.09
Race/ethnicity: Other	0.05	0.16	0.07	0.23
School NSLP	0.04*	0.01	0.13*	0.05
School NSLP data availability	−0.15	0.16	−0.21	0.23
Grade 9 educational expectations (Y_4)				
Gender	0.41	0.23	0.14	0.8
SES	0.20*	0.03	0.24*	0.04
Race/ethnicity: Black	1.46*	0.35	0.51*	0.14
Race/ethnicity: Hispanic	0.44	0.33	0.16	0.12
Race/ethnicity: Asian/Pacific Islander	0.65*	0.27	0.23*	0.10
Race/ethnicity: Other	1.05*	0.45	0.37*	0.16
School NSLP	0.05	0.06	0.04	0.05
School NSLP data availability	−0.10	0.52	−0.04	0.18
Grade 9 algebra achievement (Y_5)				
Gender	−0.03	0.05	−0.04	0.07
SES	0.05*	0.01	0.25*	0.04
Race/ethnicity: Black	−0.20*	0.07	−0.31*	0.11
Race/ethnicity: Hispanic	0.11	0.09	0.17	0.13
Race/ethnicity: Asian/Pacific Islander	0.39*	0.07	0.58*	0.10
Race/ethnicity: Other	−0.01	0.10	−0.01	0.15

Segment 1: Demographic variables and grade 9 key variables	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
School NSLP	−0.04*	0.01	−0.15*	0.04
School NSLP data availability	−0.25*	0.11	−0.37*	0.16

* $p < 0.05$.
NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group. The standardized coefficients for dummy coded variables (Black, Hispanic, Asian/Pacific Islander, Other, Gender, and School NSLP data availability) were based on STDY standardization.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Relationships between the five endogenous variables measured at grade 11 and the grade 9 endogenous variables

Table 8-b presents the results for the relationships between the five endogenous variables measured at grade 11 and the grade 9 endogenous variables. Note that the endogenous variables at grade 11 are assumed to be unrelated to the student and school demographic variables except through their relationship to the endogenous variables measured at grade 9.

Mathematics Identity (Grade 11) (Y6)

As hypothesized, mathematics identity at grade 11 was significantly related to grade 9 mathematics identity (0.44), as was sense of mathematics self-efficacy (0.12) and mathematics achievement (0.17). While interest in mathematics and educational expectations at grade 9 were hypothesized to be related to having a mathematics identity at grade 11, neither of these relationships were statistically significant.

Mathematics Self-Efficacy (Grade 11) (Y7)

As hypothesized, mathematics self-efficacy at grade 11 was significantly related to grade 9 mathematics self-efficacy (0.24), grade 9 mathematics identity (0.19), and grade 9 mathematics achievement (0.11). While both mathematics interest and educational expectations at grade 9 were hypothesized to be related to grade 11 mathematics self-efficacy, neither relationship was statistically significant thus duplicating the pattern of relationships observed for the prediction of having a mathematics identity at grade 11.

Mathematics Interest (Grade 11) (Y8)

As hypothesized, one’s interest in mathematics at grade 11 is related to having an interest in mathematics at grade 9 (0.26). However, none of the other hypothesized relationships with the grade 9 endogenous variables were statistically significant, except for educational expectations (0.11).

Educational Expectations (Grade 11) (Y9)

As hypothesized, grade 11 educational expectations were significantly associated with grade 9 educational expectations (0.47), but were also significantly related to mathematics performance at grade 9 (0.21). None of the other three hypothesized relationships were statistically significant.

Mathematics Course Difficulty (Y10)

The highest difficulty level of mathematics courses taken from up to grade 11 was hypothesized to be related to the three mathematics motivation indices at grade 9 as well as to educational expectations and mathematics performance at grade 9. However, none of the three mathematics motivation indices measured at grade 9 were significantly related to the mathematics course difficulty variable. Grade 9 mathematics achievement showed the strongest relationship with mathematics course difficulty (0.34) at grade 11; the only other significant relationship was with educational expectations at grade 9 (0.10).

The correlations among the disturbance/error terms of grade 11 endogenous variables are shown in Appendix F.

Table 8-b. Unstandardized and standardized structural coefficients associated with the grade 11 endogenous variables

Segment II: Grade 9 and 11 key variables	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 11 mathematics identity (Y_6)				
Grade 9 mathematics identity	0.53*	0.05	0.44*	0.04
Grade 9 mathematics self-efficacy	0.18*	0.06	0.12*	0.04
Grade 9 mathematics interest	−0.01	0.06	−0.01	0.04
Grade 9 educational expectations	<0.01	0.01	<0.01	0.04
Grade 9 algebra achievement	0.25*	0.05	0.17*	0.03
Grade 11 mathematics self-efficacy (Y_7)				
Grade 9 mathematics identity	0.17*	0.04	0.19*	0.05
Grade 9 mathematics self-efficacy	0.27*	0.07	0.24*	0.05
Grade 9 mathematics interest	−0.08	0.06	−0.08	0.06
Grade 9 educational expectations	0.01	0.01	0.03	0.04
Grade 9 algebra achievement	0.12*	0.04	0.11*	0.04
Grade 11 mathematics interest (Y_8)				
Grade 9 mathematics identity	0.09	0.05	0.10	0.06
Grade 9 mathematics self-efficacy	0.03	0.06	0.03	0.05
Grade 9 mathematics interest	0.27*	0.05	0.26*	0.05
Grade 9 educational expectations	0.03*	0.01	0.11*	0.04
Grade 9 algebra achievement	0.06	0.05	0.05	0.04
Grade 11 educational expectations (Y_9)				
Grade 9 mathematics identity	−0.15	0.14	−0.04	0.04
Grade 9 mathematics self-efficacy	0.34	0.19	0.08	0.05
Grade 9 mathematics interest	0.28	0.18	0.07	0.05
Grade 9 educational expectations	0.45*	0.03	0.47*	0.03
Grade 9 algebra achievement	0.88*	0.15	0.21*	0.04
Grade 11 mathematics course difficulty (Y_{10})				
Grade 9 mathematics identity	0.08	0.07	0.06	0.05
Grade 9 mathematics self-efficacy	−0.04	0.10	−0.03	0.06
Grade 9 mathematics interest	0.04	0.08	0.03	0.06
Grade 9 educational expectations	0.04*	0.02	0.10*	0.05
Grade 9 algebra achievement	0.55*	0.07	0.34*	0.04

* $p < 0.05$.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

The relationship of grade 12 NAEP mathematics performance to the endogenous variables at grade 11 and the pre-existing student and school demographic variables

Table 8-c presents the results for the relationships between grade 12 NAEP mathematics performance to the endogenous variables at grade 11 and the exogenous student and school demographic variables.

Grade 12 NAEP Mathematics Performance (Y11)

As expected, how well a student performed on the grade 9 algebra had the strongest association with grade 12 mathematics performance (0.54). Among the three motivation variables hypothesized to relate to grade 12 mathematics performance, only one did relate—having a grade 11 mathematics identity (0.19).

The unstandardized coefficient for grade 12 mathematics identity is 5.55, controlling for all other variables in the model. This means that a 1-point difference on the 3-point mathematics identity index is associated with a 5.55-point difference on the NAEP mathematics achievement score—roughly one-fifth of its standard deviation. Students' educational expectations at grade 11 also showed a modest, but significant relationship with grade 12 mathematics performance (0.12), as did the difficulty of mathematics courses taken through grade 11 (0.12).

Among the student and school demographic (exogenous) variables, the largest standardized regression coefficients were associated with NSLP data availability (−0.62). Also the percentage of students in the school eligible for NSLP performed lower (−0.18). The higher the percentage for this variable, the lower the student's grade 12 NAEP mathematics performance was. As noted above, that the created variable was significant probably means that these schools had relatively high percentages of students below or near the poverty line. Finally, moderate negative relationships with grade 12 NAEP mathematics performance were associated with being Black (−0.35), Hispanic (−0.21), and female (−0.12).

Table 8-c. Unstandardized and standardized structural coefficients associated with the grade 12 NAEP mathematics achievement

Segment III: Grade 11, demographic variables and grade 12 NAEP	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 12 NAEP (Y_{11})				
Grade 11 mathematics identity	5.55*	1.08	0.19*	0.04
Grade 11 mathematics self-efficacy	1.06	1.37	0.03	0.04
Grade 11 mathematics interest	1.15	1.32	0.03	0.03
Grade 11 educational expectations	1.20*	0.32	0.12*	0.03
Grade 11 mathematics course difficulty	3.14*	0.83	0.12*	0.03
Grade 9 mathematics achievement	22.83*	1.27	0.54*	0.03
Gender	−3.39*	1.51	−0.12*	0.05
SES	0.55*	0.23	0.07*	0.03
Race/ethnicity: Black	−9.83*	2.30	−0.35*	0.08
Race/ethnicity: Hispanic	−5.91*	2.43	−0.21*	0.09
Race/ethnicity: Asian/Pacific Islander	−2.13	2.11	−0.08	0.08
Race/ethnicity: Other	−8.36	4.74	−0.30	0.17
School NSLP	−2.02*	0.38	−0.18*	0.03
School NSLP data availability	−17.35*	3.56	−0.62*	0.13

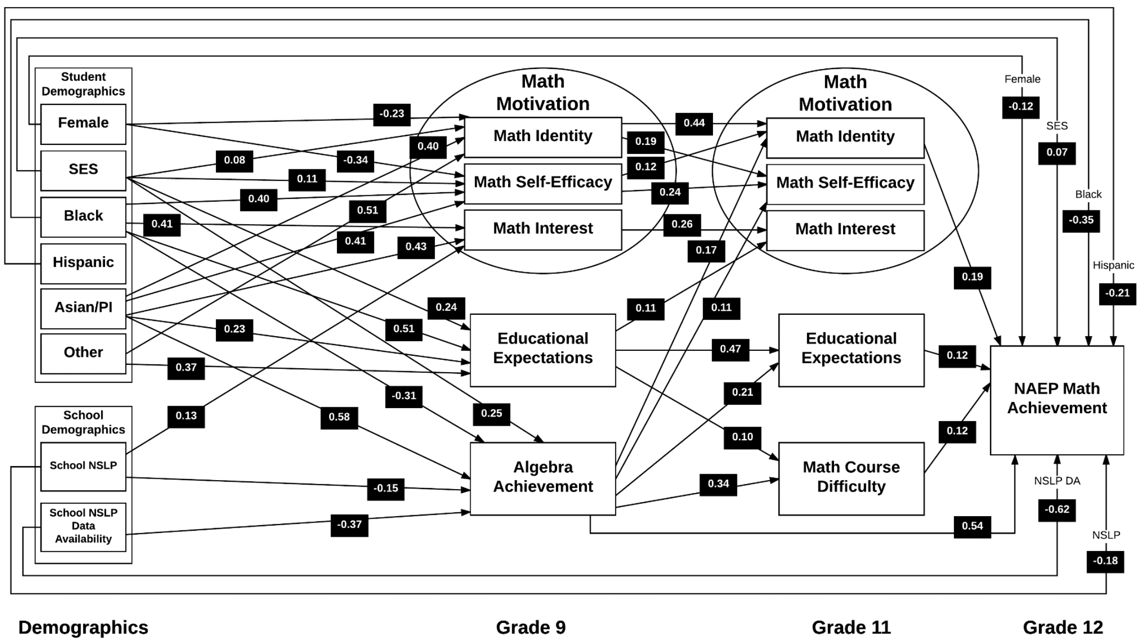
* $p < 0.05$.
NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group. The standardized coefficients for dummy coded variables (Black, Hispanic, Asian/Pacific Islander, Other, Gender, and School NSLP data availability) were based on STDY standardization.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Summary

In examining the relationships of mathematics identity, self-efficacy, and interest to grade 12 NAEP mathematics achievement, only mathematics identity at grade 11 was statistically significant. Its standardized coefficient was second only to that of grade 9 algebra performance in its relationship to grade 12 NAEP mathematics achievement. The other endogenous variables significantly related to grade 12 NAEP mathematics achievement were grade 11 educational expectations and mathematics course difficulty through the end of grade 11. Some of the student and school contextual variables also displayed significant relationships with students' grade 12 NAEP mathematics achievement. Black and Hispanic students had lower grade 12 NAEP mathematics scores than did White students, after controlling for all other variables. Similarly, female students had lower grade 12 NAEP mathematics scores than did male students. And SES was still positively associated with grade 12 NAEP mathematics scores. The school-level percentage of students eligible for NSLP and NSLP data availability were both negatively related to grade 12 NAEP performance.

While grade 11 mathematics self-efficacy did not show a significant relationship with grade 12 NAEP performance when controlling for grade 11 mathematics identity, mathematics self-efficacy at grade 9 appears to play an important role in the model because of its relationship to mathematics identity at grade 11 as noted above. Having an interest in mathematics at grade 11 was not related to grade 12 NAEP mathematics performance when controlling for mathematics identity. Finally, educational expectations in grade 11 had a direct effect on grade 12 NAEP mathematics performance, while grade 9 educational expectations were significantly related to the difficulty of the mathematics courses taken in grade 11. The overall SEM results are depicted in figure 2.

Figure 2. Overall SEM results



NOTE: Only the significant paths ($p < 0.05$) are shown in the figure. Correlations among the disturbance terms of the endogenous variables at grade 9 and at grade 11 are not shown.

An Examination of the Fit of the Overall Conceptual Model for Key Subgroups

MPlus was used to estimate the invariance of the hypothesized model across gender and racial/ethnic groups using methodology described in the Analysis Methods section above.

Comparison between male and female students

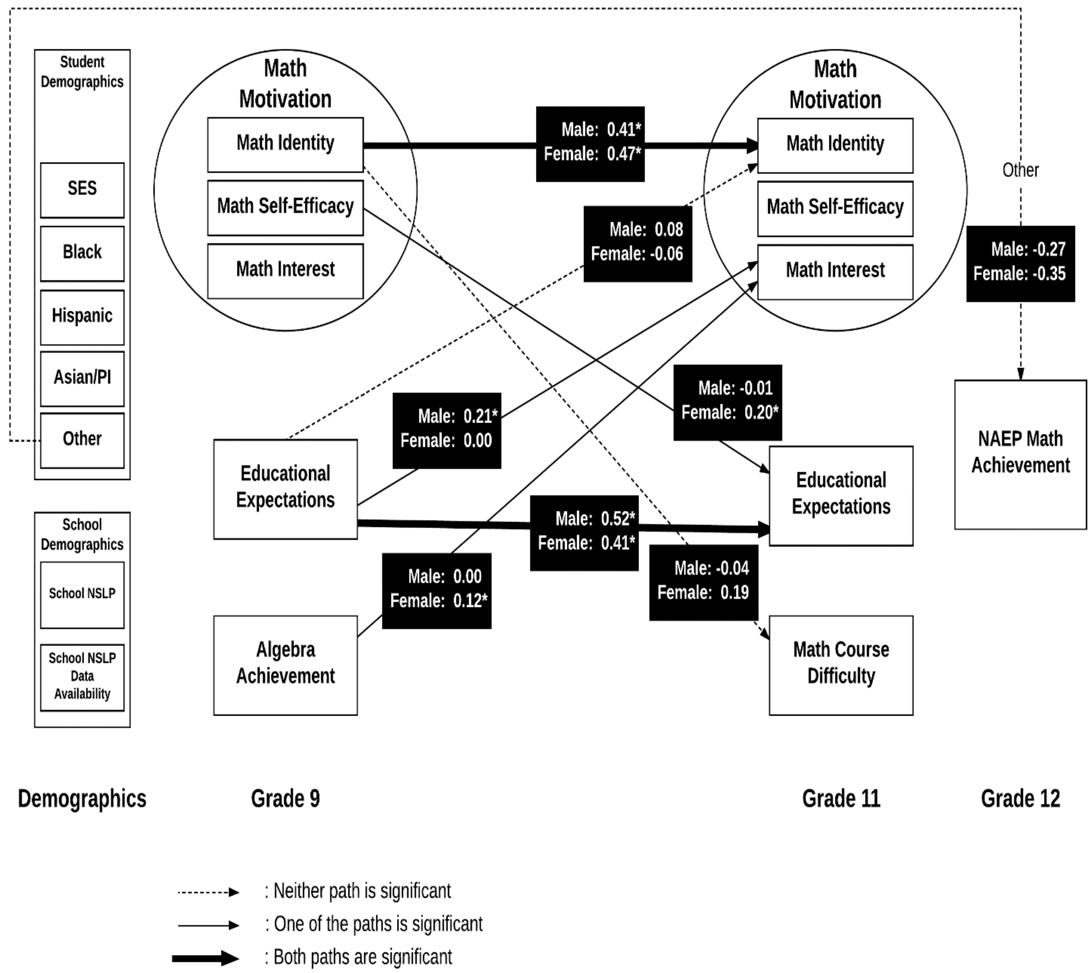
The male/female multiple group model that freely estimated all of the parameters had an adequate model fit with a RMSEA of 0.04, CFI of 0.96, and TLI of 0.87. In the next step, all of the parameters in the model were constrained to be equal across the male and female groups to examine parameter invariance between male and female students. The result of the chi-square difference test was statistically significant, which indicated that one or more of the parameters differed for male and female students. The iterative procedure described above found that of the 93 estimated parameters, 8 structural parameters were significantly different for male and female students. The hybrid model had an adequate model fit with a RMSEA of 0.03, CFI of 0.97, and TLI of 0.93.

Tables 9-a, 9-b, and 9-c present the final multiple group SEM model results for the gender comparison. The eight structural parameters that were freed up are italicized in the tables. An examination of Table 9-c in comparison with Table 8-c shows that the pattern of relationships of the grade 11 endogenous and the exogenous variables to grade 12 mathematics performance was identical.

That is, of the three motivational variables, mathematics identity was the only one that was statistically significant and operated identically in its importance for grade 12 mathematics achievement for male and female students. The other variables that were significant in the overall model in Table 8-c were also significant in the gender subgroup model—grade 9 algebra achievement, grade 11 educational expectations, and the difficulty of mathematics courses taken. The exogenous variables that were significant are SES, being Black (negatively related), being Hispanic (negatively related), being Asian/Pacific Islander, percentage of students at school eligible for NSLP (negatively related), and NSLP data availability (negatively related). Again, all of these estimates were done under the assumption that they were the same for both male and female students. Note that the parameter estimate for Race: Other had to be freely estimated for male and female students, but when this was done, neither coefficient was statistically significant.

All of the other coefficients that differed for male and female students were located in the grade 11 part of the model. As seen in Table 9-b, the relationship of grade 9 mathematics identity with grade 11 mathematics identity was significantly stronger for female students than for male students, although still statistically significant for both. The relationship of grade 9 educational expectations with grade 11 mathematics interest was statistically significant for male students, but not for female students. In contrast, the relationship of grade 9 algebra performance to grade 11 mathematics interest was positive and significant for female students, but was not significant for male students. Another difference was in the relationship of grade 9 mathematics self-efficacy to grade 11 educational expectations. The relationship was large and positive for female students and non-significant for male students. The relationship between grade 9 educational expectations and grade 11 educational expectations, while statistically significant for both male and female students, was stronger for male students. There were two other coefficients which needed freed up estimates for male and female students, but in both cases neither of the resulting estimates were statistically significant for either the male or female students—the relationship of grade 9 educational expectations to grade 11 mathematics identity and the relationship of grade 9 mathematics identity to the difficulty of the mathematics courses taken. Figure 3 displays all structural parameters that differed for male and female students.

Figure 3. Multiple group SEM model: Male vs. Female



NOTE: The multiple group SEM model for the gender comparison is a hybrid model in which all but eight structural parameters are constrained to be equal across male and female groups. The eight parameters include seven structural parameters between endogenous variables at grades 9 and 11 and one from an exogenous variable and grade 12 mathematics achievement; all are shown in the figure. Correlations among the disturbance terms of the endogenous variables at grade 9 and at grade 11 are not shown in the figure.

The results in Table 9-a—the relationships of the exogenous variables with the grade 9 endogenous variables—do not warrant discussion except to say that *the pattern of results was identical to that seen in Table 8-a.* That is, the variables that were shown to be significant in the overall model were also significant in the gender subgroup model, and those that were not significant in the overall model were also not significant in the gender subgroup model.

Table 9-a. Unstandardized and standardized structural coefficients associated with the grade 9 endogenous variables: Male vs. Female

Coefficients	Male				Female			
	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 9 mathematics identity								
SES	0.02*	0.01	0.08*	0.04	0.02*	0.01	0.08*	0.04
Race/ethnicity: Black	0.18*	0.09	0.22*	0.11	0.18*	0.09	0.23*	0.12
Race/ethnicity: Hispanic	0.11	0.11	0.13	0.13	0.11	0.11	0.14	0.14
Race/ethnicity: Asian/Pacific Islander	0.31*	0.08	0.38*	0.10	0.31*	0.08	0.41*	0.10
Race/ethnicity: Other	0.40*	0.18	0.48*	0.23	0.40*	0.18	0.52*	0.24
School NSLP	0.01	0.02	0.04	0.04	0.01	0.02	0.04	0.05
School NSLP data availability	−0.1	0.13	−0.12	0.16	−0.10	0.13	−0.13	0.17
Grade 9 mathematics self-efficacy								
SES	0.02*	0.01	0.12*	0.04	0.02*	0.01	0.11*	0.03
Race/ethnicity: Black	0.26*	0.07	0.43*	0.11	0.26*	0.07	0.41*	0.10
Race/ethnicity: Hispanic	0.14	0.09	0.23	0.15	0.14	0.09	0.22	0.14
Race/ethnicity: Asian/Pacific Islander	0.25*	0.06	0.41*	0.10	0.25*	0.06	0.39*	0.10
Race/ethnicity: Other	0.23	0.14	0.38	0.22	0.23	0.14	0.36	0.21
School NSLP	0.01	0.01	0.04	0.05	0.01	0.01	0.03	0.04
School NSLP data availability	−0.06	0.09	−0.10	0.15	−0.06	0.09	−0.09	0.14
Grade 9 mathematics interest								
SES	0.01	0.01	0.05	0.04	0.01	0.01	0.06	0.04
Race/ethnicity: Black	0.28*	0.09	0.40*	0.12	0.28*	0.09	0.42*	0.12
Race/ethnicity: Hispanic	0.13	0.10	0.18	0.14	0.13	0.10	0.18	0.14
Race/ethnicity: Asian/Pacific Islander	0.29*	0.07	0.41*	0.09	0.29*	0.07	0.43*	0.10
Race/ethnicity: Other	0.05	0.16	0.07	0.22	0.05	0.16	0.07	0.23
School NSLP	0.04*	0.01	0.13*	0.05	0.04*	0.01	0.13*	0.05
School NSLP data availability	−0.15	0.16	−0.20	0.22	−0.15	0.16	−0.21	0.23
Grade 9 educational expectations								
SES	0.20*	0.03	0.24*	0.04	0.20*	0.03	0.24*	0.04
Race/ethnicity: Black	1.48*	0.35	0.52*	0.12	1.48*	0.35	0.52*	0.12
Race/ethnicity: Hispanic	0.43	0.33	0.15	0.12	0.43	0.33	0.15	0.12
Race/ethnicity: Asian/Pacific Islander	0.69*	0.27	0.24*	0.10	0.69*	0.27	0.24*	0.09
Race/ethnicity: Other	1.01*	0.44	0.36*	0.16	1.01*	0.44	0.35*	0.15

Coefficients	Male				Female			
	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
School NSLP	0.05	0.06	0.04	0.05	0.05	0.06	0.04	0.05
School NSLP data availability	−0.10	0.51	−0.04	0.18	−0.10	0.51	−0.04	0.18
Grade 9 algebra achievement								
SES	0.05*	0.01	0.24*	0.03	0.05*	0.01	0.27*	0.04
Race/ethnicity: Black	−0.19*	0.07	−0.27*	0.10	−0.19*	0.07	−0.31*	0.11
Race/ethnicity: Hispanic	0.11	0.08	0.16	0.11	0.11	0.08	0.19	0.13
Race/ethnicity: Asian/Pacific Islander	0.40*	0.07	0.57*	0.09	0.40*	0.07	0.66*	0.11
Race/ethnicity: Other	0.02	0.10	0.02	0.14	0.02	0.10	0.03	0.17
School NSLP	−0.04*	0.01	−0.14*	0.03	−0.04*	0.01	−0.15*	0.04
School NSLP data availability	−0.22*	0.10	−0.31*	0.15	−0.22*	0.10	−0.36*	0.17

* $p < 0.05$.
NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group. The standardized coefficients for dummy coded variables (Black, Hispanic, Asian/Pacific Islander, Other, Gender, and School NSLP data availability) were based on STDY standardization. Variable of School NSLP data availability is created to measure whether missing school NSLP data is associated with the model result.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table 9-b. Unstandardized and standardized structural coefficients associated with the grade 11 endogenous variables: Male vs. Female

	Male				Female			
Coefficients	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 11 mathematics identity								
Grade 9 mathematics identity	*0.47**	*0.06*	*0.41**	*0.05*	*0.58**	*0.05*	*0.47**	*0.04*
Grade 9 mathematics self-efficacy	0.16*	0.06	0.10*	0.04	0.16*	0.06	0.11*	0.04
Grade 9 mathematics interest	−0.01	0.06	−0.01	0.04	−0.01	0.06	−0.01	0.04
Grade 9 educational expectations	*0.03*	*0.02*	*0.08*	*0.05*	*−0.02*	*0.02*	*−0.06*	*0.05*
Grade 9 algebra achievement	0.25*	0.05	0.19*	0.04	0.25*	0.05	0.16	0.03
Grade 11 mathematics self-efficacy								
Grade 9 mathematics identity	0.16*	0.04	0.19*	0.05	0.16*	0.04	0.18*	0.04
Grade 9 mathematics self-efficacy	0.25*	0.06	0.22*	0.05	0.25*	0.06	0.24*	0.05
Grade 9 mathematics interest	−0.07	0.05	−0.07	0.05	−0.07	0.05	−0.06	0.05
Grade 9 educational expectations	0.01	0.01	0.04	0.04	0.01	0.01	0.04	0.04
Grade 9 algebra achievement	0.12*	0.04	0.12*	0.03	0.12*	0.04	0.11*	0.03
Grade 11 mathematics interest								
Grade 9 mathematics identity	0.09	0.05	0.10	0.05	0.09	0.05	0.10	0.05
Grade 9 mathematics self-efficacy	0.02	0.06	0.02	0.05	0.02	0.06	0.02	0.05
Grade 9 mathematics interest	0.26*	0.05	0.25*	0.05	0.26*	0.05	0.25*	0.04
Grade 9 educational expectations	*0.06**	*0.02*	*0.21**	*0.06*	*<0.01*	*0.01*	*<0.01*	*0.05*
Grade 9 algebra achievement	*<0.01*	*0.06*	*<0.01*	*0.06*	*0.14**	*0.04*	*0.12**	*0.03*
Grade 11 educational expectations								
Grade 9 mathematics identity	−0.11	0.13	−0.03	0.04	−0.11	0.13	−0.03	0.04
Grade 9 mathematics self-efficacy	*−0.04*	*0.25*	*−0.01*	*0.06*	*0.83**	*0.21*	*0.20**	*0.05*
Grade 9 mathematics interest	0.21	0.17	0.06	0.05	0.21	0.17	0.05	0.04
Grade 9 educational expectations	*0.49**	*0.04*	*0.52**	*0.04*	*0.39**	*0.05*	*0.41**	*0.04*
Grade 9 algebra achievement	0.84*	0.14	0.22*	0.04	0.84*	0.14	0.19*	0.03
Grade 11 mathematics course difficulty								
Grade 9 mathematics identity	−0.06	0.08	−0.04	0.06	0.25	0.08	0.19	0.05
Grade 9 mathematics self-efficacy	−0.05	0.09	−0.03	0.05	−0.05	0.09	−0.03	0.06

Coefficients	Male				Female			
	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 9 mathematics interest	0.02	0.08	0.01	0.05	0.02	0.08	0.01	0.05
Grade 9 educational expectations	0.04*	0.02	0.10*	0.04	0.04*	0.02	0.11*	0.04
Grade 9 algebra achievement	0.57*	0.06	0.37*	0.04	0.57*	0.06	0.33*	0.04

* $p < 0.05$.
NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group. Italicized parameters were freed up in the model. The standardized coefficients for dummy coded variables (Black, Hispanic, Asian/Pacific Islander, Other, Gender, and School NSLP data availability) were based on STDY standardization.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table 9-c. Unstandardized and standardized structural coefficients associated with the grade 12 NAEP mathematics achievement: Male vs. Female

	Male				Female			
Coefficients	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 12 NAEP								
Grade 11 mathematics identity	5.54*	1.08	0.18*	0.04	5.54*	1.08	0.20*	0.04
Grade 11 Mathematics self-efficacy	1.05	1.37	0.03	0.03	1.05	1.37	0.03	0.04
Grade 11 mathematics interest	1.15	1.32	0.03	0.03	1.15	1.32	0.03	0.03
Grade 11 educational expectations	1.20*	0.31	0.11*	0.03	1.20*	0.31	0.12*	0.03
Grade 11 mathematics course difficulty	3.14*	0.83	0.12*	0.03	3.14*	0.83	0.12*	0.03
Grade 9 algebra achievement	22.85*	1.28	0.56*	0.03	22.85*	1.28	0.51*	0.03
SES	0.55*	0.23	0.07*	0.03	0.55*	0.23	0.07*	0.03
Race/ethnicity: Black	−9.82*	2.29	−0.34*	0.08	−9.82*	2.29	−0.36*	0.08
Race/ethnicity: Hispanic	−5.90*	2.41	−0.21*	0.09	−5.90*	2.41	−0.22*	0.09
Race/ethnicity: Asian/Pacific Islander	−2.13	2.11	−0.07	0.07	−2.13	2.11	−0.08	0.08
Race/ethnicity: Other	*−7.58*	*6.78*	*−0.27*	*0.24*	*−9.48*	*5.86*	*−0.35*	*0.22*
School NSLP	−2.02*	0.38	−0.18*	0.03	−2.02*	0.38	−0.18*	0.03
School NSLP data availability	−17.41*	3.54	−0.61*	0.12	−17.41*	3.54	−0.64*	0.13

* $p < 0.05$.
NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group. Italicized parameters were freed up in the model. The standardized coefficients for dummy coded variables (Black, Hispanic, Asian/Pacific Islander, Other, Gender, and School NSLP data availability) were based on STDY standardization.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Comparison between White students and Black students

The model fit of the White/Black comparison model was not as good as that reported above for the male/female model with a RMSEA of 0.04, CFI of 0.94, and TLI of 0.87.

Tables 10-a, 10-b, and 10-c present the parameter estimates for the White/Black comparison model. The procedure for deriving a final hybrid model was the same as the procedure used in generating the parameter estimates for the gender subgroup analysis reported above. In the case of the White/Black model, of the 75 estimated parameters, 10 needed to be freed to obtain the reported fit.

The structure of the key findings from the overall model reported in Tables 8-a, 8-b, and 8-c was virtually the same for the White/Black hybrid model. An examination of Table 9-c in comparison with Table 8-c shows that the pattern of relationships of the grade 11 endogenous and exogenous variables to grade 12 mathematics performance were identical to those in Table 8-c with one very important exception—while the coefficient between identity and grade 12 mathematics performance was in the right direction and moderate in size, it was not statistically significant for Black students, though it was for White students. The other variables that were significant in the overall model in Table 8-c were also significant in the White/Black subgroup model—grade 9 algebra achievement, grade 11 educational expectations, and the difficulty of mathematics courses taken. The exogenous variables that were significant are SES, being Black (negatively related), being Hispanic (negatively related), being Asian/Pacific Islander, percentage of students at school eligible for NSLP (negatively related), and NSLP data availability (negatively related). Again, all of these estimates were done under the assumption that they were the same for both male and female students.

The relationships of grade 9 mathematics identity and mathematics self-efficacy to grade 11 mathematics identity were both significant and fit the assumption that the estimates were the same for White and Black students (Table 10-b). Two of the 10 parameters that needed to be freed up to get the model fit occurred in this part of the model.

The relationship between grade 9 mathematics interest and grade 11 mathematics identity was slightly negative for White students but positive for Black students, although neither coefficient was statistically significant. The direction of the relationship of grade 9 educational expectations to grade 11 mathematics identity also differed for White and Black students; the relationship was not significant for White students, but was significantly negative for Black students.

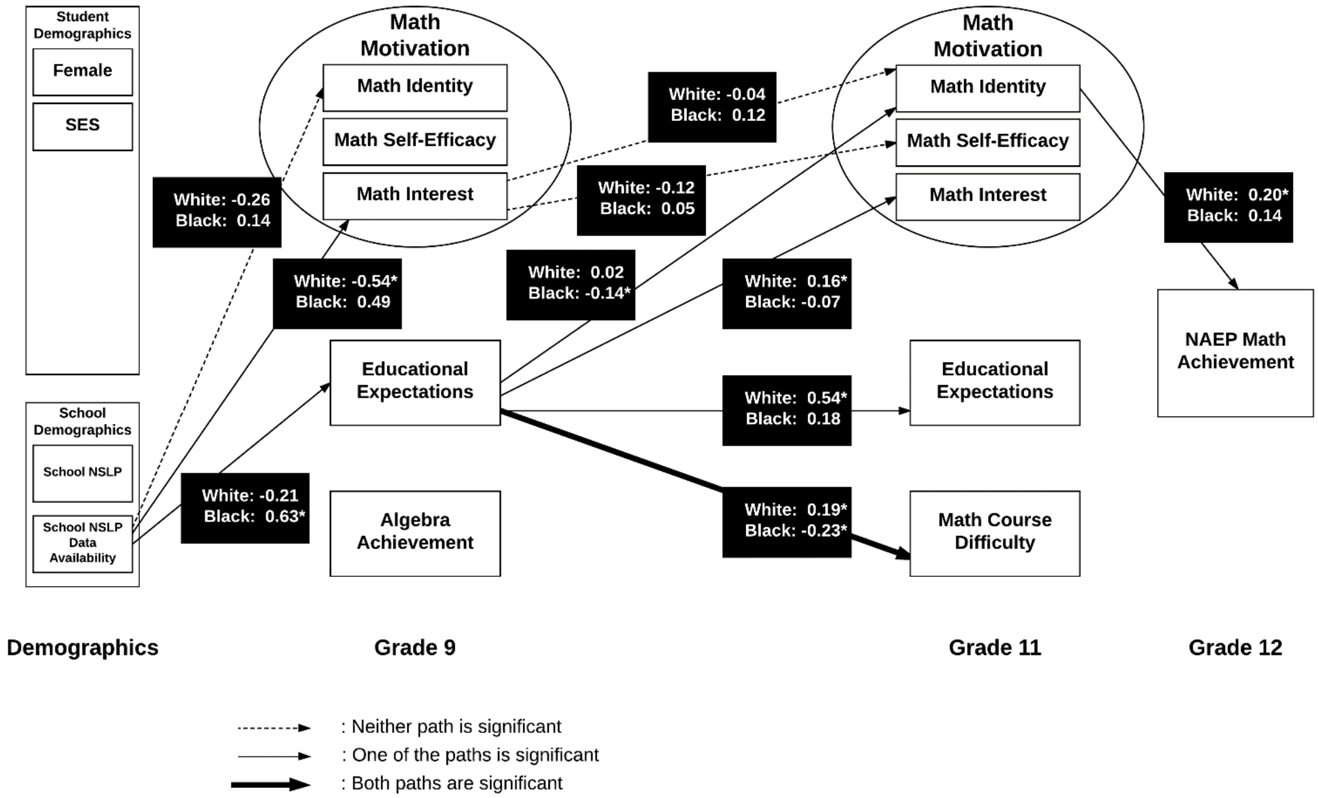
The relationship between the grade 9 endogenous variables and grade 11 mathematics-self efficacy followed the identical pattern as the overall model in Table 10-a. However, the relationship between grade 9 mathematics interest and grade 11 self-efficacy was freed up, but in doing so, neither the White nor Black estimate was statistically significant, as is consistent with the relationship between these two variables in the overall model.

In the overall model, two of the endogenous variables—grade 9 mathematics interest and grade 9 educational expectations—were significantly related to grade 11 mathematics interest. That same pattern was observed in the White/Black subgroup model, except that the relationship of grade 9 educational expectations to grade 11 mathematics interest for Black students was not significant.

The pattern of relationships between the grade 9 endogenous variables, grade 11 educational expectations, and the difficulty of mathematics courses taken at the end of grade 11 was identical to that found in the overall model shown in Table 8-b. However, there were two cases where the strength of the relationships differed for White and Black students. The relationship between grade 9 and grade 11 educational expectations was significant for White students, but not for Black students. While the relationship of grade 9 educational expectations to the difficulty of mathematics courses taken was positive for White students, it was significantly negative for Black students. That is, while counterintuitive, the higher Black students' grade 9 educational expectations were, the less likely they were to take difficult mathematics courses.

Similar to the discussion of the gender subgroup results, the results in Table 10-a do not warrant detailed discussion—the *pattern of results was almost identical to those in Table 8-a*. However, there were three cases in which relationships between Black and White students were freed up to obtain the model fit. In all three cases it was the relationship of NSLP data availability that had to be freed up for White and Black students. In two of the cases the resulting coefficients for White and Black students were not statistically significant (predicting grade 9 mathematics identity and interest), which is consistent with the results found in the overall model. But in one of the cases (predicting grade 9 educational expectations), NSLP data being unavailable was negatively related for Black students and not significant for White students. Figure 4 displays all structural parameters that were different between White and Black students.

Figure 4. Multiple group SEM model: White vs. Black



NOTE: The multiple group SEM model for the White and Black comparison is a hybrid model in which all but ten parameters were constrained to be equal across the White and Black groups. The ten parameters include only structural parameters among the endogenous variables and are shown in the figure. Correlations among the disturbance terms of the endogenous variables at grade 9 and at grade 11 are not shown in the figure.

While the overall pattern of results for the White/Black model was similar to that of the overall model, there were some significant differences. While grade 11 mathematics identity was significantly related to grade 12 mathematics achievement for White students, the same was not true for Black students. There were also three differences in the relationships involving grade 9 educational expectations for White and Black students. Grade 9 educational expectations were *negatively* associated with grade 11 mathematics identity for Black students, but not for White students. While grade 9 educational expectations were positively associated with grade 11 mathematics interest for White students, the same was not true for Black students. Finally, grade 9 educational expectations were positively related to grade 11 mathematics course difficulty level for White students, but negatively related for Black students. These results will be analyzed further in the Discussion section.

Table 10-a. Unstandardized and standardized structural coefficients associated with the grade 9 endogenous variables: White vs. Black

Coefficients	White				Black			
	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 9 mathematics identity								
Gender	−0.17*	0.07	−0.22*	0.09	−0.17*	0.07	−0.22*	0.09
SES	0.02	0.01	0.07	0.04	0.02	0.01	0.08	0.05
School NSLP	0.01	0.02	0.03	0.04	0.01	0.02	0.06	0.07
School NSLP data availability	*−0.21*	*0.15*	*−0.26*	*0.19*	*0.11*	*0.24*	*0.14*	*0.30*
Grade 9 mathematics self-efficacy								
Gender	−0.19*	0.06	−0.30*	0.09	−0.19*	0.06	−0.31*	0.10
SES	0.02*	0.01	0.11*	0.04	0.02*	0.01	0.12*	0.04
School NSLP	0.01	0.01	0.03	0.05	0.01	0.01	0.05	0.08
School NSLP data availability	−0.06	0.10	−0.09	0.20	−0.06	0.10	−0.10	0.18
Grade 9 mathematics interest								
Gender	−0.03	0.07	−0.04	0.09	−0.03	0.07	−0.04	0.10
SES	0.02	0.01	0.07	0.04	0.02	0.01	0.08	0.05
School NSLP	0.05*	0.02	0.15*	0.05	0.05*	0.02	0.24*	0.08
School NSLP data availability	*−0.38**	*0.18*	*−0.54**	*0.25*	*0.33*	*0.18*	*0.49*	*0.25*
Grade 9 educational expectations								
Gender	0.55*	0.27	0.20*	0.09	0.55*	0.27	0.18*	0.09
SES	0.21*	0.04	0.22*	0.04	0.21*	0.04	0.22*	0.04
School NSLP	0.08	0.07	0.06	0.05	0.08	0.07	0.09	0.08
School NSLP data availability	*−0.59*	*0.59*	*−0.21*	*0.21*	*1.92**	*0.90*	*0.63**	*0.30*
Grade 9 algebra achievement								
Gender	−0.03	0.05	−0.04	0.08	−0.03	0.05	−0.04	0.08
SES	0.05*	0.01	0.22*	0.04	0.05*	0.01	0.23*	0.05
School NSLP	−0.05*	0.01	−0.16*	0.04	−0.05*	0.01	−0.25*	0.06
School NSLP data availability	−0.20	0.12	−0.32	0.20	−0.20	0.12	−0.31	0.19

* $p < 0.05$.
NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group. Italicized parameters were freed up in the model. The standardized coefficients for dummy coded variables (Black, Hispanic, Asian/Pacific Islander, Other, Gender, and School NSLP data availability) were based on STDY standardization.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table 10-b. Unstandardized and standardized structural coefficients associated with the grade 11 endogenous variables: White vs. Black

Coefficients	White				Black			
	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 11 mathematics identity								
Grade 9 mathematics identity	0.54*	0.06	0.46*	0.05	0.54*	0.06	0.46*	0.06
Grade 9 mathematics self-efficacy	0.13*	0.07	0.09*	0.04	0.13*	0.07	0.09*	0.04
Grade 9 mathematics interest	_−0.06_	_0.07_	_−0.04_	_0.05_	_0.16_	_0.10_	_0.12_	_0.07_
Grade 9 educational expectations	_0.01_	_0.02_	0.02	0.05	_−0.04*_	_0.02_	_−0.14*_	_0.07_
Grade 9 algebra achievement	0.28*	0.07	0.18*	0.04	0.28*	0.07	0.19*	0.05
Grade 11 mathematics self-efficacy								
Grade 9 mathematics identity	0.17*	0.05	0.19*	0.05	0.17*	0.05	0.19*	0.05
Grade 9 mathematics self-efficacy	0.25*	0.08	0.22*	0.06	0.25*	0.08	0.21*	0.07
Grade 9 mathematics interest	_−0.12_	_0.07_	−0.12	0.07	_0.05_	_0.10_	_0.05_	_0.10_
Grade 9 educational expectations	0.01	0.01	0.04	0.05	0.01	0.01	0.04	0.05
Grade 9 algebra achievement	0.14*	0.05	0.13*	0.04	0.14*	0.05	0.13*	0.04
Grade 11 mathematics interest								
Grade 9 mathematics identity	0.10	0.06	0.12	0.07	0.10	0.06	0.12	0.07
Grade 9 mathematics self-efficacy	−0.03	0.07	_−0.03_	_0.06_	−0.03	0.07	−0.03	0.06
Grade 9 mathematics interest	0.27*	0.05	0.26*	0.05	0.27*	0.05	0.28*	0.06
Grade 9 educational expectations	_0.04*_	_0.01_	_0.16*_	_0.05_	_−0.01_	_0.02_	_−0.07_	_0.08_
Grade 9 algebra achievement	0.05	0.06	0.04	0.05	0.05	0.06	0.05	0.06
Grade 11 educational expectations								
Grade 9 mathematics identity	−0.08	0.16	−0.02	0.05	−0.08	0.16	−0.02	0.05
Grade 9 mathematics self-efficacy	0.29	0.24	0.07	0.06	0.29	0.24	0.06	0.05
Grade 9 mathematics interest	0.20	0.22	0.05	0.06	0.20	0.22	0.05	0.05
Grade 9 educational expectations	_0.53*_	_0.04_	_0.54*_	_0.04_	_0.17_	_0.09_	_0.18_	_0.09_
Grade 9 algebra achievement	0.89*	0.20	0.20*	0.05	0.89*	0.20	0.20*	0.05
Grade 11 mathematics course difficulty								
Grade 9 mathematics identity	0.05	0.08	0.04	0.06	0.05	0.08	0.04	0.06
Grade 9 mathematics self-efficacy	<0.01	0.10	<0.01	0.06	<0.01	0.10	<0.01	0.06
Grade 9 mathematics interest	0.03	0.10	0.02	0.06	0.03	0.10	0.02	0.07
Grade 9 educational expectations	0.07*	0.02	0.19*	0.06	−0.07*	0.03	−0.23*	0.07
Grade 9 algebra achievement	0.53*	0.08	0.31*	0.04	0.53*	0.08	0.34*	0.06

* $p < 0.05$.
NOTE: Italicized parameters were freed up in the model.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table 10-c. Unstandardized and standardized structural coefficients associated with the grade 12 NAEP mathematics achievement: White vs. Black

Coefficients	White				Black			
	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 12 NAEP								
Grade 11 mathematics identity	*5.53**	*1.32*	*0.20**	*0.05*	*3.81*	*2.42*	*0.14*	*0.08*
Grade 11 mathematics self-efficacy	1.26	1.55	0.04	0.04	1.26	1.55	0.03	0.04
Grade 11 mathematics interest	1.42	1.56	0.04	0.04	1.42	1.56	0.04	0.04
Grade 11 educational expectations	1.25*	0.36	0.13*	0.04	1.25*	0.36	0.14*	0.04
Grade 11 mathematics course difficulty	3.23*	0.94	0.13*	0.04	3.23*	0.94	0.12*	0.04
Grade 9 algebra achievement	22.64*	1.56	0.54*	0.04	22.64*	1.56	0.55*	0.05
Gender	−3.60*	1.72	−0.14*	0.07	−3.60*	1.72	−0.14*	0.07
SES	0.55*	0.27	0.07*	0.03	0.55*	0.27	0.07*	0.04
School NSLP	−2.02*	0.44	−0.16*	0.04	−2.02*	0.44	−0.26*	0.06
School NSLP data availability	−17.25*	4.22	−0.67*	0.16	−17.25*	4.22	−0.67*	0.17

* $p < 0.05$.

NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group. Italicized parameters were freed up in the model. The standardized coefficients for dummy coded variables (Black, Hispanic, Asian/Pacific Islander, Other, Gender, and School NSLP data availability) were based on STDY standardization.

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Comparison between White students and Hispanic students

The White/Hispanic multiple group Structural Equation Model fit the data similar to the fit of the White/Black model, with a RMSEA of 0.04, CFI of 0.95, and TLI of 0.89. Tables 11-a, 11-b, and 11-c present the parameter estimates for the White/Hispanic subgroup analysis. The procedure for deriving a final hybrid model was the same as the procedure used in generating the parameter estimates for the gender subgroup analysis reported above. In the case of the White/Hispanic model, of the 75 estimated parameters, 6 needed to be freed to obtain the reported fit.

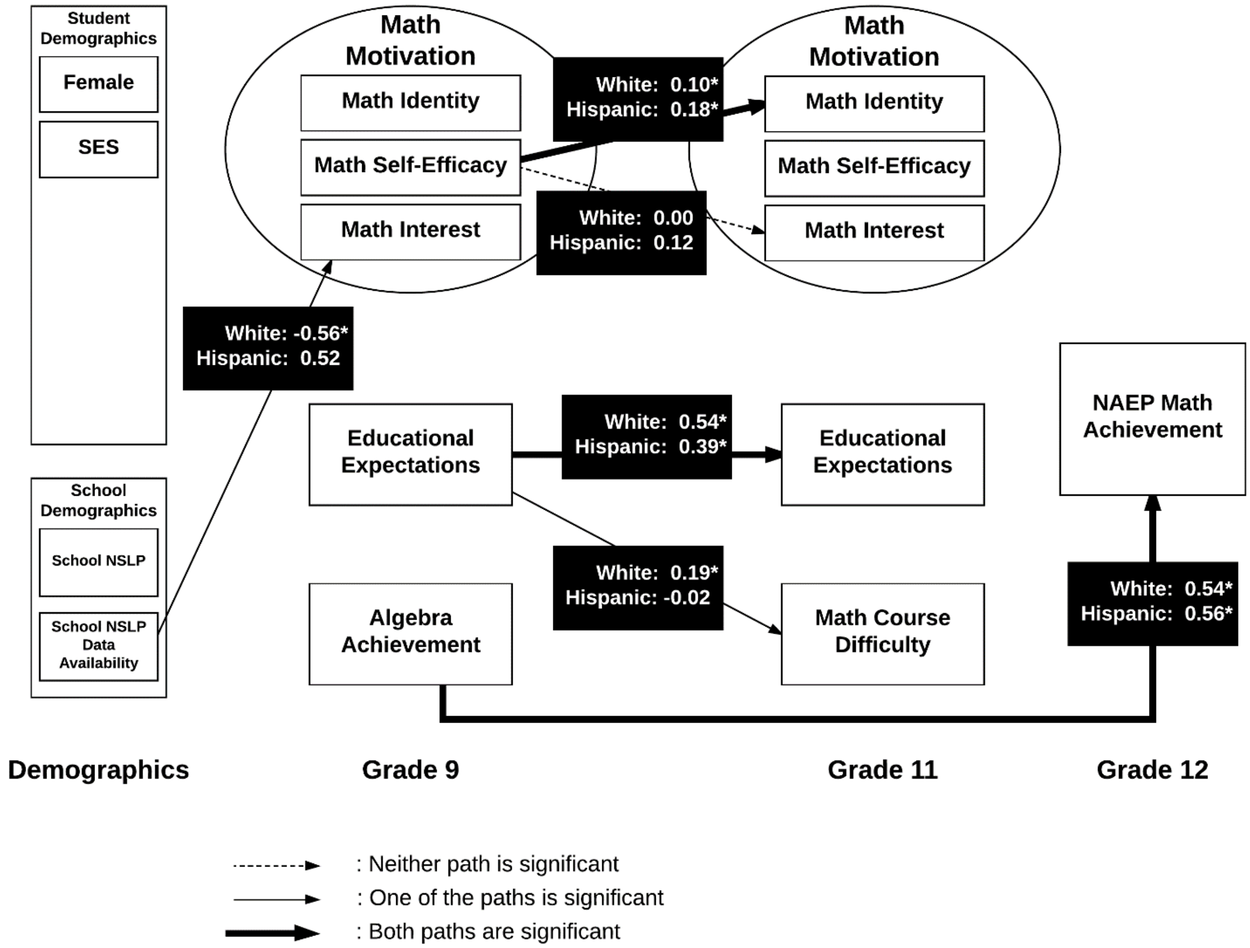
The key findings from the overall model reported in Tables 8-a, 8-b, and 8-c were virtually the same as for the White/Hispanic model. As was also true for the gender subgroup model and mostly true for the White/Black subgroup comparisons, the pattern of relationships of the grade 11 endogenous and exogenous variables to grade 12 mathematics performance was identical. That is, of the three motivational variables, mathematics identity was the only one that was statistically significant and operated identically in its importance for grade 12 mathematics achievement for male and female students. The other variables that were significant in the overall model in Table 8-c were also significant in the White/Hispanic subgroup model—grade 9 algebra achievement, grade 11 educational expectations, and the difficulty of mathematics courses taken. The exogenous variables that were significant were SES, percentage of students at school eligible for NSLP (negatively related), and NSLP data availability (negatively related). For the block of variables that relate to grade 12 mathematics achievement, in all cases the model fit when the assumption of equal parameter estimates for White and Hispanic students was applied.

When examining the relationship of the grade 9 endogenous variables to the grade 11 endogenous variables, the pattern of relationships to the overall model was also identical, with one small exception (Table 11-b). The relationship of grade 9 educational expectations to grade 11 mathematics course difficulty was positive and significant for White students but not significant for Hispanic students. The relationship between grade 9 mathematics self-efficacy and grade 11 mathematics identity was positive and significant for both White and Hispanic students, with somewhat stronger effects for White students. The coefficient linking grade 9 mathematics self-efficacy and grade 11 mathematics interest was freed up, however the relationships were not significant for either White or Hispanic students. Otherwise the only other modification that had to be made in the model for this block of variables was to free up the coefficient linking grade 9 educational expectations to grade 11 educational expectations. The relationships were both positive but it was somewhat stronger for White than Hispanic students.

An examination of the relationships of the exogenous variables to the grade 9 endogenous variables (Table 11-a) revealed that *the pattern of results was nearly identical to that seen in Table 8-a.* That is, the variables that were shown to be significant in the overall model were also significant in the White/Hispanic subgroup model, with two exceptions. First, even though the coefficient linking SES to grade 9 mathematics identity was identical (0.02) in both models, it was not significant in the White/Hispanic model, probably because of the smaller sample size for the White/Hispanic subgroup comparison. Second, the relationship between NSLP data availability and grade 9 mathematics interest was negative but not statistically significant in the overall comparison, while it was significantly negatively related for White students.

The only other place in the model where the parameters had to be estimated separately for White and Hispanic students occurred in the relationships of the exogenous variables to the grade 9 endogenous variables (Table 11-a), even though overall the pattern of relationships was very similar to that in the overall model. Figure 5 displays all six parameters that were estimated separately for White and Hispanic students.

Figure 5. Multiple group SEM model: White vs. Hispanic



NOTE: The multiple group SEM model for the White and Hispanic comparison is a hybrid model in which all but six parameters were constrained to be equal across the White and Hispanic groups, the six parameters included four structural parameters between the grade 9 and 11 endogenous variables and one structural parameter between an exogenous variable and a grade 9 endogenous variable and one structural parameter between one grade 9 exogenous variable and grade 12 NAEP achievement; all are shown in the figure. The one covariance between exogenous variables that was also freed up is not shown in the figure. Correlations among the among the disturbance terms of the endogenous variables at grade 9 and at grade 11 are not shown in the figure

Table 11-a. Unstandardized and standardized structural coefficients associated with the grade 9 endogenous variables: White vs. Hispanic

Coefficients	White				Hispanic			
	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 9 mathematics identity								
Gender	−0.20*	0.07	−0.25*	0.09	−0.20*	0.07	−0.25*	0.08
SES	0.02	0.01	0.06	0.04	0.02	0.01	0.06	0.04
School NSLP	<0.01	0.02	<0.01	0.05	<0.01	0.02	<0.01	0.06
School NSLP data availability	−0.20	0.16	−0.25	0.20	−0.20	0.16	−0.24	0.19
Grade 9 mathematics self-efficacy								
Gender	−0.24*	0.06	−0.38*	0.09	−0.24*	0.06	−0.40*	0.10
SES	0.02*	0.01	0.08*	0.04	0.02*	0.01	0.10*	0.04
School NSLP	−0.01	0.01	−0.02	0.04	−0.01	0.01	−0.03	0.06
School NSLP data availability	−0.07	0.11	−0.11	0.18	−0.07	0.11	−0.12	0.19
Grade 9 mathematics Interest								
Gender	−0.06	0.07	−0.08	0.09	−0.06	0.07	−0.09	0.10
SES	0.01	0.01	0.04	0.04	0.01	0.01	0.05	0.05
School NSLP	0.04*	0.02	0.11*	0.04	0.04*	0.02	0.15*	0.06
School NSLP data availability	*−0.39**	*0.18*	*−0.56**	*0.25*	*0.34*	*0.18*	*0.52*	*0.28*
Grade 9 educational expectations								
Gender	0.33	0.26	0.12	0.09	0.33	0.26	0.12	0.09
SES	0.19*	0.04	0.20*	0.04	0.19*	0.04	0.22*	0.05
School NSLP	0.03	0.07	0.02	0.05	0.03	0.07	0.03	0.07
School NSLP data availability	−0.80	0.57	−0.28	0.20	−0.80	0.57	−0.28	0.20
Grade 9 algebra achievement								
Gender	−0.06	0.05	−0.09	0.08	−0.06	0.05	−0.08	0.08
SES	0.05*	0.01	0.22*	0.04	0.05*	0.01	0.22*	0.04
School NSLP	−0.05*	0.01	−0.15*	0.04	−0.05*	0.01	−0.19*	0.05
School NSLP data availability	−0.30*	0.14	−0.48*	0.22	−0.30*	0.14	−0.44*	0.21

* $p < 0.05$.
NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group. Italicized parameters were freed up in the model. The standardized coefficients for dummy coded variables (Black, Hispanic, Asian/Pacific Islander, Other, Gender, and School NSLP data availability) were based on STDY standardization.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table 11-b. Unstandardized and standardized structural coefficients associated with the grade 11 endogenous variables: White vs. Hispanic

Coefficients	White				Hispanic			
	Unstandardized coefficient	S.E.	Standardized coefficient	S.E	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 11 mathematics identity								
Grade 9 mathematics identity	0.54*	0.06	0.45*	0.05	0.54*	0.06	0.45*	0.06
Grade 9 mathematics self-efficacy	*0.15**	*0.07*	*0.10**	*0.05*	*0.29**	*0.12*	*0.18**	*0.08*
Grade 9 mathematics interest	−0.06	0.06	−0.04	0.04	−0.06	0.06	−0.04	0.04
Grade 9 educational expectations	0.01	0.02	0.03	0.04	0.01	0.02	0.03	0.04
Grade 9 algebra achievement	0.27*	0.07	0.17*	0.04	0.27*	0.07	0.19*	0.04
Grade 11 mathematics self-efficacy								
Grade 9 mathematics identity	0.17*	0.05	0.19*	0.05	0.17*	0.05	0.21*	0.06
Grade 9 mathematics self-efficacy	0.27*	0.07	0.24*	0.06	0.27*	0.07	0.24*	0.07
Grade 9 mathematics interest	−0.11	0.06	−0.11	0.06	−0.11	0.06	−0.11	0.06
Grade 9 educational expectations	0.01	0.01	0.05	0.04	0.01	0.01	0.05	0.05
Grade 9 algebra achievement	0.13*	0.05	0.11*	0.04	0.13*	0.05	0.13*	0.05
Grade 11 mathematics interest								
Grade 9 mathematics identity	0.08	0.06	0.09	0.06	0.08	0.06	0.09	0.06
Grade 9 mathematics self-efficacy	*<0.01*	*0.08*	*<0.01*	*0.07*	*0.14*	*0.12*	*0.12*	*0.10*
Grade 9 mathematics interest	0.28*	0.05	0.27*	0.05	0.28*	0.05	0.24*	0.05
Grade 9 educational expectations	0.04*	0.01	0.15*	0.05	0.04*	0.01	0.14*	0.05
Grade 9 algebra achievement	0.06	0.06	0.05	0.05	0.06	0.06	0.05	0.05
Grade 11 educational expectations								
Grade 9 mathematics identity	−0.12	0.15	−0.03	0.04	−0.12	0.15	−0.04	0.05
Grade 9 mathematics self-efficacy	0.26	0.21	0.06	0.05	0.26	0.21	0.06	0.05
Grade 9 mathematics interest	0.29	0.20	0.07	0.05	0.29	0.20	0.08	0.05
Grade 9 educational expectations	*0.53**	*0.04*	*0.54**	*0.04*	*0.34**	*0.06*	*0.39**	*0.07*
Grade 9 algebra achievement	0.85*	0.18	0.19*	0.04	0.85*	0.18	0.23*	0.05
Grade 11 mathematics course difficulty								
Grade 9 mathematics identity	0.09	0.08	0.07	0.06	0.09	0.08	0.07	0.07
Grade 9 mathematics self-efficacy	−0.07	0.10	−0.04	0.06	−0.07	0.10	−0.05	0.06
Grade 9 mathematics interest	0.06	0.10	0.04	0.06	0.06	0.10	0.04	0.06
Grade 9 educational expectations	0.07*	0.02	0.19*	0.06	−0.01	0.03	−0.02	0.08
Grade 9 algebra achievement	0.51*	0.08	0.30*	0.05	0.51*	0.08	0.35*	0.06

* $p < 0.05$.
NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group. Italicized parameters were freed up in the model.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table 11-c. Unstandardized and standardized structural coefficients associated with the grade 12 NAEP mathematics achievement: White vs. Hispanic

Coefficients	White				Hispanic			
	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.	Unstandardized coefficient	S.E.	Standardized coefficient	S.E.
Grade 12 NAEP								
Grade 11 mathematics identity	5.77*	1.25	0.21*	0.05	5.77*	1.25	0.20*	0.05
Grade 11 Mathematics self-efficacy	1.14	1.57	0.03	0.04	1.14	1.57	0.03	0.04
Grade 11 mathematics interest	0.98	1.45	0.03	0.04	0.98	1.45	0.03	0.04
Grade 11 educational expectations	1.27*	0.37	0.14*	0.04	1.27*	0.37	0.11*	0.03
Grade 11 mathematics course difficulty	3.27*	0.95	0.14*	0.04	3.27*	0.95	0.12*	0.04
Grade 9 algebra achievement	*22.53**	*1.67*	*0.54**	*0.04*	*22.89**	*3.21*	*0.56**	*0.05*
Gender	−3.52*	1.69	−0.14*	0.07	−3.52*	1.69	−0.13*	0.06
SES	0.54*	0.26	0.07*	0.03	0.54*	0.26	0.07*	0.03
School NSLP	−1.93*	0.43	−0.15*	0.03	−1.93*	0.43	−0.20*	0.05
School NSLP data availability	−17.21*	4.32	−0.67*	0.17	−17.21*	4.32	−0.62*	0.16

* $p < 0.05$.

NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group. Italicized parameters were freed up in the model. The standardized coefficients for dummy coded variables (Black, Hispanic, Asian/Pacific Islander, Other, Gender, and School NSLP data availability) were based on STDY standardization.

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Summary of Findings

The third research question examined how a set of motivational beliefs (including having a mathematics identity, a sense of self-efficacy while doing mathematics, and an interest in mathematics, as well as educational expectations) related to mathematics coursetaking in high school, and how these factors in turn related to mathematics achievement. The findings indicated that of the mathematics motivation variables in the study, when controlling for other variables in the model, only having a mathematics identity had a significant relationship with mathematics achievement. Other variables that were significantly related with grade 12 mathematics achievement were grade 9 algebra achievement, grade 11 educational expectations, and difficulty of the mathematics courses taken. While mathematics self-efficacy was not directly related to grade 12 mathematics achievement, it played an important intervening role in its relationship to having a mathematics identity in grade 11.

The multiple-group SEM analyses revealed that the proposed motivation framework fit the data for all high school students well, regardless of their gender or race/ethnicity. However, this was truer for White and Hispanic students than for Black students, for whom the model fit less well in places.

Discussion of the Implications of the Results for Mathematics Motivation

The discussion is divided into four parts: (1) the continuity of mathematics motivation; (2) mathematics motivation and mathematics achievement; (3) gender differences in mathematics motivation; and (4) race/ethnicity and mathematics motivation.

The Continuity of Mathematics Motivation

Continuity, which is an essential characteristic of psychological constructs, is the key element to understand an individual's development. Continuity is defined as the underlying stability of development over time (Edme & Harmon, 1984; Lerner et al., 1996). Researchers have studied the continuity of academic motivation across domains, time, and groups. The current investigation, using a longitudinal nationally representative sample, elucidates the developmental continuity of high school students' mathematics motivation from freshman year to junior year.

Specifically, this study found that students' mathematics motivation at grade 9 was significantly positively related to mathematics motivation at grade 11. However, there were some differences in the strength of those relationships over time. As seen in Table 4, mathematics identity was the most stable of the three with a correlation of 0.56, compared to over time correlations of 0.42 for mathematics self-efficacy and 0.37 for mathematics interest. However, there were some differences in the way that self-efficacy and interest were measured in 2009 and 2012, and these could partially or fully explain the smaller over time correlations for these two constructs (see the note on Table 3). Regardless, overall the findings provide evidence for the continuity of students' mathematics motivation across the high school years (Gottfried, Fleming & Gottfried, 2001; Wigfield et al., 1997). The current study extends the finding to a national representative sample of high school students. Furthermore, the current study indicates that the continuity of mathematics motivation applies to all students regardless of their gender and race/ethnicity.

Mathematics Motivation and Grade 12 Mathematics Achievement

Of the three mathematics motivation variables (identity, self-efficacy, and interest) measured at grades 9 and 11, only mathematics identity at grade 11 showed a significant relationship with students grade 12 mathematics achievement. Academic identities (e.g., science identity, reader identity) have received increasing attention in the literature, especially for their role in promoting under-represented students' involvement in STEM fields. In this study, the measure of mathematics identity focused on seeing oneself as "a math person" and having that view supported by others. That is, one not only sees oneself as being "a math person," but one is also identified by significant others (e.g., teachers, parents, friends) as "a math person." The impact of content-specific identity on students' academic behaviors, decisions, and achievement have been reported by other researchers. Stets et al. (2016) found that students' science identity was the only factor predicating whether students entered a science occupation after controlling for other factors like students' science self-efficacy, students' GPA, and other demographic background characteristics. This study's findings are in line with their study; mathematics identity was also the only mathematics motivation variable that was significantly associated with National Assessment of Educational Achievement (NAEP) mathematics achievement.

Consistent with the theoretical perspective of Stets and Burke (2000), Ervin and Stryker (2001) and Brenner et al. (2017), the current study reported that SEM path models from grade 9 to grade 11 indicated an intimate relationship between mathematics identity and mathematics self-efficacy. Grade 9 mathematics identity significantly predicted grade 11 mathematics identity and self-efficacy. Similarly, grade 9 mathematics self-efficacy significantly predicted grade 11 mathematics identity and self-efficacy. Stets et al. (2017) did not find that science self-efficacy was related to choosing a science occupation when controlling for mathematics identity—paralleling the results from this study where there was no significant path between grade 11 mathematics self-efficacy and grade 12 mathematics achievement. This differs from the results reported by Brenner et al. (2017), who found that the relationship of identity prominence and salience to role-specific self-efficacy over time was statistically significant; however, both relationships were quite weak. This does not mean that self-efficacy is unimportant. The evidence from this study strongly suggests that feeling efficacious about doing mathematics strengthens one's mathematics identity, which in turn leads to higher achievement. Surprisingly, mathematics interest appeared not to play a major role in mathematics achievement. It was not related to mathematics achievement either directly or indirectly though mathematics self-efficacy or through mathematics identity. But this finding is consistent with a recent study by Eccles and Wang (2016) that found that mathematics interest was unrelated to male and female students' pursuit of careers in mathematics and science, whereas having a mathematics ability self-concept was.

Gender Differences in Mathematics Motivation

In the present study, female students identified less with mathematics, felt less efficacious about doing mathematics, and indicated less interest in mathematics than male students at both grades 9 and 11. This finding is in line with Eccles et al. (1993), who found that female students' motivation-related beliefs usually followed gender role stereotypes. Male students reported higher levels of mathematics identity and self-efficacy, even though male and female students performed at a similar level in mathematics.

In general, the literature on gender and motivation finds that girls' mathematics motivational beliefs decline at a slower rate than boys, although all students experience declines in their mathematics motivational beliefs over the course of schooling (Wigfield & Eccles, 2000; Wigfield, et al., 1997). This study similarly found declines in self-efficacy and interest in mathematics overall and for both male and female students. However, there was growth in mathematics identity, both overall and separately for male and female students. Given the finding that self-efficacy at grade 9 was a significant predictor of grade 11 mathematics identity (controlling for the difficulty of the mathematics courses taken at grade 11-as well as for other variables), it is puzzling that even with the overall decline in mathematics self-efficacy (and interest), there was growth in mathematics identity over time.[19] There is no ready explanation for this finding—additional research will need to see if the finding can be replicated and if so, how it might be explained.

Finally, gender was significantly negatively related to grade 12 mathematics achievement in the overall model, even when controlling for all of the endogenous and the remaining student- and school-level exogenous variables. On average, female students scored over three points lower on the NAEP grade 12 mathematics assessment in the final SEM model than did male students, which is about a tenth of a standard deviation.

Race/Ethnicity Similarities and Differences

Overall, the proposed conceptual framework for explaining NAEP mathematics achievement fit well for all students. The hypotheses that defined the conceptual model fit better for White and Hispanic students than for Black students, and there were some differences when comparing the results for Hispanic and White students as well.

White-Hispanic. Within the relationship of the grade 11 endogenous and exogenous variables to grade 12 NAEP mathematics performance, mathematics identity appeared to play an identical role for White and Hispanic students. There were a few differences when examining the relationship of the grade 9 endogenous variables to the grade 11 endogenous variables. For example, the relationship between grade 9 mathematics self-efficacy and grade 11 mathematics identity was somewhat stronger for Hispanic than for White students. That is, feelings of having control over the ability to do mathematics was more related to having a mathematics identity for Hispanic than for White students. It is unclear whether this difference can be explained by culture or whether there is another explanation. There was a significant relationship between grade 9 educational expectations and grade 11 mathematics coursetaking difficulty level for White students, but not for Hispanic students. It is unclear what barriers might exist or other explanations there might be for why Hispanic students' high levels of educational expectations

---

[19] As noted at the bottom of Table 3, there were some differences in the way in which both mathematics self-efficacy and interest were measured in 2012 compared to 2009. As a result, inferences concerning differences in mean levels over time on these two variables should be drawn with caution. That stated, the results for these two variables were consistent with the findings in the literature. Furthermore, since change in measurement procedures over time was the same for all subgroup members, an examination of differences over time by subgroup should not be problematic.

did not translate into taking more difficult mathematics courses in high school. One possible explanation might be that Hispanic students were more likely to attend schools with fewer advanced mathematics courses offered. Grade 9 educational expectations were less strongly related to grade 11 educational expectations for Hispanic than for White students, though both relationships were statistically significant. Again, it is unclear what accounts for this difference. Overall, White and Hispanic students followed similar patterns in their mathematic attitudes and performance.

White-Black. By contrast, the conceptual model for Black and White students reveals more differences than found for either the male-female or the White-Hispanic comparisons. When examining the role of mathematics motivation on grade 12 mathematics achievement, none of the relationships were statistically significant. While the coefficient linking mathematics identity to grade 12 mathematics achievement for Black students was quite large (though not as large as for Whites), it was not statistically significant (at least partially because of large standard errors). The other endogenous variables found to be related to achievement in the overall model were significant in the model for both White and Black students, namely grade 9 algebra achievement, grade 11 educational expectations, and the difficulty of mathematics courses taken in high school.

Black students on average scored higher on the measures of grade 9 mathematics self-efficacy and interest than White students. The difference between White and Black students on measures of grade 9 mathematics identity was in the same direction, but it was not statistically significant. However, Black students' high level of mathematics motivation was not accompanied by higher levels of mathematics achievement.

This disjuncture between Black students' attitudes toward the role of education and their educational performance has been noted by other researchers as well (Ainsworth-Darnell & Downey, 1998; Downey & Ainsworth-Darnell, 2002; Farkas, Lleras, & Maczuga, 2002; Mickelson, 1990). One reason hypothesized for the weaker relationship between their attitudes and behavior is "oppositional culture" (Ogbu, 2008). According to this thesis, Black youth understand that they do not have the same opportunities as White youth and therefore put in less academic effort than their white peers. Furthermore, Black students who are committed to schoolwork and do try hard may be mocked as "acting White" by their Black peers. Thus even though Black students may arrive at high school with strong educational aspirations, it may be difficult for them to perform because of this oppositional culture.

Another hypothesis is stereotype threat (Steele, 1997). Steele and his students demonstrated in a number of experiments that calling attention to an aspect of someone's identity (e.g., being Black) can make them act in a way more consistent with stereotypes about that identity. So, for example, if a Black student is having trouble doing mathematics, the student may become more conscious of their race causing the student to draw on the stereotype that Black students are not very good at mathematics. This would be especially true in classes in which Blacks are in the minority given research which shows that one's ethnic identity is more likely to be activated in classrooms where one is in the minority than when one is in the majority (McGuire, McGuire, Child & Fujioka, 1978). Teachers' attitudes about the ability of Black students could also be subtly communicated to Black students as another way to activate stereotype threat. And the more difficult the mathematics task being faced, the more deleterious the effect on performance is likely to be.

Another possibility is that Black students might have fewer STEM role models than White students. Hines et al. (2003) suggested that minority students may be less likely to realize the importance of mathematics coursework to future life and work because of a lack of evidence of the successes of people like themselves in the field. Conversely, White students are presented with ample evidence of the successes of similar people in mathematics and other STEM fields.

Limitations and Next Steps

Although the fact that this was a nationally representative, longitudinal sample aids the study's generalizability, there are some limitations as well. Even though analyses indicated that the factor structures of the three motivation measures were stable over time, only the mathematics identity was measured identically in grades 9 and 11. More specifically, grade 9 self-efficacy and interest were tied to the specific mathematics course the participants were taking, whereas the questions for this measure were not tied to a specific mathematics course in grade 11. Whether this could account for why these two measures were less stable (e.g., had lower correlations) over time cannot be judged from these data.

A second limitation of the study was the lack of data from peers. The Wisconsin Longitudinal study demonstrated years ago the strong impact that peers' expectations and plans have on one's own expectations and plans. (For example, Sewell & Shah, 1968; Sewell, et al., 1970.)

Finally, while the results overall and by subgroup indicated the primacy of mathematics identity over self-efficacy and interest in the prediction of grade 12 NAEP mathematics performance, there was substantial multicollinearity among the three measures of mathematics motivation. Gordon (1968) pointed out that errors in drawing substantive conclusions about the importance of a variable can be easily made in the presence of high multicollinearity. Although not discussed here in detail, this study's models were also run with only one of each of the three motivation measures, and all three were significantly related to grade 12 mathematics performance individually. However, when comparing the standardized coefficients for the three models, the one associated with mathematics identity was the largest. And the role found for mathematics identity but not self-efficacy in the prediction of a STEM-related outcome is consistent with that of Stets et al. (2016).

There are several directions in which further research can go. For example, the HSLS contains data collected from the students' parents which would allow for an examination of the role of their expectations for the student on mathematics performance. In addition, when the data from the Second Follow-up (2016) are available, it will be possible to examine the role of mathematics motivation in grade 11 in college-level STEM coursetaking, students' performance in these courses, and whether they have declared a STEM major. These additional studies will contribute to an understanding of the role that mathematics motivation plays in choosing STEM majors and eventually in whether one chooses a STEM career.

References

Adelman, C. (2006). *The toolbox revisited: Paths to degree completion from high school through college.* Retrieved from U.S. Department of Education, Office of Vocational and Adult Education website: https://www2.ed.gov/rschstat/research/pubs/toolboxrevisit/toolbox.pdf.

Ainsworth-Darnell, J. W., & Downey, J. W. (1998). Assessing the oppositional culture explanation for racial/ethnic differences in school performance. *American Sociological Review, 63*(4), 536–553. doi:10.2307/2657266.

Anderson, E. L., & Kim, D. (2006). *Increasing the success of minority students in science and technology*. Retrieved from American Council on Education website: http://www.acenet.edu/news-room/Pages/Increasing-the-Success-of-Minority-Students-in-Science-and-Technology.aspx.

Andersen, L., & Ward, T. J. (2014). Expectancy-value models for the STEM persistence plans of ninth-grade, high-ability students: A comparison between Black, Hispanic, and White students. *Science Education*, *98*(2), 216–242. doi:10.1002/sce.21092.

Asparouhov, T., & Muthén, B. (2010). Weighted least squares estimation with missing data. *Mplus Technical Appendix*, *2010*, 1–10.

Atwater, M. M., Wiggins, J., & Gardner, C. M. (1995). A study of urban middle school students with high and low attitudes toward science. *Journal of Research in Science Teaching*. *32*(6), 665–677. doi:10.1002/tea.3660320610.

Azmitia, M., Syed, M., & Radmacher, K. (2008). On the intersection of personal and social identities: Introduction and evidence from a longitudinal study of emerging adults. *New Directions for Child and Adolescent Development, 2008*(120), 1–16. doi:10.1002/cd.212.

Bandura, A. (1994). Self-efficacy. In V.S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (vol. 4, pp. 71–81). New York: Academic Press.

Beal, S. J., & Crockett, L. J. (2010). Adolescents' occupational and educational aspirations and expectations: Links to high school activities and adult educational attainment. *Developmental psychology*, *46*(1), 258.

Beede, D. N., Julian, T. A., Langdon, D., McKittrick, G., Khan, B., & Doms, M. E. (2011). *Women in STEM: A gender gap to innovation* (ESA Issue Brief Number 04–11). Retrieved from U.S. Department of Commerce, Economics and Statistics Administration website: http://www.esa.doc.gov/reports/women-stem-gender-gap-innovation.

Bleeker, M. M., & Jacobs, J. E. (2004). Achievement in math and science: Do mothers' beliefs matter 12 years later? *Journal of Educational Psychology*, *96*(1), 97.

Bollen, K. (1989). *Structural equations with latent variables*. New York: John Wiley and Sons.

Bollen, K. (1993). Liberal democracy: Validity and method factors in cross-national measures. *American Journal of Political Science*, 1207–1230.

Brenner, P. S., Serpe, R. T., & Stryker, S. (2017). Role-specific self-efficacy as precedent and product of the identity model. *Sociological Perspectives*, 1–24. doi:10.1177/0731121417697306.

Bozick, R., Alexander, K., Entwisle, D., Dauber, S., & Kerr, K. (2010). Framing the future: Revisiting the place of educational expectations in status attainment. *Social Forces, 88*(5), 2027–2052. doi:10.1353/sof.2010.0033.

Byrne, B.M. (1998), *Structural Equation Modeling with LISREL, PRELIS and SIMPLIS: Basic Concepts, Applications and Programming*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Carnevale, A. P., Smith, N., & Strohl, J. (2013). *Recovery: Job growth and education requirements through 2020*. Retrieved from Georgetown University, Center for Education and the Workforce website: https://cew.georgetown.edu/cew-reports/recovery-job-growth-and-education-requirements-through-2020.

Catsambis, S. (2005). The gender gap in mathematics. *Gender differences in mathematics: An integrative psychological approach*, 220–245.

Chemers, M. M., Zurbriggen, E. L., Syed, M., Goza, B. K., & Bearman, S. (2011). The role of efficacy and identity in science career commitment among underrepresented minority students. *Journal of Social Issues*, *67*(3), 469–491.

Coley, R. J. (2002). An Uneven Start: Indicators of Inequality in School Readiness. Policy Information Report.

Corbett, C. & Hill, C. (2015). *Solving the equation: The variables for women's success in engineering and computing*. Retrieved from American Association of University Women website: http://www.aauw.org/research/solving-the-equation.

Cribbs, J. D., Hazari, Z., Sonnert, G., & Sadler, P. M. (2015). Establishing an explanatory model for mathematics identity. *Child Development*, *86*(4), 1048–1062. doi:10.1111/cdev.12363.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297–334. doi:10.1007/BF02310555.

Deci, E, L. (1975). *Intrinsic motivation*. New York: Plenum.

Downey, D. B. (2008). Black/White differences in school performance: The oppositional culture explanation. *Annual Review of Sociology*, *34*, 107–126.

Downey, D. B., & Ainsworth-Darnell, J. W. (2002). The search for oppositional culture among Black students. *American Sociological Review*, *67*(1), 156–164. doi:10.2307/3088939.

Dweck, C. S. (2008). *Mindsets and math/science achievement*. Prepared for the Carnegie Corporation of New York-Institute for Advanced Study Commission on Mathematics and Science Education. Retrieved from https://lincs.ed.gov/professional-development/resource-collections/profile-534.

Eccles J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), Achievement and achievement motivation (pp. 75–146). San Francisco, CA: W. H. Freeman.

Eccles, J. S., & Barber, B. L. (1999). Student council, volunteering, basketball, or marching band: What kind of extracurricular involvement matters?. *Journal of adolescent research*, *14*(1), 10–43.

Eccles, J. S., & Wang, M. T. (2016). What motivates females and males to pursue careers in mathematics and science? *International Journal of Behavioral Development*, *40*(2), 100–106.

Eccles, J., Wigfield, A., Harold, R. D., & Blumenfeld, P. (1993). Age and gender differences in children's self- and task perceptions during elementary school. *Child Development, 64*(3), 830–847. doi:10.1111/j.1467–8624.1993.tb02946.x.

Eccles, J. S., & Wigfield, A. (1995). In the mind of the actor: The structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and Social Psychology Bulletin, 21*(3), 215–225. doi:10.1177/0146167295213003.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*(1), 109–132. doi:10.1146/annurev.psych.53.100901.135153.

Eccles, J. S. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist*, *44*(2), 78–89. doi:10.1080/00461520902832368.

Edme, R. N., & Harmon, R. J. (1984). Entering a new era in the search for developmental continuities. In R. N. Edme & R. J. Harmon (Eds.), *Continuities and discontinuities in development* (pp.1–11). New York, NY: Springer.

Ervin, L. H., & Stryker, S. (2001). Theorizing the relationship between self-esteem and identity. *Extending self-esteem theory and research: Sociological and psychological currents*, 29–55.

Farkas, G, Lleras, C. & Maczuga, S. (2002). Does oppositional culture exist in minority and poverty peer groups? *American Sociological Review, 67*(1), 148–155. doi:10.2307/3088938.

Freeman, C. E. (2004). *Trends in educational equity of girls & women: 2004* (NCES 2005−016). Retrieved from U.S. Department of Education, National Center for Education Statistics website: https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2005016.

Freiberg, H. J. (Ed). (1999). *School climate: Measuring, improving, and sustaining healthy learning environments*. London: Falmer Press.

Gasson, R. M., Haller, A. O., & Sewell, W. H. (1972). *Attitudes and facilitators in the attainment of status*. Washington DC: American Sociological Association.

Gordon, R. A. (1968). Issues in multiple regression. *American Journal of Sociology*, *73*(5), 592–616.

Gottfried, A. E., Fleming, J. S., & Gottfried, A. W. (2001). Continuity of academic intrinsic motivation from childhood through late adolescence: A longitudinal study. *Journal of Educational Psychology*, *93*(1), 3.

Gregory, A., & Weinstein, R. S. (2004). Connection and regulation at home and in school: Predicting growth in achievement for adolescents. *Journal of Adolescent Research*, *19*(4), 405–427.

Herrera, F. A., & Hurtado, S. (2011). *Maintaining initial interests: Developing science, technology, engineering, and mathematics (STEM) career aspirations among underrepresented racial minority students*. Paper presented at the Association for Educational Research Annual Meeting, New Orleans, LA.

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational psychologist*, *41*(2), 111–127.

Hines, S. M., Murphy, M., Pezone, M., Singer, A., & Stacki, S. L. (2003). New Teachers' Network: A University-Based Support System for Educators in Urban and Suburban "Ethnic Minority" School Districts. *Equity & Excellence in Education*, *36*(4), 300–307.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling: a multidisciplinary journal*, *6*(1), 1–55.

Jencks, C., & Phillips, M. (1998). America's next achievement test: Closing the Black-White test score gap. *American Prospect*, 44–53.

Jöreskog, K. G. (1969). A general approach to confirmatory maximum likelihood factor analysis. *Psychometrika*, *34*(2), 183–202.

Joyce, B. A., & Farenga, S. J. (2000).Young girls in science: Academic ability, perceptions, and future participation in science. *Roeper Review*, *22*(4), 261–262. doi:10.1080/02783190009554048.

Lameva, B., & Chonteva, Z. (2013, June). *A cross-ethnic comparison of mathematics achievement in the trends in international mathematics and science study (2011)*. Paper presented at IEA International Research conference, Singapore.

Lerner, R. M., Lerner, J. V., von Eye, A., Ostrum, C. W., Nitz, K., Talwar-Soni, R., & Tubman, J. G. (1996). Continuity and discontinuity across the transition of early adolescence: A development contextual perspective. In J. A. Graber, J. Brooks-Gunn, & A. C. Petersen (Eds.), *Transitions through adolescence: Interpersonal domains and context* (pp. 3–22). Mahwah, NJ: Erlbaum.

Lewis, B. F., & Connell, S. (2005). African American students' career considerations and reasons for enrolling in advanced science courses. *Negro Educational Review, 56*(2/3), 221. Retrieved from https://eric.ed.gov/?id=EJ768453.

Liem, A. D., Lau, S., & Nie, Y. (2008). The role of self-efficacy, task value, and achievement goals in predicting learning strategies, task disengagement, peer relationship, and achievement outcome. *Contemporary educational psychology*, *33*(4), 486–512.

Marsh, H. W. (1990). A multidimensional, hierarchical model of self-concept: Theoretical and empirical justification. *Educational psychology review*, *2*(2), 77–172.

Marsh, H. W. "The multidimensional structure of academic self-concept: Invariance over gender and age." *American Educational Research Journal*30, no. 4 (1993): 841–860.

Marsh, H. W., Byrne, B. M., & Shavelson, R. J. (1988). A multifaceted academic self-concept: Its hierarchical structure and its relation to academic achievement. *Journal of educational psychology*, *80*(3), 366.

McCall, G. J., & Simmons, J. L. (1978). Identities and interactions: An examination of human associations in everyday life (Rev. ed.). *New York*.

McGuire, W. J., McGuire, C. V., Child, P., & Fujioka, T. (1978). Salience of ethnicity in the spontaneous self-concept as a function of one's ethnic distinctiveness in the social environment. *Journal of Personality and Social Psychology, 36*, 511–520.

Myers, C. B., & Pavel, D. M. (2011). Underrepresented students in STEM: The transition from undergraduate to graduate programs. *Journal of Diversity in Higher Education*, *4*(2), 90.

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

Nurmi, J. E. (2004). Socialization and self-development. *Handbook of adolescent psychology*, *2*, 85–124.

Ogbu, J. U. (Ed.). (2008). *Minority status, oppositional culture, & schooling*. Routledge.

Ou, S. R., & Reynolds, A. J. (2008). Predictors of educational attainment in the Chicago Longitudinal Study. *School Psychology Quarterly*, *23*(2), 199.

Perry, L. B., & McConney, A. (2010). Does the SES of the school matter? An examination of socioeconomic status and student achievement using PISA 2003. *Teachers College Record, 112*(4), 1137–1162. Retrieved from https://eric.ed.gov/?id=EJ888473.

Pintrich, P. R., & Schunk, D. H. (2002). *Motivation in education: Theory, research, and applications* (2nd ed.). Upper Saddle River, NJ: Prentice-Hall.

Rose, H., & Betts, J. R. (2001). *Math matters: The links between high school curriculum, college graduation, and earnings*. Retrieved from Public Policy Institute of California website: http://www.ppic.org/publication/math-matters-the-links-between-high-school-curriculum-college-graduation-and-earnings.

Rothstein, R. (2004). *Class and schools*. Teachers College, Columbia University.

Rumberger, R. W., & Palardy, G. J. (2005). Does segregation still matter? The impact of student composition on academic achievement in high school. *Teachers college record, 107*(9), 1999. doi:10.1111/j.1467–9620.2005.00583.x.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American psychologist*, *55*(1), 68.

Schiefele, U. (2001). The role of interest in motivation and learning. *Intelligence and personality: Bridging the gap in theory and measurement*, 163–194.

Schultz, P. W., Hernandez, P. R., Woodcock, A., Estrada, M., Chance, R. C., Aguliar, M., & Serpe, R. T. (2011). Patching the pipeline: Reducing educational disparities in the sciences through minority training programs. *Educational Evaluation and Policy Analysis, 33*(1), 95–114. doi:10.3102/0162373710392371.

Sciarra, D. (2010). Predictive factors in intensive math course-taking in high school. *Professional School Counseling*, *13*(3), 196–207.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.

Sewell, W. H., & Shah, V. P. (1968). Parents' education and children's educational aspirations and achievements. *American Sociological Review* (33), 191–209. Retrieved from http://www.ssc.wisc.edu/wlsresearch/publications/files/public/Sewell-Shah_Parents.Education.C.E.A.A.pdf.

Sewell, W. H., Haller, A. O., & Ohlendorf, G. W. (1970). The educational and early occupational status attainment process: Replication and revision. *American Sociological Review, 35*(6), 1014–1027. doi:10.2307/2093379.

Shapka, J. D. (2009). Trajectories of math achievement and perceived math competence over high school and postsecondary education: Effects of an all-girl curriculum in high school. *Educational Research and Evaluation*, *15*(6), 527–541.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental psychology*, *42*(1), 70.

Snyder, T. D., & Hoffman, C. M. (2001). *Digest of education statistics 2000*. Retrieved from U.S. Department of Education, National Center for Education Statistics website: https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2002130.

Snyder, T. D., & Tan, A. G. (2006). *Digest of education statistics 2005*. Retrieved from U.S. Department of Education, National Center for Education Statistics website: https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2006030.

Snyder, T. D., Brey, C., & Dillow, S. (2016)*Digest of education statistics 2005*. Retrieved from U.S. Department of Education, National Center for Education Statistics website: https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2016014.

Steele, C. M. (1997). A threat in the air: How stereotypes shape the intellectual identities and performance of women and African-Americans. *American Psychologist, 52*(6), 613–629. doi:10.1037/0003−066X.52.6.613.

Steele, C. M. (2011). *Whistling Vivaldi: And other clues to how stereotypes affect us (issues of our time)*. New York, NY: WW Norton & Company.

Stets, J. E., & Burke, P. J. (2000). Identity theory and social identity theory. *Social psychology quarterly*, 224–237.

Stets, J. E., Brenner, P. S., Burke, P. J., & Serpe, R. T. (2017). The science identity and entering a science occupation. *Social Science Research*, *64*, 1–14.

Stone, G. P. (1995/1962),“Appearance and the Self”, Mary Ellen Roach-Higgins, Joanne B. Eicher, och Kim Johnson, KP (red.), *Dress and Identity*. 19–39.

Stryker, S. (1968). Identity salience and role performance: The relevance of symbolic interaction theory for family research. *Journal of Marriage and the Family, 30*(4), 558–564. doi:10.2307/349494.

Stryker, S. (1980). *Symbolic interactionism: A social structural version*. Menlo Park, CA: Benjamin-Cummings Publishing Company.

Stryker, S., & Burke, P. J. (2000). The past, present, and future of an identity theory. *Social psychology quarterly*, 284–297.

Stryker, S. (2004). Integrating emotion into identity theory. In *Theory and research on human emotions* (pp. 1–23). Emerald Group Publishing Limited.

Syed, M., Azmitia, M., & Cooper, C. R. (2011). Identity and academic success among underrepresented ethnic minorities: An interdisciplinary review and integration. *Journal of Social Issues, 67*(3), 442–468. doi:10.1111/j.1540–4560.2011.01709.x.

Useem, E. L. (1992). Getting on the fast track in mathematics: School organizational influences on math track assignment. *American Journal of Education*, *100*(3), 325–353.

Valian, V. (2007). *Women at the Top in Science--And Elsewhere*. American Psychological Association.

Wang, M. T., & Degol, J. (2013). Motivational pathways to STEM career choices: Using expectancy-value perspective to understand individual and gender differences in STEM fields. *Developmental Review, 33*(4), 304–340. doi:10.1016/j.dr.2013.08.001.

Wang, X. (2013). Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support. *American Educational Research Journal, 50*(5), 1081–1121. doi:10.3102/0002831213488622

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge university press.

Wigfield, A. (1994). Expectancy-value theory of achievement motivation: A developmental perspective. *Educational Psychology Review*, *6*(1), 49–78.

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary educational psychology*, *25*(1), 68–81.

Wigfield, A., Eccles, J. S., Yoon, K. S., Harold, R. D., Arbreton, A. J., Freedman-Doan, C., & Blumenfeld, P. C. (1997). Change in children's competence beliefs and subjective task values across the elementary school years: A 3-year study. *Journal of educational psychology*, *89*(3), 451.

Wigfield, A., Tonk, S., & Eccles, J. (2004). Expectancy value theory in cross-cultural perspective. In D. M. McInerney & S. Van Etten, *Big Theories Revisited,* (pp. 165–198).

Wigfield, A., Eccles, J. S., Davis-Kean, P., Roeser, R., & Scheifele, U. (2006). Motivation to succeed. *Handbook of Child Psychology. Social, Emotional, and Personality Development*, *3*, 933–1002.

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology, 25*(1), 82–91. doi:10.1006/ceps.1999.1016.

Zimmerman, B. J., & Kitsantas, A. (1997). Developmental phases in self-regulation: Shifting from process goals to outcome goals. *Journal of educational psychology*, *89*(1), 29.

Zimmerman, B. J., & Kitsantas, A. (1999). Acquiring writing revision skill: Shifting from process to outcome self-regulatory goals. *Journal of educational Psychology*, *91*(2), 241.

Appendix A

Table A-1. Items in the construction of the SES index and their coding

Items	Value
NSLP eligibility	
No info on NSLP	0
Eligible for NSLP	0
Not eligible for NSLP	4
Parent education	
Missing or unknown pared	0
Did not graduate from HS	1
Graduated from HS	2
Some college after HS	3
Graduated from college	4
Books	
Missing info on books	0
Few books (0–10)	1
Enough to fill one shelf (11–15)	2
Enough to fill one bookcase (26–100)	3
Enough to fill several bookcases (more than 100 books)	4
Household possessions	
Missing info or one HH possession	0
2 HH possessions	0
3 HH possessions	1
4 HH possessions	2
5 HH possessions	3
6 HH possessions	4

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Appendix B: Imputing the New Set of Plausible Values

First, Marginal Maximum Likelihood (MML) regression models were conducted in the AM[20] software and the results from these models (see Appendix B1–B5 for regression results) were used to create a new set of plausible values following a procedure similar to the one developed by Hedges and Bandeira (2013). The plausible values were computed by estimating a mean expected score for each student, using the results from the regression model with the estimation of imputation error variance, which was then used to generate 20 plausible values for each student. Because there were five datasets created through the imputation techniques of handling missing data, imputation of plausible values was conducted separately for each of five imputation datasets.

The specifics of the imputation procedure were as follows.

1. Compute predicted NAEP scores for each student in the full HSLS sample using the results from the MML regression model.

2. Get the variance-covariance matrix for the regression from AM.

3. Compute the standard error of prediction for the students in the HSLS-NAEP overlap sample using the following equation:

   Let $\sum$ represent the variance covariance matrix from AM.

   $$\sum = (X'X)^{-1}\,\sigma$$

   where X represents the vector of variables used in the model for the overlap sample used in the estimation and σ is the root mean square error from regression.

   Let Z represent the vector of variables used in the model for the whole HSLS sample. Then the standard error of prediction for each student is

   $$SE_{prediction} = Diagonal(Z'\sum Z)$$

4. Using the individual-level predicted values and standard errors, draw 20 values from a normal distribution with a mean equal to the predicted NAEP score and the standard deviation equal to the standard error of prediction/forecast.

[20] AM is a statistical software package for analyzing data from complex samples, especially large-scale assessments.

Table B-1. MML composite regression result: Dataset 1

Parameter name	Estimate	Standard error	t statistic	*p* > |t|
Constant	126.07	7.77	−3.52	<0.01
Grade 9 mathematics identity	1.63	1.98	0.82	0.42
Grade 9 mathematics self-efficacy	0.62	2.51	0.25	0.81
Grade 9 mathematics interest	−2.73	2.68	−1.02	0.31
Grade 9 educational expectations	1.33	0.44	3.06	<0.01
Grade 11 mathematics identity	5.60	2.00	2.80	0.01
Grade 11 mathematics self-efficacy	0.61	2.06	0.30	0.77
Grade 11 mathematics interest	2.64	3.02	0.88	0.39
Grade 11 educational expectations	0.49	0.43	1.14	0.26
Mathematics course difficulty	3.23	1.28	2.54	0.01
Grade 9 algebra achievement	21.72	1.92	11.34	<0.01
Gender	−3.08	2.43	−1.27	0.21
SES	0.46	0.39	1.18	0.24
Black	−10.43	4.15	−2.51	0.02
Hispanic	−6.61	3.43	−1.93	0.06
Asian/Pacific Islander	−1.97	2.89	−0.68	0.50
Others	−8.86	4.55	−1.95	0.06
Teacher expectations	−1.26	1.40	−0.89	0.38
School NSLP	−2.06	0.61	−3.39	<0.01
School NSLP data availability	−17.49	5.41	−3.23	<0.01
Teacher expectations missing	−10.80	8.00	−1.35	0.18
Root MSE	15.45			

NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table B-2. MML composite regression result: Dataset 2

Parameter name	Estimate	Standard error	t statistic	*p* > |t|
Constant	127.72	7.56	−3.40	<0.01
Grade 9 mathematics identity	1.82	1.93	0.94	0.35
Grade 9 mathematics self-efficacy	−0.87	2.33	−0.37	0.71
Grade 9 mathematics interest	−1.80	2.49	−0.72	0.47
Grade 9 educational expectations	1.35	0.44	3.09	<0.01
Grade 11 mathematics identity	5.90	2.02	2.93	0.01
Grade 11 mathematics self-efficacy	0.64	2.02	0.32	0.75
Grade 11 mathematics interest	2.14	2.92	0.73	0.47
Grade 11 educational expectations	0.50	0.44	1.16	0.25
Mathematics course difficulty	3.17	1.30	2.45	0.02
Grade 9 algebra achievement	21.83	1.90	11.52	<0.01
Gender	−3.27	2.44	−1.34	0.18
SES	0.47	0.39	1.20	0.23
Black	−10.35	4.20	−2.46	0.02
Hispanic	−6.44	3.44	−1.87	0.07
Asian/Pacific Islander	−1.78	2.83	−0.63	0.53
Others	−8.65	4.58	−1.89	0.06
Teacher expectations	−1.28	1.36	−0.94	0.35
School NSLP	−2.10	0.60	−3.52	<0.01
School NSLP data availability	−17.62	5.32	−3.31	<0.01
Teacher expectations missing	−10.84	7.77	−1.40	0.17
Root MSE	15.41			

NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table B-3. MML composite regression result: Dataset 3

Parameter name	Estimate	Standard error	t statistic	*p* > |t|
Constant	126.70	7.82	−3.42	<0.01
Grade 9 mathematics identity	1.64	1.96	0.84	0.41
Grade 9 mathematics self-efficacy	0.72	2.44	0.30	0.77
Grade 9 mathematics interest	−3.20	2.54	−1.26	0.21
Grade 9 educational expectations	1.34	0.44	3.07	<0.01
Grade 11 mathematics identity	5.89	2.03	2.90	0.01
Grade 11 mathematics self-efficacy	0.41	2.04	0.20	0.84
Grade 11 mathematics interest	2.74	2.86	0.96	0.34
Grade 11 educational expectations	0.44	0.44	0.99	0.33
Mathematics course difficulty	3.20	1.31	2.44	0.02
Grade 9 algebra achievement	21.70	1.91	11.34	<0.01
Gender	−2.93	2.41	−1.21	0.23
SES	0.46	0.39	1.19	0.24
<Black	−10.30	4.19	−2.46	0.02
Hispanic	−6.58	3.44	−1.91	0.06
Asian/Pacific Islander	−1.78	2.90	−0.61	0.54
Others	−8.67	4.60	−1.88	0.06
Teacher expectations	−1.33	1.37	−0.97	0.34
School NSLP	−2.12	0.59	−3.57	<0.01
School NSLP data availability	−17.78	5.35	−3.33	<0.01
Teacher expectations missing	−11.11	7.80	−1.42	0.16
Root MSE	15.37			

NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table B-4. MML composite regression result: Dataset 4

Parameter name	Estimate	Standard error	t Statistic	$p > \|t\|$
Constant	126.98	7.49	−3.53	<0.01
Grade 9 mathematics identity	1.56	1.95	0.80	0.43
Grade 9 mathematics self-efficacy	−0.10	2.18	−0.05	0.96
Grade 9 mathematics interest	−2.05	2.64	−0.78	0.44
Grade 9 educational expectations	1.32	0.43	3.08	<0.01
Grade 11 mathematics identity	6.02	2.04	2.95	<0.01
Grade 11 mathematics self-efficacy	0.33	2.07	0.16	0.88
Grade 11 mathematics interest	2.63	2.93	0.90	0.37
Grade 11 educational expectations	0.46	0.45	1.04	0.30
Mathematics course difficulty	3.17	1.29	2.46	0.02
Grade 9 algebra achievement	21.82	1.92	11.37	<0.01
Gender	−3.11	2.38	−1.31	0.20
SES	0.48	0.39	1.24	0.22
Black	−10.29	4.12	−2.50	0.02
Hispanic	−6.49	3.42	−1.90	0.06
Asian/Pacific Islander	−1.94	2.89	−0.67	0.50
Others	−8.55	4.55	−1.88	0.07
Teacher expectations	−1.22	1.39	−0.88	0.38
School NSLP	−2.11	0.60	−3.53	<0.01
School NSLP data availability	−17.56	5.37	−3.27	<0.01
Teacher expectations missing	−10.61	7.89	−1.35	0.18
Root MSE	15.39			

NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table B-5. MML composite regression result: Dataset 5

Parameter name	Estimate	Standard error	t statistic	*p* > |t|
Constant	127.14	8.11	−3.24	<0.01
Grade 9 mathematics identity	1.74	2.04	0.85	0.40
Grade 9 mathematics self-efficacy	0.35	2.49	0.14	0.89
Grade 9 mathematics interest	−3.06	2.74	−1.12	0.27
Grade 9 educational expectations	1.33	0.43	3.07	<0.01
Grade 11 mathematics identity	5.86	2.01	2.92	0.01
Grade 11 mathematics self-efficacy	0.41	2.05	0.20	0.84
Grade 11 mathematics interest	2.70	2.92	0.93	0.36
Grade 11 educational expectations	0.46	0.44	1.05	0.30
Mathematics course difficulty	3.21	1.26	2.55	0.01
Grade 9 algebra achievement	21.74	1.92	11.31	<0.01
Gender	−2.97	2.37	−1.25	0.22
SES	0.45	0.39	1.16	0.25
Black	−10.38	4.15	−2.50	0.02
Hispanic	−6.51	3.38	−1.92	0.06
Asian/Pacific Islander	−1.75	2.83	−0.62	0.54
Others	−8.76	4.46	−1.97	0.05
Teacher expectations	−1.27	1.41	−0.90	0.37
School NSLP	−2.10	0.60	−3.52	<0.01
School NSLP data availability	−17.70	5.41	−3.27	<0.01
Teacher expectations missing	−10.87	8.06	−1.35	0.18
Root MSE	15.36			

NOTE: For gender, male was the reference group. For race/ethnicity, White was the reference group.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Appendix C

Table C-1. Mathematics course and its difficulty rating for grade 11 from the HSLS

Variable name	Variable label	Mathematics course	Difficulty rating
S2MSPR12	S2 D13 Teenager taking mathematics class(es) in spring 2012		
S2PREALGM12	S2 D15A Taking pre-algebra spring 2012	Pre-algebra	1
S2ALG1M12	S2 D15B Taking algebra I (including IA and IB) spring 2012	Algebra I (including IA and IB)	2
S2INTGM112	S2 D15M Taking integrated mathematics I spring 2012	Integrated mathematics I	2
S2REVIEWM12	S2 D15R Taking business/general/applied/technical/review mathematics in spring 2012	Business/general/applied/technical/review mathematics	2
S2ALG2M12	S2 D15C Taking algebra II spring 2012	Algebra II	3
S2ANGEOM12	S2 D15F Taking analytic geometry spring 2012	Analytic geometry	3
S2STAT12	S2 D15L Taking statistics or probability other than AP spring 2012	Statistics or probability other than AP	3
S2INTGM212	S2 D15N Taking integrated mathematics II spring 2012	integrated mathematics II	3
S2ALG3M12	S2 D15D Taking algebra III spring 2012	Algebra III	4
S2GEOM12	S2 D15E Taking geometry spring 2012	Geometry	4
S2TRIGM12	S2 D15G Taking trigonometry spring 2012	Trigonometry	4
S2INTGM312	S2 D15O Taking integrated mathematics III or above spring 2012	Integrated mathematics III or above	4
S2PRECALC12	S2 D15H Taking pre-calculus or analysis and functions spring 2012	Pre-calculus or analysis	5
S2CALC12	S2 D15J Taking calculus other than AP spring 2012	Calculus other than AP	5
S2IBMATHSTD12	S2 D15P Taking IB mathematics standard level spring 2012	IB mathematics standard level	5
S2APCALC12	S2 D15I Taking Advanced Placement (AP) calculus AB or BC spring 2012	Advanced Placement (AP) calculus AB or BC	6
S2APSTAT12	S2 D15K Taking Advanced Placement (AP) statistics spring 2012	Advanced Placement (AP) statistics	6
S2IBMATHHI12	S2 D15Q Taking IB mathematics higher level spring 2012	IB mathematics higher level	6

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File.

Appendix D

Table D-1. Exploratory factor analysis of math motivation questionnaire: Grade 9

	2-factor solution		3-factor solution			4-factor solution			
Root mean square error of approximation	0.065		0.024			0.021			
Comparative fit index	0.956		0.996			0.998			
Tucker-Lewis index	0.928		0.990			0.993			
Variable description	Self-efficacy	Identity & interest	Identity	Self-efficacy	Interest	Identity	Self-efficacy	Interest	Enjoying math
Y1ID1: You see yourself as a math person	0.06	**0.86**	**1.06**	−0.09	#	**1.01**	−0.03	−0.02	0.05
Y1ID2: Others see you as a math person	0.06	**0.77**	**0.80**	0.03	−0.01	**0.79**	0.07	0.01	−0.04
Y1SE1: You are confident that you can do an excellent job on tests in this course	**0.81**	0.09	0.01	**0.85**	0.04	0.04	**0.60**	0.01	0.31
Y1SE2: You are certain that you can understand the most difficult material presented in the textbook used in this course	**0.84**	−0.01	0.07	**0.84**	−0.11	0.08	**1.30**	−0.04	−0.01
Y1SE3: You are certain that you can master the skills being taught in this course	**0.90**	#	−0.08	**0.96**	#	−0.01	**0.74**	0.06	0.13
Y1SE4: You are confident that you can do an excellent job on assignments in this course	**0.91**	0.02	−0.06	**0.96**	0.02	−0.03	**0.68**	0.01	**0.31**
Y1INT1: You are enjoying this class very much	0.03	**0.76**	0.05	0.25	**0.60**	0.05	0.07	**0.41**	**0.49**
Y1INT2: You think this class is a waste of your time	−0.18	**0.85**	0.03	0.07	**0.69**	0.09	0.03	**0.91**	−0.03
Y1INT3: You think this class is boring	−0.32	**0.97**	−0.17	−0.03	**1.02**	−0.03	−0.06	**0.75**	0.19
Y1INT4: What is your favorite school subject?	0.08	**0.57**	**0.34**	0.10	0.28	**0.32**	0.03	0.13	**0.32**
Y1INT5: You really enjoy math	0.03	**0.74**	**0.65**	0.01	0.19	**0.65**	0.02	0.16	0.05

#Rounds to zero.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File.
NOTE: Bold text displays the factor structure under each factor solution model.

Table D-2. Exploratory factor analysis of math motivation questionnaire: Grade 11

	2-factor solution		3-factor solution			4-factor solution			
Root mean square error of approximation	0.073		0.024			0.020			
Comparative fit index	0.965		0.997			0.999			
Tucker-Lewis index	0.944		0.994			0.995			
Variable description	Identity & Interest	Self-efficacy	Identity	Self-efficacy	Interest	Identity	Self-efficacy	Enjoying math	Interest
Y2ID1: You see yourself as a math person	**0.95**	#	**0.95**	#	0.10	**1.03**	−0.02	−0.02	0.01
Y2ID2: Others see you as a math person	**0.79**	0.10	**0.74**	0.20	−0.02	**0.76**	0.19	0.02	−0.07
Y2SE1: You are confident that you can do an excellent job on tests in this course	#	**0.94**	#	**0.94**	#	−0.01	**0.93**	0.01	0.02
Y2SE2: You are certain that you can understand the most difficult material presented in the textbook used in this course	0.13	**0.68**	0.15	**0.67**	0.01	0.03	**0.60**	0.34	−0.02
Y2SE3: You are certain that you can master the skills being taught in this course	−0.01	**0.90**	0.01	**0.90**	−0.02	0.03	**0.90**	−0.05	#
Y2SE4: You are confident that you can do an excellent job on assignments in this course	0.01	**0.92**	−0.01	**0.92**	0.02	−0.02	**0.90**	0.03	0.04
Y2INT1: You are enjoying this class very much	**0.62**	0.23	0.25	0.25	**0.51**	0.07	0.10	**0.49**	**0.46**
Y2INT2: You think this class is a waste of your time	**0.66**	−0.05	−0.01	0.04	**0.71**	0.02	0.06	−0.12	**0.76**
Y2INT3: You think this class is boring	**0.76**	−0.08	−0.01	−0.06	**0.94**	−0.01	−0.04	0.06	**0.85**
Y2INT4: What is your favorite school subject?	**0.76**	#	**0.61**	−0.03	**0.31**	**0.64**	#	−0.04	0.21
Y2INT5: You really enjoy math	**0.82**	0.03	**0.63**	0.02	**0.37**	**0.61**	−0.01	0.12	0.24

Rounds to zero.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File.
NOTE: Bold text displays the factor structure under each factor solution model.

Appendix E

Table E-1. Confirmatory factor analyses results: 3-factor structure

	Grade 9			Grade 11		
Root mean square error of approximation	0.033			0.045		
Comparative fit index	0.989			0.987		
Tucker-Lewis index	0.984			0.982		
Variable description	Identity	Self-efficacy	Interest	Identity	Self-efficacy	Interest
ID1: You see yourself as a mathematics person	0.96			0.95		
ID2: Others see you as a mathematics person	0.85			0.89		
INT5: You really enjoy mathematics[1]	0.82			0.87		
SE1: You are confident that you can do an excellent job on tests in this course		0.89			0.94	
SE2: You are certain that you can understand the most difficult material presented in the textbook used in this course		0.83			0.80	
SE3: You are certain that you can master the skills being taught in this course		0.90			0.89	
SE4: You are confident that you can do an excellent job on assignments in this course		0.92			0.92	
INT1: You are enjoying this class very much			0.90			0.97
INT2: You think this class is a waste of your time			0.78			0.65
INT3: You think this class is boring			0.73			0.72
INT4: What is your favorite school subject?1						

[1]This item was excluded from the confirmatory factor analysis based on the exploratory factor analysis results.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File.

Appendix F

Table F-1. Correlations among the disturbance terms of the endogenous variables at grade 9 and at grade 11: overall model

	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|
Grade 9 mathematics identity with						
Grade 9 mathematics self-efficacy	0.27	0.02	<0.01	0.56	0.03	<0.01
Grade 9 mathematics interest	0.28	0.02	<0.01	0.52	0.03	<0.01
Grade 9 educational expectations	0.51	0.09	<0.01	0.23	0.04	<0.01
Grade 9 algebra achievement	0.17	0.02	<0.01	0.34	0.03	<0.01
Grade 9 mathematics self-efficacy with						
Grade 9 mathematics interest	0.22	0.02	<0.01	0.52	0.03	<0.01
Grade 9 educational expectations	0.37	0.09	<0.01	0.22	0.05	<0.01
Grade 9 algebra achievement	0.10	0.01	<0.01	0.27	0.04	<0.01
Grade 9 mathematics interest with						
Grade 9 educational expectations	0.27	0.09	<0.01	0.15	0.04	<0.01
Grade 9 algebra achievement	0.07	0.02	<0.01	0.16	0.04	<0.01
Grade 9 educational expectations with						
Grade 9 algebra achievement	0.30	0.05	<0.01	0.18	0.03	<0.01
Grade 11 mathematics identity with						
Grade 11 mathematics self-efficacy	0.24	0.02	<0.01	0.49	0.03	<0.01
Grade 11 mathematics interest	0.26	0.03	<0.01	0.50	0.03	<0.01
Grade 11 educational expectations	0.22	0.08	<0.01	0.13	0.05	<0.01
Grade 11 mathematics course difficulty	0.11	0.04	<0.01	0.15	0.05	<0.01
Grade 11 mathematics self-efficacy with						
Grade 11 mathematics interest	0.21	0.02	<0.01	0.50	0.05	<0.01
Grade 11 educational expectations	0.21	0.06	<0.01	0.15	0.04	<0.01
Grade 11 mathematics course difficulty	<0.01	0.03	0.94	<0.01	0.05	0.94
Grade 11 mathematics interest with						
Grade 11 educational expectations	0.25	0.07	<0.01	0.17	0.05	<0.01
Grade 11 mathematics course difficulty	0.07	0.03	0.02	0.11	0.05	0.02
Grade 11 educational expectations with						
Grade 11 mathematics course difficulty	0.41	0.09	<0.01	0.19	0.04	<0.01

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table F-2. Correlations among the disturbance terms of the endogenous variables at grade 9 and at grade 11: Male vs. Female

	Male						Female					
	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|
Grade 9 mathematics identity with												
Grade 9 mathematics self-efficacy	0.28	0.04	<0.01	0.56	0.04	<0.01	0.27	0.03	<0.01	0.55	0.03	<0.01
Grade 9 mathematics interest	0.29	0.04	<0.01	0.51	0.04	<0.01	0.27	0.03	<0.01	0.54	0.04	<0.01
Grade 9 educational expectations	0.65	0.14	<0.01	0.29	0.06	<0.01	0.36	0.11	<0.01	0.17	0.05	<0.01
Grade 9 algebra achievement	0.18	0.03	<0.01	0.34	0.05	<0.01	0.15	0.02	<0.01	0.35	0.04	<0.01
Grade 9 mathematics self-efficacy with												
Grade 9 mathematics interest	0.21	0.04	<0.01	0.50	0.06	<0.01	0.23	0.03	<0.01	0.54	0.04	<0.01
Grade 9 educational expectations	0.50	0.14	<0.01	0.30	0.07	<0.01	0.23	0.12	0.05	0.13	0.06	0.04
Grade 9 algebra achievement	0.10	0.02	<0.01	0.25	0.06	<0.01	0.10	0.02	<0.01	0.30	0.04	<0.01
Grade 9 mathematics interest with												
Grade 9 educational expectations	0.35	0.13	0.01	0.19	0.06	<0.01	0.19	0.12	0.10	0.11	0.06	0.10
Grade 9 algebra achievement	0.07	0.03	0.01	0.16	0.06	0.01	0.06	0.02	<0.01	0.16	0.04	<0.01
Grade 9 educational expectations with												
Grade 9 algebra achievement	0.36	0.09	<0.01	0.20	0.05	<0.01	0.24	0.07	<0.01	0.16	0.04	<0.01

	Male						Female					
	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|
Grade 11 mathematics identity with												
Grade 11 mathematics self-efficacy	0.22	0.03	<0.01	0.44	0.05	<0.01	0.26	0.04	<0.01	0.53	0.04	<0.01
Grade 11 mathematics interest	0.24	0.04	<0.01	0.48	0.05	<0.01	0.26	0.03	<0.01	0.52	0.04	<0.01
Grade 11 educational expectations	0.20	0.10	0.05	0.13	0.06	0.05	0.26	0.11	0.02	0.15	0.06	0.01
Grade 11 mathematics course difficulty	0.10	0.06	0.09	0.13	0.07	0.07	0.11	0.04	0.01	0.16	0.06	<0.01
Grade 11 mathematics self-efficacy with												
Grade 11 mathematics interest	0.19	0.03	<0.01	0.43	0.07	<0.01	0.24	0.03	<0.01	0.58	0.04	<0.01
Grade 11 educational expectations	0.14	0.08	0.10	0.10	0.06	0.10	0.32	0.09	<0.01	0.23	0.06	<0.01
Grade 11 mathematics course difficulty	−0.06	0.05	0.30	−0.09	0.08	0.30	0.05	0.03	0.15	0.08	0.06	0.14
Grade 11 mathematics interest with												
Grade 11 educational expectations	0.24	0.10	0.01	0.17	0.07	0.01	0.25	0.08	<0.01	0.17	0.05	<0.01
Grade 11 mathematics course difficulty	0.10	0.05	0.06	0.14	0.07	0.04	0.04	0.03	0.17	0.07	0.05	0.17

	Male						Female					
	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|
Grade 11 educational expectations with												
Grade 11 mathematics course difficulty	0.34	0.14	0.01	0.16	0.06	0.01	0.45	0.11	<0.01	0.21	0.05	<0.01

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table F-3. Correlations among the disturbance terms of the endogenous variables at grade 9 and at grade 11: White vs. Black

	White						Black					
	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|
Grade 9 mathematics identity with												
Grade 9 mathematics self-efficacy	0.28	0.03	<0.01	0.57	0.04	<0.01	0.24	0.04	<0.01	0.53	0.05	<0.01
Grade 9 mathematics interest	0.30	0.03	<0.01	0.55	0.03	<0.01	0.25	0.05	<0.01	0.47	0.08	<0.01
Grade 9 educational expectations	0.46	0.11	<0.01	0.21	0.05	<0.01	0.65	0.20	<0.01	0.29	0.08	<0.01
Grade 9 algebra achievement	0.17	0.02	<0.01	0.35	0.04	<0.01	0.13	0.04	<0.01	0.27	0.08	<0.01
Grade 9 mathematics self-efficacy with												
Grade 9 mathematics interest	0.22	0.03	<0.01	0.53	0.04	<0.01	0.21	0.04	<0.01	0.53	0.08	<0.01
Grade 9 educational expectations	0.41	0.12	<0.01	0.24	0.06	<0.01	0.25	0.15	0.10	0.14	0.08	0.09
Grade 9 algebra achievement	0.09	0.02	<0.01	0.25	0.05	<0.01	0.06	0.03	0.05	0.18	0.08	0.03
Grade 9 mathematics interest with												
Grade 9 educational expectations	0.30	0.12	0.01	0.16	0.06	0.01	0.16	0.18	0.37	0.08	0.09	0.36
Grade 9 algebra achievement	0.06	0.02	<0.01	0.16	0.05	<0.01	0.04	0.04	0.37	0.09	0.10	0.37
Grade 9 educational expectations with												
Grade 9 algebra achievement	0.25	0.07	<0.01	0.16	0.04	<0.01	0.41	0.14	<0.01	0.24	0.07	<0.01

	White						Black					
	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|
Grade 11 mathematics identity with												
Grade 11 mathematics self-efficacy	0.24	0.03	<0.01	0.48	0.04	<0.01	0.23	0.04	<0.01	0.50	0.06	<0.01
Grade 11 mathematics interest	0.26	0.03	<0.01	0.52	0.04	<0.01	0.16	0.05	<0.01	0.36	0.10	<0.01
Grade 11 educational expectations	0.22	0.10	0.03	0.14	0.06	0.02	0.07	0.20	0.71	0.04	0.10	0.71
Grade 11 mathematics course difficulty	0.12	0.05	0.02	0.16	0.06	0.01	<0.01	0.07	0.97	<0.01	0.10	0.97
Grade 11 mathematics self-efficacy with												
Grade 11 mathematics interest	0.21	0.03	<0.01	0.49	0.06	<0.01	0.16	0.04	<0.01	0.42	0.09	<0.01
Grade 11 educational expectations	0.19	0.08	0.01	0.14	0.06	0.01	0.01	0.18	0.98	<0.01	0.11	0.98
Grade 11 mathematics course difficulty	−0.02	0.04	0.70	−0.03	0.07	0.70	0.01	0.05	0.89	0.01	0.09	0.89
Grade 11 mathematics interest with												
Grade 11 educational expectations	0.22	0.09	0.01	0.15	0.06	0.01	0.08	0.18	0.64	0.05	0.11	0.64
Grade 11 mathematics course difficulty	0.08	0.04	0.05	0.13	0.06	0.04	−0.06	0.05	0.28	−0.10	0.09	0.26

	White						Black					
	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|
Grade 11 educational expectations with												
Grade 11 mathematics course difficulty	0.34	0.12	0.01	0.16	0.06	<0.01	0.43	0.24	0.07	0.18	0.09	0.05

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

Table F-4. Correlations among the disturbance terms of the endogenous variables at grade 9 and at grade 11: White vs. Hispanic

	White						Hispanic					
	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|
Grade 9 mathematics identity with												
Grade 9 mathematics self-efficacy	0.28	0.03	<0.01	0.24	0.05	<0.01	0.57	0.04	<0.01	0.50	0.07	<0.01
Grade 9 mathematics interest	0.30	0.03	<0.01	0.22	0.06	<0.01	0.55	0.03	<0.01	0.42	0.10	<0.01
Grade 9 educational expectations	0.46	0.11	<0.01	0.41	0.23	0.08	0.21	0.05	<0.01	0.19	0.10	0.06
Grade 9 algebra achievement	0.17	0.02	<0.01	0.21	0.06	<0.01	0.35	0.05	<0.01	0.41	0.08	<0.01
Grade 9 mathematics self-efficacy with												
Grade 9 mathematics interest	0.22	0.03	<0.01	0.21	0.05	<0.01	0.53	0.04	<0.01	0.53	0.09	<0.01
Grade 9 educational expectations	0.41	0.13	<0.01	0.19	0.14	0.17	0.24	0.06	<0.01	0.12	0.09	0.16
Grade 9 algebra achievement	0.09	0.02	<0.01	0.18	0.04	<0.01	0.24	0.05	<0.01	0.45	0.08	<0.01
Grade 9 mathematics interest with												
Grade 9 educational expectations	0.30	0.12	0.01	0.10	0.17	0.58	0.16	0.06	0.01	0.05	0.10	0.58
Grade 9 algebra achievement	0.06	0.02	<0.01	0.11	0.05	0.03	0.16	0.05	<0.01	0.26	0.11	0.01
Grade 9 educational expectations with												
Grade 9 algebra achievement	0.25	0.07	<0.01	0.39	0.14	0.01	0.16	0.04	<0.01	0.22	0.07	<0.01

	White						Hispanic					
	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|	Unstandardized coefficient	S.E.	*p* > |t|	Standardized coefficient	S.E.	*p* > |t|
Grade 11 mathematics identity with												
Grade 11 mathematics self-efficacy	0.24	0.03	<0.01	0.21	0.05	<0.01	0.48	0.04	<0.01	0.47	0.08	<0.01
Grade 11 mathematics interest	0.26	0.03	<0.01	0.23	0.05	<0.01	0.51	0.04	<0.01	0.47	0.07	<0.01
Grade 11 educational expectations	0.22	0.10	0.03	0.18	0.16	0.25	0.14	0.06	0.02	0.12	0.10	0.21
Grade 11 mathematics course difficulty	0.12	0.05	0.02	0.09	0.05	0.10	0.16	0.06	0.01	0.13	0.07	0.08
Grade 11 mathematics self-efficacy with												
Grade 11 mathematics interest	0.21	0.03	<0.01	0.25	0.06	<0.01	0.49	0.06	<0.01	0.61	0.07	<0.01
Grade 11 educational expectations	0.19	0.08	0.01	0.34	0.16	0.04	0.14	0.06	0.01	0.26	0.10	0.01
Grade 11 mathematics course difficulty	−0.02	0.04	0.70	0.02	0.05	0.73	−0.03	0.07	0.70	0.03	0.08	0.72
Grade 11 mathematics interest with												
Grade 11 educational expectations	0.22	0.09	0.01	0.41	0.16	0.01	0.15	0.06	0.01	0.29	0.09	<0.01
Grade 11 mathematics course difficulty	0.08	0.04	0.05	0.05	0.05	0.31	0.13	0.06	0.04	0.08	0.08	0.30
Grade 11 educational expectations with												
Grade 11 mathematics course difficulty	0.34	0.12	0.01	0.28	0.12	0.02	0.16	0.06	<0.01	0.14	0.06	0.03

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) and First Follow-up and 2013 Update Restricted-Use File, National Assessment of Educational Progress (NAEP), Grade 12 Mathematics Assessment.

About the American Institutes for Research

Established in 1946, with headquarters in Arlington, Virginia, the American Institutes for Research® (AIR®) is a nonpartisan, not-for-profit organization that conducts behavioral and social science research and delivers technical assistance to solve some of the most urgent challenges in the U.S. and around the world. We advance evidence in the areas of education, health, the workforce, human services, and international development to create a better, more equitable world. The AIR family of organizations now includes IMPAQ, Maher & Maher, and Kimetrica. For more information, visit AIR.ORG.

American Institutes for Research®
1400 Crystal Drive, 10th Floor
Arlington, VA 22202-3289
202.403.5000 | **AIR.ORG**