AMERICAN PSYCHOLOGICAL ASSOCIATION

Developmental Psychology

ISSN: 0012-1649

https://doi.org/10.1037/dev0001683

Examining Changes in Adolescents' High School Math and Science Motivational Beliefs and Their Relations to Parental STEM Support and STEM Major Choice at the Intersectionality of Gender and College Generation Status

Su Jiang[1] and Sandra D. Simpkins[2]
[1] School of Education & Human Development, Texas A&M University
[2] School of Education, University of California, Irvine

Drawing on the situated expectancy-value, dimensional comparison theories, and the intersectionality approach, this article examined the changes in adolescents' math and science motivational beliefs, the parental and college correlates of those beliefs, and the differences at the intersection of gender and college generation status (i.e., female and male first- and continuing-generation college students). Findings based on the nationally representative high-school longitudinal study data ($N = 12{,}070$; $M_{\text{age}} = 14$ years; 54% female students; 28% first-generation college students; and 14% Latinx, 9% Black, 10% Asian, and 57% White) suggest that although adolescents' math and science ability self-concepts declined during high school, their science interest remained stable, and their math and science utility values increased. Adolescents' motivational beliefs in ninth grade and the changes from ninth to 11th grade positively predicted whether they declared a science, technology, engineering, and mathematics (STEM) college major. Parents' ninth-grade STEM support was more consistently associated with adolescents' concurrent beliefs compared to the changes in their beliefs. Finally, we found that female first-generation college students, who were more likely to be Latinx and Black students, tended to have lower math and science motivational beliefs, received less parental STEM support, and were less likely to choose a STEM major than their peers. The findings of this study indicate adolescents' math and science motivational development in high school matters for their college majors and that certain understudied groups, including female first-generation college students, may experience acute marginalization in STEM and warrant further attention.

Public Significance Statement

This article examined the changes in adolescents' math and science motivational beliefs and their correlation with parental support and subsequent science, technology, engineering, and mathematics (STEM) major choices. Our findings have direct implications for policy, practice, and interventions that seek to increase the long-term pursuit of careers in STEM to focus on boosting the development of adolescents' math and science motivational beliefs during high school as well as parental STEM support. This article draws attention to a marginalized but understudied group in STEM, namely female first-generation college students.

Keywords: STEM major choice, gender, first-generation college students, math and science motivation, parental STEM support

Supplemental materials: https://doi.org/10.1037/dev0001683.supp

Approximately one third of U.S. undergraduate students, which is nearly five million individuals, identify as first-generation college students (i.e., students whose parents do not hold a college degree; RTI International, 2021). Though it is encouraging that first-generation college students comprise a substantial and growing portion of the undergraduate population, disparities persist in certain

Su Jiang https://orcid.org/0000-0002-7441-1916

The current analyses were supported by two grants from the National Science Foundation (HER-1760757, "Family support of math and science: Examining an untapped source of resilience for diverse high school students" and EHR-2054956, "Who's motivated to pursue math and science? Testing replications of processes from grade school to occupations in multiple datasets") awarded to Sandra D. Simpkins and Jacquelynne S. Eccles. The public data set of HSLS with suppression of some of the original data can be found at https://nces.ed.gov/surveys/hsls09. Materials and analysis code for this study are available by emailing the corresponding author.

Su Jiang served as lead for data curation, formal analysis, methodology, and writing–original draft and served in a supporting role for conceptualization and writing–review and editing. Sandra D. Simpkins served as lead for conceptualization, funding acquisition, project administration, resources, supervision, and writing–review and editing and served in a supporting role for writing–original draft.

Correspondence concerning this article should be addressed to Su Jiang, School of Education & Human Development, Texas A&M University, Harrington Education Center Office Tower, 4222 TAMU, 540 Ross Street, College Station, TX 77843, United States. Email: sujiang@tamu.edu

majors, including science, technology, engineering, and mathematics (STEM), where first-generation college students are less likely to choose a STEM major or earn a STEM degree compared to their continuing-generation counterparts (Bettencourt et al., 2020; Jiang et al., 2020). College generation status, which is based on parent educational attainment, is a key indicator of students' access to resources and privilege; it consistently predicts educational disparities spanning cognitive abilities in early childhood to educational attainment in adulthood (Cataldi et al., 2018; Engle & Tinto, 2008). Though numerous college initiatives focus on first-generation college students to foster diversity, equity, and inclusion, the empirical research identifying what promotes first-generation students' pursuit of STEM is limited (Bettencourt et al., 2020). Based on the intersectionality approach (Crenshaw, 1989) and situated expectancy-value theory (Eccles, 2009), examining the intersection between college generation status and gender might help provide further insight given women's historic marginalization in STEM (Hyde, 2014). Examining the intersection between college generation status and gender also provides insights into groups that experience acute marginalization but have been largely invisible in the current literature, such as female first-generation college students. Charting these processes for these groups is critical to creating a more equitable and inclusive education system, promoting economic mobility, and increasing diversity in the STEM workforce, which will help ensure that STEM innovations benefit all in our diverse society (Cataldi et al., 2018; National Science Board, 2020).

The goal of this article was to investigate the high school predictors of students' STEM college majors for female and male first- and continuing-generation college students. We argue that the disparities prevalent at the college level have origins that can be traced back to high school. Motivation scholars have theorized that individuals' STEM choices are determined by their motivational beliefs across multiple domains and contextual influences (Eccles & Wigfield, 2020; Möller & Marsh, 2013). Thus, we examined the changes in adolescents' math and science motivational beliefs as well as parental STEM support during the first year of high school to test the developmental and contextual influences on students' STEM college major choices. Though math and science are expected to influence each other and codetermine students' STEM choices based on dimensional comparison theory, little research has examined such processes (Möller & Marsh, 2013). Moreover, though parents are sources of support and resilience for students, particularly for marginalized students, little research examines parental STEM support for first-generation college students (Starr et al., 2022). Findings from this study will test central theoretical tenets and help practitioners enhance students' STEM outcomes, especially for understudied and underrepresented groups.

The Development of Adolescents' Math and Science Motivational Beliefs

Situated expectancy-value theory posits that individuals' motivational beliefs are the most proximal influences on their achievement, persistence, and choices (Eccles, 2009; Eccles & Wigfield, 2020). The two distinct motivational beliefs central to this theory are ability self-concepts and subjective task values. Ability self-concepts are defined as individuals' beliefs about their ability to succeed in a specific domain. Subjective task values include (a) the enjoyment one expects to gain from engaging in that domain, which is known as intrinsic value, and (b) the importance of the domain to one's future plans, which is known as utility value. Individuals are most likely to pursue a domain if they believe they are good at it and value it (Watt, 2006). Existing empirical work supports the theoretical links between adolescents' motivational beliefs and their later choices in math (Guo et al., 2015; Simpkins et al., 2012; Wang et al., 2015; Watt, 2006) and in science (Andersen & Ward, 2014; Guo et al., 2018; Jiang et al., 2020). Though the literature on this topic is extensive, it typically focuses on students' beliefs in one domain at one point in time despite that a core tenet of multiple motivation theories argues that the changes in adolescents' motivational beliefs across multiple domains matter for their later STEM choices (Eccles & Wigfield, 2020; Möller & Marsh, 2013).

Situated expectancy-value theory argues that adolescents' motivational beliefs change over time due to developmental processes (e.g., cognitive maturation) and contextual influences (e.g., family and school influences; Eccles, 2009). Historically, research has shown that adolescents' motivational beliefs in a variety of domains, including math and science, typically decline during adolescence (e.g., Hsieh et al., 2019; Jacobs et al., 2002; Petersen & Hyde, 2017; Wang & Degol, 2017). However, some recent studies suggest there may be more diversity in how adolescents' motivational beliefs change during high school with some findings suggesting that adolescents' science identity beliefs increase and their math and science intrinsic values remain stable (Hsieh et al., 2019; Puente et al., 2021). More work is needed to reconcile these discrepant findings and examine the potential implications of these diverse changes for their subsequent choices.

Research suggests that these changes in individuals' math motivational beliefs are as important as the level of individuals' math motivational beliefs at any one point in time (Gottfried et al., 2013; Guo et al., 2018; Musu-Gillette et al., 2015). For instance, Musu-Gillette et al. (2015) found that adolescents who possessed consistently high math motivational beliefs and those whose motivational beliefs decreased gradually were more likely to pursue a STEM-related college major or career compared to those who experienced a rapid decline in their math motivational beliefs. However, these relations were only tested in math; parallel relations in science have not been tested to our knowledge. Examining the consequences of both the initial levels and changes in adolescents' math and science motivational beliefs has implications for the timing and length of intervention efforts.

Situated expectancy-value theory and dimensional comparison theory argue that individuals' beliefs in different domains are interconnected and codetermine their performance and choices (Eccles & Wigfield, 2020; Möller & Marsh, 2013). Dimensional comparison theory posits that school domains are ordered on a continuum, with math and English at two opposite ends. Accordingly, math and English, which have the highest contrast, should negatively influence each other, which has been found in the literature (e.g., Marsh et al., 2015). The theory also suggests that complementary domains, such as math and science, should have small negative or even positive bidirectional effects. Others have argued that the relations between math and science may be more unidirectional with math serving as a gatekeeper to advanced math and science courses in high school (Douglas & Attewell, 2017; Watt et al., 2017).

Emerging studies suggest that adolescents' math and science motivational beliefs both positively predict their STEM college majors (Jiang et al., 2020; Snodgrass Rangel et al., 2020); however, math and science motivational beliefs were related to STEM outcomes in different ways. Two recent studies using the same data as the current study both provide evidence that high school students' math and science motivational beliefs matter for their high school STEM coursework and grades (Jiang et al., 2020; Snodgrass Rangel et al., 2020). In addition, adolescents' math motivational beliefs were more consistently associated with their high school STEM achievement whereas their science motivational beliefs were more related to their choices (Jiang et al., 2020; Snodgrass Rangel et al., 2020). Though these findings concerning adolescents' motivational beliefs are helpful, Jiang et al. (2020) focused on students' beliefs in ninth grade whereas Snodgrass Rangel et al. (2020) focused on students' beliefs in 11th grade. Neither study considered the changes in adolescents' motivational beliefs nor the implications of those changes despite that adolescents experience substantial changes in high school (Guo et al., 2018; Musu-Gillette et al., 2015). This article extends prior work by examining the changes in math and science motivational beliefs, the relations between math and science beliefs longitudinally, and the distinct predictive power of math and science motivational beliefs on students' STEM college majors.

Parent STEM Support and Adolescents' Math and Science Motivational Beliefs

Theories and prior literature have demonstrated that parents support their children's academic motivation, achievement, and choices throughout their education (Hill & Tyson, 2009; Wigfield et al., 2015). The parent socialization model of the situated expectancy-value theory states that parents continuously cultivate children's motivational beliefs in specific domains through a variety of strategies, including encouragement, coactivity, and provision of opportunities (Eccles & Wigfield, 2020). Parents' STEM support can trigger students' STEM interests and competencies by providing a context for encouragement, discussion, scaffolding, and role modeling (Gottfried et al., 2016; Häfner et al., 2018). Relatedly, scholars have also created broader conceptualizations of family STEM support by considering science capital, which includes science-related cultural capital (e.g., scientific literacy), science-related behaviors and practices (e.g., out-of-school science experiences), and science-related social capital (e.g., parents' science qualifications, knowing people in science; Archer et al., 2015). In support of these theories, research suggests that parents' math- and science-specific support is positively related to students' math and science motivational beliefs (e.g., Simpkins et al., 2018; Simpkins, Fredricks, et al., 2015).

To date, however, few studies have investigated if parents' STEM support can mitigate the typical decreases in adolescents' math and science motivational beliefs during high school (Gottfried et al., 2009; Hsieh et al., 2019). Although parents provide support continuously throughout children's development, scholars have argued that parents' support during transition years, like the beginning of high school, might help put adolescents on positive pathways as it predicts adolescents' college enrollment (Degol et al., 2017). Therefore, we examined whether ninth-grade parental STEM support could establish a solid foundation for success in the rest of adolescents' high school journey in STEM. Moreover, little research has explored the relations between parents' STEM support and students' math and science motivation for specific subgroups of the population, including those that experience marginalization at school (e.g., female first-generation college students). However, theory and literature suggest that it is crucial to investigate these relations within specific groups to better motivate them and address the unique challenges they face (Starr et al., 2022).

The Intersection of Gender and College Generation Status

An intersectionality approach recognizes that individuals' lives are shaped by the power and privilege (or disadvantage) associated with the multiple social categories individuals identify with, including gender, race/ethnicity, social class, disability, and sexuality (Crenshaw, 1989; Cole, 2009; Else-Quest & Hyde, 2016). Not only is it important to study the differences and similarities between (and within) groups defined by multiple social categories to more accurately describe individuals' development, but it also helps push our field forward by focusing on groups who have been systematically marginalized from psychological research (Cole, 2009). Prior studies on STEM education have documented the differences in students' math and science motivational beliefs based on gender, race/ethnicity, and the intersection of race/ethnicity with gender and found that minority students are at a disadvantage in STEM (Else-Quest et al., 2013; Hsieh et al., 2021; Simpkins, Price, et al., 2015). Drawing on the intersectionality approach (Cole, 2009; Else-Quest & Hyde, 2016), this article examines the inequalities in adolescents' STEM motivation and choice at the intersection of gender and college generation status.

College generation status (which is based on whether parents obtained a college degree) has been shown to influence adolescents' postsecondary educational outcomes, including enrollment, graduation rates, and major selection (Bui, 2002; Cataldi et al., 2018). Existing research suggests first-generation college students are more likely to identify as Latinx and Black and come from low-income families (Lohfink & Paulsen, 2005), have lower math and science motivational beliefs (Jiang et al., 2020; Snodgrass Rangel et al., 2020), are less likely to declare a STEM college major (Chen & Carroll, 2005), and tend to experience more obstacles on the way to pursue STEM college degrees compared to their continuing-generation counterparts (Gibbons & Borders, 2010; Harackiewicz et al., 2016). Scholars have argued that one challenge first-generation college students in STEM often face is parents' more limited cultural capital, such as limited parental emotional and informational support, role models, and understanding of college culture (Bourdieu, 1986; Sy et al., 2011), and science capital, such as limited science-related literacy and participation in informal science learning contexts (i.e., museums, school science fair, etc.; Archer et al., 2015; Moote et al., 2021).

According to expectancy-value theory, gender can shape adolescents' motivational development through gender-role socialization, the internalization of gender-role stereotypes, and processes related to gender identity development (Simpkins, Fredricks et al., 2015; Wigfield et al., 2015). Prior literature suggests that female adolescents are at a disadvantage in STEM, as these subjects are traditionally perceived as more appropriate for men. As a result, female adolescents tend to have lower math and science ability self-concepts and values (Else-Quest et al., 2013; Master et al., 2021; Nagy et al., 2010; Rubach et al., 2022; for an exception, see Jacobs et al., 2002) and are less likely to choose STEM majors or aspire toward STEM careers than male adolescents (Jiang et al., 2020; Wang et al., 2015) despite the fact that female adolescents tend to have similar or higher achievement in STEM (Hyde, 2014). However, scholars using the intersectionality approach have pointed out that gender disparities should be examined in relation to other social categories because each gender includes a diverse group of individuals with varied experiences (Cole, 2009; Hyde, 2014). For instance, it is unclear if being a male first-generation college student might lessen the privileged position male students hold in math and science, or if there are differences or similarities among individuals who experience privilege due to one social category but marginalization due to another social category (e.g., female continuing-generation college students vs. male first-generation college students). Describing such nuances is necessary to effectively support diverse female and male students in STEM.

Because gender and college generation status are theorized to work through distinct mechanisms (e.g., gender stereotypes vs. resources, respectively), we expected their effects in terms of oppression or privilege would be additive (Cole, 2009; Crenshaw, 1989). Female first-generation college students might experience the disadvantages of both social categories in STEM facing both gender stereotypes and lack of family resources in STEM. Understanding the unique experiences and challenges faced by individuals who belong to multiple marginalized groups can help inform policies and interventions aimed at reducing these disparities. Few existing studies examine the differences in math and science motivation at the intersection of gender and college generation status. One study, for example, found that parents of female first-generation college students provided less informational and emotional support than parents of female continuing-generation college students (Sy et al., 2011). In another study, Harackiewicz et al. (2016) found that their utility value interventions were particularly impactful for first-generation minority students. Though scholars have argued that individual strengths (e.g., motivational beliefs) and support may be more instrumental for adolescents marginalized in STEM given the number of challenges they face (Stephens et al., 2012; Wilson & Kittleson, 2013), this hypothesis has largely gone untested. Our research helps fill this gap by examining STEM motivation and choices of students at the intersection of gender and college generation status and sheds light on practical suggestions for future interventions that target the disadvantaged group, such as female first-generation college students.

The Current Study

Drawing on the situated expectancy-value theory (Eccles & Wigfield, 2020), dimensional comparison theory (Möller & Marsh, 2013), and the intersectionality approach (Crenshaw, 1989), this article examined (a) the changes in adolescents' math and science motivational beliefs from ninth to 11th grade, and (b) their associations with STEM college major and parents' STEM support. Based on prior literature (Wigfield et al., 2015), we expected that although adolescents' math and science ability self-concepts and utility values might decline from ninth to 11th grade, their math and science intrinsic values could remain stable (Hsieh et al., 2019). We expected that the changes in adolescents' motivational beliefs in math and science would be positively related, such as that having higher math motivational beliefs in ninth grade would be related to higher science motivational beliefs in ninth grade and smaller declines over time in their science motivational beliefs. We hypothesized that adolescents whose parents provided more STEM support would have higher math and science motivational beliefs in ninth grade and have smaller declines or remain stable in their math and science motivational beliefs from ninth to 11th grade. We also expected that adolescents who had higher math or science motivational beliefs in ninth grade and smaller declines or stable in their math and science motivational beliefs from ninth to 11th grade were more likely to choose a STEM major.

Another central focus of this article was examining (a) the mean-level differences in adolescents' math and science motivational beliefs, parents' STEM support, and college major choices; and (b) the process-level differences in the relations among these constructs at the intersection of gender and college generation status (Crenshaw, 1989). According to scholars (Crenshaw, 1989; Eccles & Wigfield, 2020), we hypothesized that male continuing-generation college students would have the highest parent STEM support, math and science motivational beliefs, and percentage of people who declared a STEM college major, whereas female first-generation college students would be the lowest on all of these indicators. Male first-generation college students and female continuing-generation college students were hypothesized to be in the middle. Due to the lack of literature on college generation status and the mixed results of gender differences at the process level, we do not have a specific hypothesis for process-level differences. Instead, we explored whether the relations would be different for these four groups.

Method

Participants

Data were drawn from the high-school longitudinal study (HSLS) of 2009. HSLS is a longitudinal study from the U.S. National Center for Education Statistics (NCES) that was designed to study adolescents' STEM education (Ingels et al., 2011). HSLS recruited a nationally representative sample of ninth graders across the United States from a random sample of 940 schools from 10 states. Adolescents were randomly selected from the sampled schools within strata defined by race/ethnicity in the second stage. Approximately 28 adolescents within each school were selected, and a total of 25,210 adolescents participated in the base-year study.

The analytic sample included 12,070[1] adolescents (14% Latinx, 9% Black, 10% Asian, 57% White, and 10% other race/ethnicity) who were enrolled or had ever enrolled in college by February 2016. In ninth grade, adolescents in the analytic sample were on average 14.39 years old, 54% were female adolescents, 28% were first-generation college students, and were from families with median incomes between \$55,000 and \$75,000. The analytic sample included adolescents in each of the four groups defined by gender and college generation status: 16% were female first-generation college students ($n = 1,590$), 12% were male first-generation college students ($n = 1,220$), 38% were female continuing-generation college students ($n = 3,850$), and 34% were male continuing-generation college students ($n = 3,450$).

We compared the analytic and excluded samples. We excluded those who did not enroll in college as of February 2016 ($n = 13,140$) because this study focused on college-going adolescents

[1] All the sample sizes mentioned in this article were rounded to the nearest 10 according to the IES restricted-use data guidelines.

and whether they declared a STEM college major. The analytic sample had higher math and science motivational beliefs in ninth and 11th grade though the effect sizes were small ($d = 0.01$–0.27), higher ninth-grade math achievement ($d = 0.67$), higher parent education levels ($d = 0.57$), and higher family incomes ($d = 0.45$) than the excluded sample (see all comparisons in Table S1 in the online supplemental materials).

Measures

Adolescents in ninth and 11th grade (in 2009 and 2011, respectively) reported their math and science motivational beliefs. Parents' STEM support was collected through parent surveys in ninth grade. College enrollment information was gathered in 2016, which was 3 years after high school. A complete list of items used for math and science motivational beliefs, the STEM college major, and control variables is provided in Table S2 in the online supplemental materials. A correlation table that provides the correlations among all variables used in this study is provided in Table S3 in the online supplemental materials. The data used in this study were approved under Institutional Review Board protocol at the University of California, Irvine, under the project title: Family Support of Math and Science: Examining an Untapped Source of Resilience for Diverse High School Students and Institutional Review Board Protocol: HS:2018-4349.

Adolescents' Math and Science Motivational Beliefs

Adolescents reported their motivational beliefs (i.e., ability self-concept, intrinsic value, and utility value) concerning their math and science classes using the same items in ninth and 11th grade. All scales had strong reliability and validity (Fong et al., 2021; Jiang et al., 2020). Measurement invariance was tested and confirmed the scales evidenced configural, weak, and strong measurement invariance (Grimm et al., 2016) across time (i.e., ninth and 11th grade) and across the four groups defined by gender and college generation status (see Tables S4 and S5 in the online supplemental materials).

Ability Self-Concept. The items align with the situated expectancy-value theory's definition that adolescents' ability self-concepts are the extent to which adolescents feel competent in their ability to succeed in a specific domain (Eccles & Wigfield, 2020). Four adolescent-report items were used to measure adolescents' ability self-concepts in each domain ($\alpha = .90$, .89 for math and .88, .92 for science in ninth and 11th grades, respectively; 1 = *strongly disagree*, 4 = *strongly agree*; e.g., "You are certain that you can master the skills being taught in this [math/science] course").

Intrinsic Value. Situated expectancy-value theory conceptualizes intrinsic value as the enjoyment one garners from doing tasks (Eccles & Wigfield, 2020). Three items were reported by adolescents on their intrinsic values in math and science ($\alpha = .78$, .80 for math and .81, .83 for science in ninth and 11th grades, respectively; 1 = *strongly disagree*, 4 = *strongly agree*; e.g., "You are enjoying this class very much").

Utility Value. Adolescents' math and science utility values are the importance of math and science for their future plans (Eccles & Wigfield, 2020). Adolescents reported their utility values in math and science using three items in each domain ($\alpha = .77$, .81 for math and .74, .82 for science in ninth and 11th grade, respectively; 1 = *strongly disagree*, 4 = *strongly agree*; e.g., "will be useful for a future career").

Parent STEM Support

Aligned with situated expectancy-value theory (Eccles & Wigfield, 2020), the items measuring parents' STEM support in ninth grade included coactivities and encouragement. Parents' STEM support was captured by the sum of the six parent-reported dichotomous items on their behaviors in supporting their adolescent in STEM (1 = *yes*, 0 = *no*; e.g., "helped [your ninth-grader] with a school science fair project"). Prior studies have used similar items to construct parents' STEM support composite scores when studying parental processes in STEM (Simpkins et al., 2005; Simpkins, Fredricks, et al., 2015).

Adolescents' College STEM Majors

Adolescents reported their majors or fields of study for their 4-year undergraduate degrees, 2-year associate degrees, or certificates they were actively working on or had completed by February 2016, which was 3 years after high school. Students' college majors were coded using the U.S. Department of Education's Classification of Instructional Programs, 2010 edition (CIP 2010), and then were categorized as a STEM or non-STEM field (Ingels et al., 2011). STEM major choice was a dichotomous variable of whether students' first or second major field was a STEM field, including majors such as biological and biomedical sciences, agriculture and related science, computer and information sciences, engineering, math and statistics, and economics as defined by NCES (for a full list of STEM majors, see Table S2 in the online supplemental materials).

The Intersection of Gender and College Generation Status

Adolescents' first-generation college status was a parent-reported dichotomous variable indicating that none of their parents had earned an associate's degree, bachelor's degree, or higher (Próspero & Vohra-Gupta, 2007; 1 = *first-generation college student*, 0 = *continuing-generation college student*). Adolescents reported their gender in ninth grade (1 = *female student*, 0 = *male student*). Four groups were created based on the intersection of gender and college generation status: female first-generation college students, male first-generation college students, female continuing-generation college students, and male continuing-generation college students. Gender and parents' highest education were included as covariates for the main models and were taken out for multigroup models at the intersection of gender and college generation status. Parents' highest education was reported by parents, which was the highest level of education achieved by either parent living in participants' home (1 = *less than high school*, 7 = *PhD/MD/Law/other high-level professional degrees*).

Covariates

Family income, adolescents' race/ethnicity, adolescents' ninth-grade math achievement, and parents' academic support were incorporated as covariates in the main models given their relations with the focal indicators (Else-Quest et al., 2013; Simpkins, Fredricks, et al., 2015). Family income in 2008 was reported by parents (1 = *less than or equal to $15,000*, 13 = *greater than $235,000*). Race/ethnicity variables were reported by adolescents and dummy-coded as Hispanic or Latinx, White (not of Hispanic origin), Black or African American (not of Hispanic origin), Asian (not of Hispanic origin), or other ethnic groups. Adolescents' ninth-grade math achievement is a standardized norm-referenced measurement of achievement that captured an estimate of adolescents' achievement relative to the population with a mean of 50 and a *SD* of 10 (Ingels et al., 2011). Parents' academic support was captured by the sum of the six dichotomous items reported by parents in ninth grade (1 = *yes*, 0 = *no*; e.g., "attended a general school meeting such as an open house or a back-to-school night").

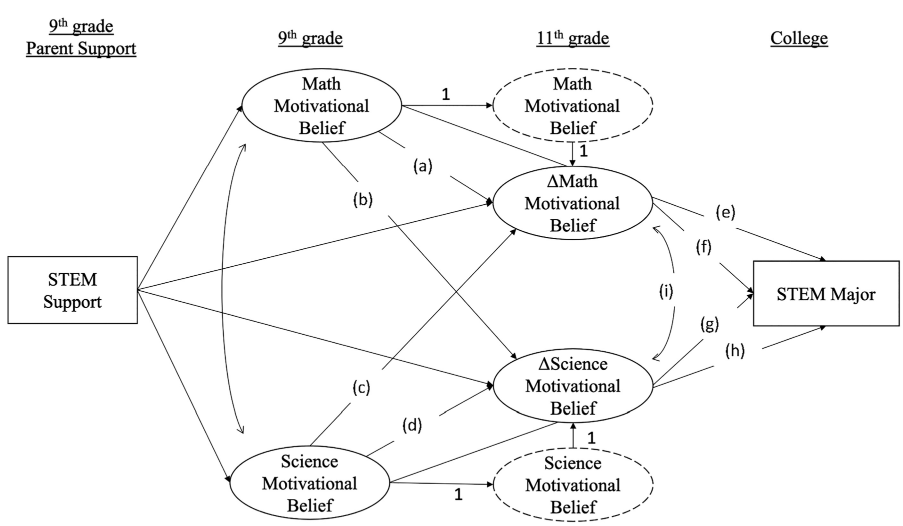
Plan of Analysis

This article examined (a) adolescents' math and science motivational beliefs at the beginning of high school, (b) within-domain math and science motivational beliefs changes during high school, (c) cross-domain relations between math and science motivational beliefs, (d) parental STEM support, and (e) their STEM college majors (see the conceptual model in Figure 1). To simultaneously test these aims, we estimated bivariate latent change score (LCS) models (McArdle, 2009) in Mplus v8.0 (Muthén & Muthén, 2012) separately for each of the three motivational beliefs (i.e., ability self-concept, intrinsic value, and utility value) to avoid multicollinearity issues. Thus, a total of three LCS models were estimated for each type of motivational beliefs. Each model captured the changes in one type of adolescents' math and science motivational beliefs from ninth to 11th grade. Adolescents' motivational beliefs were specified as latent variables using the items described in the Measures section. Models were weighted (W4W1STU) to account for the nonresponse rate in the sampling process to correct for the unequal probabilities of selection as required by Institute of Education Sciences. Strata and primary sampling unit (i.e., schools) variables were used to correct the *SE*s based on the stratified design of the data. Models were estimated using the robust maximum likelihood (MLR) estimator, which provides a robust estimation for nonnormally distributed data, such as our dichotomous STEM college major indicator when having a complex sample design. The significant level was set at $p < .01$ to take into account the large sample size, the number of tests, and to avoid Type I errors.

LCS models estimate change and time-sequential associations as time-dependent, meaning that the change of a construct from Time 1 to Time 2 depends on individuals' levels at Time 1 (Grimm et al., 2012). Compared to other time-sequence analyses (e.g., latent growth curve models, cross-lag models, and controlling for prior level of adjustment), LCS models emphasize the within-person change over time and allow for estimation of the dynamic associations with as few as two time points, which is the case for adolescents' motivational beliefs in the HSLS data set; other models (e.g., latent growth curves) require three and more time points.

We estimated bivariate LCS models to capture the relations between adolescents' math and science motivational beliefs from ninth to 11th grade (Grimm et al., 2016). In each bivariate LCS model, we estimated the mean change (Δ) in adolescents' motivational beliefs from ninth to 11th grade (e.g., see Δmath motivational beliefs in Figure 1). We also estimated the extent to which adolescents' motivational beliefs in the same domain in ninth grade were related to their changes over time (see paths a and f in Figure 1; Grimm et al., 2012). The stability path (autoregression between latent scores) and the path from the latent score at 11th grade to the LCS were fixed at 1 to meet model identification requirements (McArdle & Grimm, 2010). Based on the literature, we hypothesized that adolescents' math and science ability self-concepts and utility values might decline from ninth to 11th grade and their math and science intrinsic values could remain stable (Gottfried et al., 2009; Guo et al., 2018; Hsieh et al., 2019). In addition to

Figure 1
The Concept Map of the Multivariate Latent Change Score Model Between Math and Science Motivational Beliefs



Note. Model controlled for gender, parents' highest education, family income, adolescents' race/ethnicity, adolescents' ninth-grade math achievement, and parents' academic support. STEM = science, technology, engineering, and mathematics. Source: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

the paths that capture the change within each domain, our bivariate LCS models included relations between math and science. Specifically, we tested the extent to which changes in adolescents' math and science motivational beliefs from ninth to 11th grade were correlated (path i in Figure 1) and the extent to which adolescents' motivational beliefs in one domain in ninth grade predicted changes in their beliefs in the other domain from ninth to 11th grade (paths b and e in Figure 1).

Under the second hypothesis, we expected that adolescents' higher math and science motivational beliefs in ninth grade and the smaller declines in adolescents' math and science motivational beliefs from ninth to 11th grade would be positively associated with their STEM college major choices. Adolescents' STEM college major was included in the bivariate LCS models and regressed on the change scores (paths d and g in Figure 1) and the ninth-grade scores (paths c and h in Figure 1) of adolescents' math and science motivational beliefs in each of the three models.

We also examined the extent to which parents' STEM support in ninth grade was associated with adolescents' ninth-grade math and science motivational beliefs at ninth grade and the changes in their beliefs over time in the bivariate LCS models. Based on prior literature, we hypothesized that adolescents whose parents provided more STEM support would have higher math and science motivational beliefs in ninth grade and have smaller declines or stable changes over time. Family income, adolescent race/ethnicity, ninth-grade math achievement, and parents' general academic support were included as controls in all of the bivariate LCS models, and they predicted each of the focal indicators in Figure 1.

Lastly, we examined the intersection of gender and college generation status. We first examined the demographic disposition of race/ethnicity, mother employment status, and income at the intersection of gender and college generation status using χ^2 and analysis of variance (ANOVA) tests in STATA v14.2. Next, we expected that there would be mean-level differences in focal variables in Figure 1, as well as process-level differences in the relations among these indicators at the intersection of gender and college status. For mean-level differences, we estimated ANOVA tests for continuous variables and the χ^2 test for categorical variables controlling for race/ethnicity. For process-level differences, we estimated four-group multigroup models using the following three steps. First, we freely estimated the relational paths in Figure 1 across groups (except for the paths that were constrained to one for model estimation requirements). Second, as an omnibus test, we constrained all relational paths shown in Figure 1 to be the same across all four groups to test whether there were group differences in the overall model. Third, when the omnibus test was statistically significant across groups, we followed up with comparisons of each path across four groups to identify which specific estimates varied across which particular groups. Models were compared using the Satorra–Bentler scaled χ^2 difference test (Satorra & Bentler, 2001) as it is the recommended approach for models with MLR estimator (Muthén & Muthén, 2012).

The proportion of missing values varied between 7% and 15% for math and science motivational beliefs in ninth and 11th grade, 11% for STEM college major, and 21% for parental STEM support. Missing data were handled with full-information maximum likelihood because this approach yields less biased estimates than traditional approaches such as listwise or pairwise deletion (Enders, 2010).

Robustness Checks

We conducted three robustness checks. The first robustness check focused on the bivariate LCS models described in the Plan of Analysis section using a more limited subsample of adolescents who not only attended college but also reported college majors ($n = 10{,}740$) to test the robustness of estimating missing outcomes. The second robustness check was estimated because we had to drop adolescents who did not attend college from our main analyses. This analysis used a more inclusive sample—a sample that included adolescents who did and did not go to college ($n = 20{,}930$). Because this sample included adolescents who did not go to college or a certificate program, this model did not include STEM college major as an outcome. Rather, it included all of the relations in high school including the changes in students' motivation and the parental correlates. We conducted a third robustness check analysis to examine whether there were significant differences at the intersection of gender and race/ethnicity. Ten groups at the intersection of gender and race/ethnicity were created: Latinx females and males, White females and males, Black females and males, Asian females and males, and other females and males. We repeated the same processes for process-level differences in Figure 1 and tested whether there were significant group differences at the intersection of gender and race/ethnicity.

Transparency and Openness

We reported how we determined our sample size, all data exclusions, all manipulations, and all measures in the study, and we follow JARS (Kazak, 2018). We used the restricted version of the HSLS data set, although a public data set of HSLS with suppression of some of the original data can be found at https://nces.ed.gov/surveys/hsls09. Materials and analysis code for this study are available by emailing the corresponding author. This study's design and its analysis were not preregistered.

Results

Adolescents' math and science motivational beliefs on average ranged from 2.85 to 3.15 in ninth grade and ranged from 2.64 to 3.28 in 11th grade on a one to four scale (Table 1). Adolescents' math and science motivational beliefs (i.e., ability self-concept, intrinsic value, and utility value) were moderately correlated within each domain during ninth and 11th grade (rs = .36–.58), were weakly to moderately correlated across math and science at ninth and 11th grade (rs = .15–.43), and were weakly to moderately correlated across the two time points (rs = .10–.37). The M, SDs, and correlations of focal variables are presented in Table 1.

We examined the demographic composition of the four groups at the intersection of gender and college generation status. As presented in Table S6 in the online supplemental materials, Latinx and Black students were more likely to be first-generation college students whereas White and Asian students were more likely to be continuing-generation students. First-generation students were more likely to have mothers who were not employed, whereas continuing-generation college students were more likely to have mothers who were either employed full-time or part-time. The family income of first-generation college students was significantly lower than continuing-generation college students (Table S6 in the online supplemental materials).

To test our first three hypotheses, we estimated separate bivariate LCS models for each of the three types of adolescents' math and

Table 1
Descriptive Statistics and Correlations Among Key Variables

Indicators	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ninth-grade parent indicators														
1. Parent STEM support	—													
Ninth-grade motivational beliefs														
2. Math self-concept of ability	.08***	—												
3. Math utility value	.04**	.36***	—											
4. Math intrinsic value	.06***	.46***	.46***	—										
5. Science self-concept of ability	.10***	.40***	.17***	.19***	—									
6. Science utility value	.08***	.19***	.41***	.28***	.37***	—								
7. Science intrinsic value	.09***	.17***	.23***	.28***	.46***	.52***	—							
11th-grade motivational beliefs														
8. Math self-concept of ability	.06***	.37***	.17***	.20***	.25***	.13***	.14***	—						
9. Math utility value	.06***	.23***	.31***	.22***	.13***	.19***	.15***	.40***	—					
10. Math intrinsic value	.06***	.26***	.23***	.30***	.15***	.17***	.21***	.56***	.46***	—				
11. Science self-concept of ability	.10***	.21***	.10***	.11***	.30***	.13***	.16***	.29***	.17***	.15***	—			
12. Science utility value	.08***	.17***	.18***	.16***	.25***	.34***	.24***	.25***	.43***	.25***	.38***	—		
13. Science intrinsic value	.08***	.11***	.12***	.15***	.17***	.19***	.22***	.15***	.17***	.22***	.58***	.44***	—	
14. STEM college major	.07***	.18***	.09***	.10***	.20***	.14***	.13***	.23***	.18***	19***	.18***	.24***	.17***	—
M	3.07	2.94	3.15	2.86	2.85	2.92	2.87	2.77	3.28	2.64	2.81	3.05	2.85	0.23
SD	1.45	0.66	0.62	0.70	0.63	0.62	0.71	0.71	0.59	0.74	0.73	0.64	0.75	0.42
Skewness	−0.04	−0.35	−0.54	−0.45	−0.22	−0.33	−0.47	−0.30	−0.56	−0.22	−0.29	−0.39	−0.41	10.28
Kurtosis	2.47	3.28	3.36	2.97	3.32	3.36	2.94	2.93	3.49	2.55	2.92	3.39	2.77	2.65

Note. Source: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09). STEM = science, technology, engineering, and mathematics.
** $p < .01$. *** $p < .001$.

science motivational beliefs (i.e., ability self-concept, intrinsic value, and utility value). We controlled for family income, adolescents' race/ethnicity, adolescents' ninth-grade math achievement, and parents' academic support in all LCS models. The fit of these three structural equation models was good to excellent. The LCS model with math and science ability self-concepts showed excellent model fit, $\chi^2(234) = 1{,}283.504$, $p < .001$, comparative fit index (CFI) = .967, root-mean-square error of approximation (RMSEA) = .022, standardized root-mean-square residual (SRMR) = .041. Items in the ability self-concept model evidenced significant loadings for the latent variables of math ability self-concept, $\beta = .69–.86$, $p < .001$; and science ability self-concept, $\beta = .72–.89$, $p < .001$. The math and science intrinsic value model fit the data well, $\chi^2(138) = 1{,}395.171$, $p < .001$, CFI = .895, RMSEA = .031, SRMR = .063. Factor loadings were statistically significant for math intrinsic value, $\beta = .66–.77$, $p < .001$, and science intrinsic value, $\beta = .68–.81$, $p < .001$. The LCS model with math and science utility values was also a good fit to the data, $\chi^2(138) = 1{,}392.672$, $p < .001$, CFI = .909, RMSEA = .031, SRMR = .063. Factor loadings were statistically significant for math utility value, $\beta = .56–.83$, $p < .001$; and science utility value, $\beta = .66–.87$, $p < .001$.

Changes in Adolescents' Math and Science Motivational Beliefs

We expected that adolescents' math and science ability self-concepts and utility values might decline from ninth to 11th grade and their math and science intrinsic values could remain stable.

Adolescents' Ability Self-Concepts

The mean changes of adolescents' math and science ability self-concepts were both significant and negative, $\Delta\mu = -.215$, $p < .001$ for math and $\Delta\mu = -.063$, $p = .001$ for science, indicating adolescents' math and science ability self-concepts, on average, declined from ninth to 11th grade. There were significant interindividual differences (or variance) in the changes of adolescents' math and science ability self-concepts (math: $s^2 = .35$, $p < .001$; science: $s^2 = .42$, $p < .001$). Within each domain, adolescents' ninth-grade ability self-concepts negatively predicted subsequent changes in their ability self-concepts (math: $\beta = -.59$, $p < .001$; science: $\beta = -.54$, $p < .001$). In contrast, adolescents' ninth-grade ability self-concepts positively predicted subsequent changes in the other domain; for example, adolescents' ninth-grade math ability self-concepts positively predicted the changes in their science ability self-concepts from ninth to 11th grade (math predicting science: $\beta = .09$, $p < .001$; science predicting math: $\beta = .10$, $p < .001$). The standardized focal path coefficients are shown in Figure 2. These findings suggest that adolescents with higher math ninth-grade ability self-concepts were more likely to show larger declines in their math ability self-concepts over time but smaller declines in the science ability self-concepts over time. Parallel findings emerged concerning adolescents' ninth-grade science ability self-concepts. Finally, the changes in adolescents' math and science ability self-concepts were significantly and positively related ($r = .22$, $p < .001$).

Adolescents' Intrinsic Values

Adolescents' math intrinsic values demonstrated significant declines from ninth to 11th grade, $\Delta\mu = -.291$, $p < .001$, but their science intrinsic values did not significantly change over time, $\Delta\mu = -.034$, $p = .095$. There was significant variance or interindividual differences in the changes in adolescents' math and science intrinsic values (math: $s^2 = .29$, $p < .001$; science: $s^2 = .38$, $p < .001$). Similar to adolescents' ability self-concepts, adolescents' ninth-grade math and science intrinsic values were negatively related to subsequent changes within that same domain (math: $\beta = -.66$, $p < .001$; science: $\beta = -.60$, $p < .001$), but positively related to changes in the other domain (math predicting science: $\beta = .09$, $p < .001$; science predicting math: $\beta = .17$, $p < .001$). Finally, the changes in adolescents' math and science intrinsic values were significantly and positively related ($r = .19$, $p < .001$). The standardized focal path coefficients are shown in Figure 3.

Adolescents' Utility Values

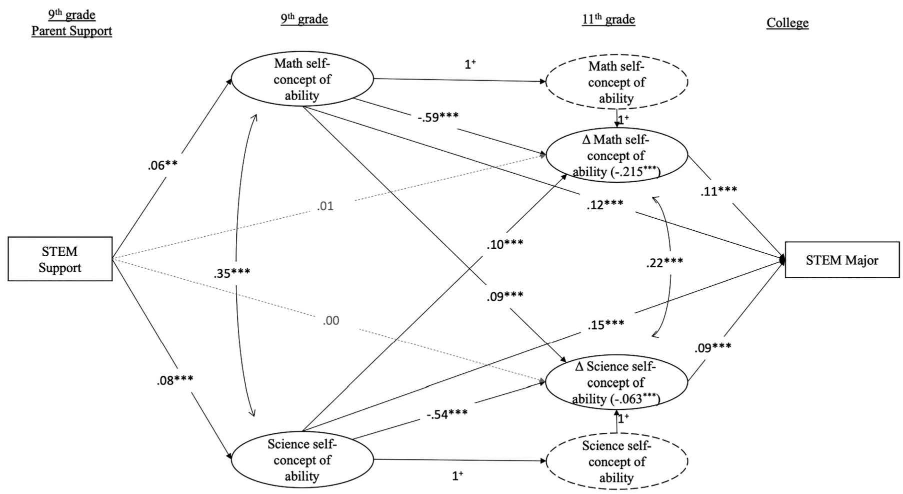
Unlike adolescents' ability self-concepts and intrinsic values which typically declined from ninth to 11th grade (with the exception of science intrinsic values), adolescents' utility values significantly increased in both domains, $\Delta\mu = .291$, $p < .001$ for math and $\Delta\mu = .232$, $p < .001$ for science, and evidence significant interindividual differences (math: $s^2 = .19$, $p < .001$; science: $s^2 = .22$, $p < .001$). Similar to the two other motivational beliefs, adolescents' ninth-grade science utility values were negatively related to subsequent changes in science ($\beta = -.51$, $p < .001$) but positively related to subsequent changes in math ($\beta = .11$, $p < .001$). For math, utility values were negatively related to a subsequent change in math ($\beta = -.59$, $p < .001$), but were not significantly related to changes in adolescents' science utility values based on our criteria of $p < .01$ ($\beta = .06$, $p = .04$). Finally, the changes in adolescents' math and science utility values were significantly and positively related ($r = .38$, $p < .001$). The standardized focal path coefficients are shown in Figure 4. All standardized path coefficients including covariates can be found in Tables S7–S9 in the online supplemental materials.

Math and Science Motivational Beliefs Predicting STEM Major Choice

We hypothesized that having higher math and science motivational beliefs in ninth grade and smaller declines or stability in adolescents' math and science motivational beliefs from ninth to 11th grade would positively predict adolescents declaring a STEM major in college. As shown in Figure 2, adolescents' math and science ability self-concepts in ninth grade and the changes in adolescents' math and science ability self-concepts from ninth to 11th grade all positively predicted their STEM major choice in college ($\beta = .12$ and $\beta = .15$ for math and science ability self-concept in ninth grade, respectively, and $\beta = .11$ and $\beta = .09$ for change, $p < .001$). This means that students who had higher math and science ability self-concepts at the beginning of high school and students who had a smaller decline in math and science ability self-concepts from ninth to 11th grade were more likely to pursue a STEM college degree. Similarly, as shown in Figure 3, adolescents' math and science intrinsic values in ninth grade ($\beta = .12$ and $\beta = .14$, $p < .001$) and the changes in adolescents' math and science intrinsic values from ninth to 11th grade ($\beta = .10$ and $\beta = .13$, $p < .001$) all significantly and positively predicted adolescents' STEM major choices in college. For utility value (Figure 4),

Figure 2

Standardized Coefficients of the Predictive Paths in the Multivariate Latent Change Score Model Between Math and Science Self-Concept of Ability With Predictors and Outcomes



Note. Dotted gray lines were nonsignificant paths. Model controlled for gender, parents' highest education, family income, adolescents' race/ethnicity, adolescents' ninth-grade math achievement, and parents' academic support. Model fit: $\chi^2(234) = 1{,}283.504$, $p < .001$, CFI = .967, RMSEA = .022, SRMR = .041. +Paths were fixed to 1. STEM = science, technology, engineering, and mathematics; CFI = comparative fit index; RMSEA = root-mean-square error of approximation; SRMR = standardized root-mean-square residual. Source: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
** $p < .01$. *** $p < .001$.

adolescents' science utility values at ninth grade and the changes over time significantly and positively predicted adolescents' STEM major choices ($\beta = .20$ and $\beta = .19$ respectively, $p < .001$), but adolescents' math utility values did not significantly predict college major choices. In summary, both ninth grade and the changes in adolescents' math and science motivational beliefs positively predicted their STEM major choice in college, with the exception that adolescents' math utility values did not predict their STEM major choice in college.

Parent STEM Support and Adolescents' Math and Science Motivational Beliefs

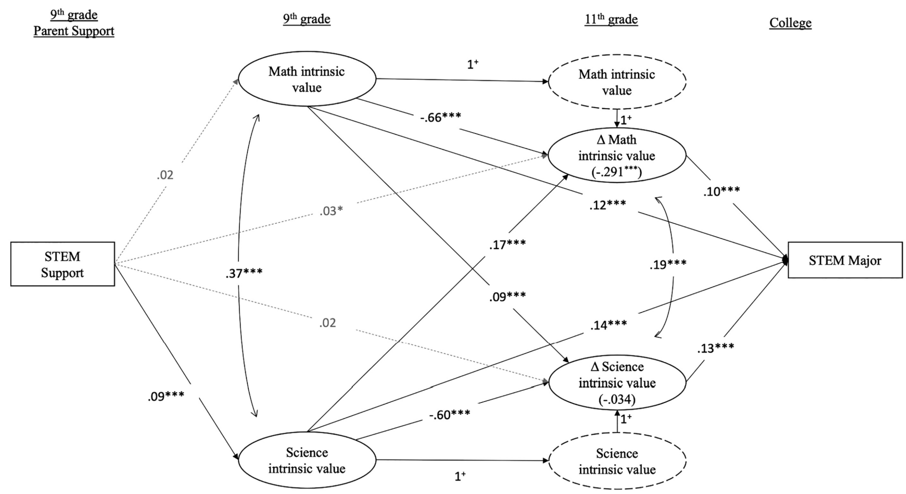
We hypothesized that adolescents whose parents evidenced higher STEM support in ninth grade would have higher math and science motivational beliefs in ninth grade and have smaller declines or stability in their math and science motivational beliefs from ninth to 11th grade. In the ability self-concept model shown in Figure 2, parents' STEM support was significantly and positively related to adolescents' math and science ability self-concepts in ninth grade ($\beta = .06$, $p < .01$, and $\beta = .08$, $p < .001$, respectively), but not the changes in adolescents' ability self-concepts. In the intrinsic value model (Figure 3), parents' STEM support in ninth grade was significantly and positively related to adolescents' science intrinsic values in ninth grade ($\beta = .09$, $p < .001$), but not math intrinsic values in ninth grade nor the changes in adolescents' intrinsic values. In the utility value model, parents' STEM support in ninth grade significantly predicted adolescents' science utility values in ninth grade ($\beta = .10$, $p < .001$) but not math utility values in ninth grade nor the changes in adolescents' utility values. In summary, parents' STEM support in ninth grade was more likely to be positively related to all three ninth-grade science motivational beliefs and their math ability self-concepts but was not significantly related to the changes in adolescents' math and science motivational beliefs from ninth to 11th grade.

The Intersection of Gender and College Generation Status

We examined the mean-level differences in the focal indicators included in this study as well as the process-level differences in their relations at the intersection of gender and college generation status. Mean-level ANOVA and χ^2 analysis results (Table 2) showed that parents of continuing-generation college students reported higher STEM support in ninth grade than parents of first-generation college students. Within first-generation and continuing-generation college students, parents of sons provided more STEM support in ninth grade than parents of daughters. Aligned with our hypotheses, male continuing-generation college students had the highest math and science ability self-concepts in ninth and 11th grade and were more likely to choose STEM majors in college, whereas female first-generation college students had the lowest math and science ability self-concepts and were less likely to choose a STEM major, and the other two groups were in the middle. The differences in adolescents' math and science intrinsic values across the four groups were mostly subtle and nonsignificant. As for utility value, male adolescents often scored higher than female adolescents within first-generation and continuing-generation college groups.

Figure 3

Standardized Coefficients of the Predictive Paths in the Multivariate Latent Change Score Model Between Math and Science Intrinsic Value With Predictors and Outcomes



Note. Dotted gray lines were nonsignificant paths. Model controlled for gender, parents' highest education, family income, adolescents' race/ethnicity, adolescents' ninth-grade math achievement, and parents' academic support. Model fit: $\chi^2(138) = 1{,}395.171$, $p < .001$, CFI = .895, RMSEA = .031, SRMR = .063. +Paths were fixed to 1. STEM = science, technology, engineering, and mathematics; CFI = comparative fit index; RMSEA = root-mean-square error of approximation; SRMR = standardized root-mean-square residual. Source: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
* $p < .05$. *** $p < .001$.

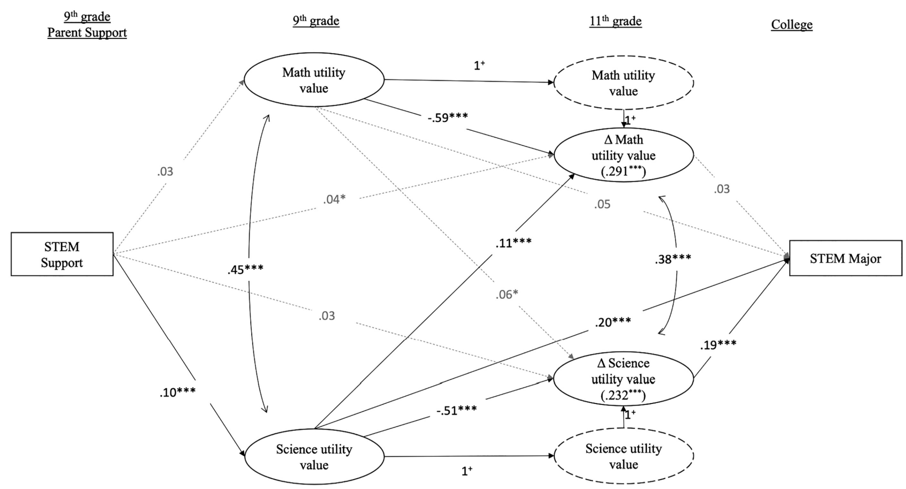
Process-level differences in the relations between focal variables were tested by examining if the paths in the LCS models were significantly different across the four groups defined by female and male first- and continuing-generation college students. When we constrained all focal paths shown in Figures 2–4 to be equal across the four groups, we found that the relations in the ability self-concept model and intrinsic value models were not significantly different across the four groups, $\Delta\chi^2(60) = 69.375$, $p = .955$, $\Delta\chi^2(60) = 69.197$, $p = .036$, respectively. Only the utility value model was significantly different across the four groups, $\Delta\chi^2(60) = 196.803$, $p < .001$. We estimated a series of follow-up tests to identify which paths in the utility value model were significantly different across the four groups. The results are presented in Table 3. The correlations between math and science utility values in ninth grade were significant and positive across the four groups but were stronger for female first-generation college students ($r = .72$) compared to their peers. The same pattern holds for the correlations between math and science utility value change scores. The paths from math and science utility values in ninth grade and the changes from ninth to 11th grade to STEM major choices were significantly different across the four groups. Adolescents' math utility values at ninth grade and the changes in their math utility values only significantly predicted later STEM major choices for male continuing-generation college students, but not for the other three groups. Science utility values in ninth were significantly related to STEM major choices for all groups, but the relation was significantly weaker for female first-generation college students compared to male first-generation college students. The changes in science utility values were significantly related to STEM major choices for most of the groups except for female first-generation college students. Overall, mean-level differences were found for parental support, adolescents' math and science ability self-concepts, and STEM college major for the four groups at the intersection of gender and college generation status, whereas process-level differences were subtle among the four groups and only emerged for utility values.

Robustness Checks

We conducted three robustness checks. For the first robustness check, we reestimated the three models in Figures 2–4 for participants who had data in the last round of data collection ($n = 10{,}740$). For the second robustness check, we reestimated the high school portion of the three models in Figures 2–4 with a more inclusive sample that included students who did not attend college ($n = 20{,}930$). The results from both robustness checks were very similar to the main analysis which proves the robustness of the results mentioned above (Figures S1–S6 in the online supplemental materials). The paths that were different on significant levels between the main and robustness checks were at the $p < .05$ level, which was not reported as significant in this study. The third robustness check examined whether there were process-level differences among focal paths in Figure 1 at the intersection of gender and race/ethnicity. Our results indicate that groups at the intersection of gender and race/ethnicity were not significantly different from each other at the process level. The results were presented in Supplementary Material A in the online supplemental materials. However, race/ethnicity as a control significantly predicted some of the motivational constructs. Specifically, we found that Asian and Black students tend to have

Figure 4

Standardized Coefficients of the Predictive Paths in the Multivariate Latent Change Score Model Between Math and Science Utility Value With Predictors and Outcomes



Note. Dotted gray lines were nonsignificant paths. Model controlled for gender, parents' highest education, family income, adolescents' race/ethnicity, adolescents' ninth-grade math achievement, and parents' academic support. Model fit: $\chi^2(138) = 1{,}392.672$, $p < .001$, CFI = .909, RMSEA = .031, SRMR = .063. +Paths were fixed to 1. STEM = science, technology, engineering, and mathematics; CFI = comparative fit index; RMSEA = root-mean-square error of approximation; SRMR = standardized root-mean-square residual. Source: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
$^{*} p < .05$. $^{***} p < .001$.

higher levels of math motivational beliefs than White students. And Asian students were more likely to choose a STEM major than White students (Tables S7–S9 in the online supplemental materials).

Discussion

Drawing on the situated expectancy-value theory (Eccles & Wigfield, 2020), dimensional comparison theory (Möller & Marsh, 2013), and the intersectionality approach (Crenshaw, 1989), this article examined the dual change processes of adolescents' math and science motivational beliefs from ninth to 11th grade and how their beliefs were related to parental support in ninth grade and their STEM college majors 7 years later. This article extended the literature in several regards, including examining the relations between math and science motivational beliefs as they develop together during high school and testing whether the changes in adolescents' motivational beliefs were related to their STEM major choices. Little research, to the best of our knowledge, has examined these constructs and key theoretical questions at the intersection of gender and college generation status. This article has theoretical and practical applications for supporting adolescents' STEM choices, especially for acutely marginalized groups, such as female first-generation college students.

Changes in Adolescents' Math and Science Motivational Beliefs

Our results build on the growing evidence that different motivational beliefs may follow unique developmental trends during high school. Aligning with prior literature (Dotterer et al., 2009; Hsieh et al., 2019; Puente et al., 2021; Wigfield et al., 2015), we found adolescents' math and science ability self-concepts and math intrinsic values decreased; however, adolescents' science intrinsic values remained stable, and their math and science utility values increased. Adolescents may become less confident in their math and science classes because of multiple factors including facing academic challenges in more advanced courses, experiencing negative feedback or failure, and comparing themselves unfavorably to peers (Wigfield et al., 2015). At the same time, adolescents placed more importance on their math and science classes toward the end of high school when they were thinking about graduation and college. These findings highlight the need to examine specific motivational beliefs (e.g., separating overall subject task values into utility values and intrinsic values) when studying the development of math and science motivational beliefs because they are theoretically distinct and may follow different developmental functions (Eccles & Wigfield, 2020). For all six math and science motivational beliefs, we found that higher math and science motivational beliefs in ninth grade were associated with decreases in same-domain motivational beliefs from ninth to 11th grade. Though this could be the result of ceiling effects and how people's scores often move toward the mean over time (Vogt, 2005), it is also possible that some highly motivated students find high school math and science too challenging or less interesting or, perhaps, find a stronger pull toward another domain (and away from STEM; e.g., Wan et al., 2021). More work is needed to examine the reason why higher motivational beliefs in ninth grade were associated with decreases over time within each domain.

We also found that adolescents' math and science motivational beliefs were interconnected, such that having high motivational

Table 2

Comparison of Focal Constructs Among the Intersection of Gender and College Generation Status

Indicator	Female first-generation college students ($n = 1{,}590$) M (SD)	Male first-generation college students ($n = 1{,}220$) M (SD)	Female continuing-generation college students ($n = 3{,}580$) M (SD)	Male continuing-generation college students ($n = 3{,}450$) M (SD)	Statistical significance[1] (effect sizes)	Significant comparisons
Ninth-grade parent indicators						
Parent STEM support	2.78 (1.50)[a]	2.97 (1.51)[b]	3.13 (1.40)[c]	3.44 (1.40)[d]	87.62*** (0.03)	F-FG < M-FG < F-CG < M-CG
Ninth-grade motivational beliefs						
Math self-concept of ability	2.90 (0.63)[a]	3.06 (0.61)[c]	2.98 (0.63)[b]	3.13 (0.61)[d]	57.20*** (0.02)	F-FG < F-CG < M-FG < M-CG
Math utility value	3.19 (0.58)[bc]	3.24 (0.59)[c]	3.08 (0.61)[a]	3.17 (0.61)[b]	22.07*** (0.01)	F-CG < M-CG < M-FG
Math intrinsic value	2.95 (0.66)[a]	2.90 (0.68)[a]	2.92 (0.66)[a]	2.92 (0.67)[a]	1.17 (0.00)	
Science self-concept of ability	2.78 (0.60)[a]	2.91 (0.61)[b]	2.86 (0.61)[b]	3.06 (0.60)[c]	80.96*** (0.03)	F-FG < M-FG, F-CG < M-CG
Science utility value	2.96 (0.60)[a]	2.94 (0.61)[a]	2.95 (0.59)[a]	2.96 (0.61)[a]	0.59 (0.00)	
Science intrinsic value	2.91 (0.67)[a]	2.91 (0.70)[a]	2.90 (0.69)[a]	2.96 (0.70)[a]	4.33** (0.00)	F-CG < M-CG
11th-grade motivational beliefs						
Math self-concept of ability	2.71 (0.71)[a]	2.89 (0.69)[c]	2.78 (0.71)[b]	2.98 (0.66)[d]	69.86*** (0.02)	F-FG < F-CG < M-FG < M-CG
Math utility value	3.29 (0.57)[a]	3.34 (0.58)[b]	3.27 (0.58)[a]	3.35 (0.58)[b]	12.53*** (0.00)	F-FG, F-CG < M-FG, M-CG
Math intrinsic value	2.68 (0.75)[a]	2.71 (0.76)[a]	2.69 (0.73)[a]	2.74 (0.72)[a]	3.74 (0.00)	
Science self-concept of ability	2.78 (0.69)[a]	2.89 (0.69)[b]	2.80 (0.74)[a]	3.01 (0.69)[c]	62.46*** (0.02)	F-FG, F-CG < M-FG, < M-CG
Science utility value	3.10 (0.61)[ab]	3.06 (0.63)[a]	3.11 (0.62)[b]	3.14 (0.64)[b]	4.84*** (0.00)	M-FG < M-CG
Science intrinsic value	2.91 (0.73)[a]	2.87 (0.74)[a]	2.88 (0.78)[a]	2.95 (0.76)[b]	4.65** (0.00)	M-FG, F-CG < M-CG
STEM outcomes						
STEM college major	0.11 (0.32)[a]	0.27 (0.44)[c]	0.18 (0.39)[b]	0.34 (0.48)[d]	[+]386.89*** (.02)	F-FG < F-CG < M-FG < M-CG

Note. Within rows, means sharing a letter in superscripts are not significantly different at $p < .01$. Source: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09). F-FG = female first-generation college students; M-FG = male first-generation college students; F-CG = female continuing-generation college students; M-CG = male continuing-generation college students; STEM = science, technology, engineering, and mathematics; ANOVA = analysis of variance.
[1]ANOVA F test or chi-square results are presented.
[+] Chi-square test results.
** $p < .01$. *** $p < .001$.

beliefs in one domain helped slow decreases or supported increases in the other domain (Eccles, 2009; Möller & Marsh, 2013). This result supports a core tenet of dimensional comparison theory that math and science are complementary domains that have positive effects on each other (Möller & Marsh, 2013). Though scholars have tested the tenets of dimensional comparison theory in terms of the negative associations between math and English (Marsh et al., 2015), these findings provide some of the first evidence concerning the positive relations among complementary domains. Some scholars have argued that math is the gateway domain to future math and science performance and choices (Shapka et al., 2006; Watt et al., 2017). Our results suggest that direction is not limited to math supporting science, but that there are reciprocal relations between math and science over time, where science motivational beliefs also support the development of math motivational beliefs during high school.

Another major contribution of this article is that the changes in adolescents' math and science motivational beliefs from ninth to 11th grade increased the odds they selected STEM as a college major even after accounting for adolescents' motivational beliefs at the beginning of high school and a host of control variables including family indicators and adolescents' math achievement. Specifically, adolescents who had smaller declines in their math and science ability self-concepts and intrinsic values or larger increases in their science utility values were more likely to choose a STEM major compared to their peers. These findings underscore the importance of examining the developmental changes in adolescents' motivational beliefs and that interventions that provide support throughout high school may be more effective than interventions offered at just one time. Though both math and science ability self-concepts and intrinsic values predicted STEM college major, only science utility values predicted their majors; math utility values were not significantly associated. This pattern aligns with prior literature that used variable-centered and person-centered approaches and found that science utility values directly predicted STEM major choices, whereas math utility values predicted STEM major choices through high school grade point average and course selection (Jiang et al., 2020; Snodgrass Rangel et al., 2020). As prior literature suggested that math is the gatekeeper of students' achievement and choices in STEM, our results suggested that science is also necessary for keeping adolescents in the STEM pipeline (Shapka et al., 2006). Our study along with prior literature has provided evidence that math and science motivational beliefs function differently in predicting STEM outcomes (Jiang et al., 2020; Snodgrass Rangel et al., 2020). Our findings have direct implications for policy, practice, and interventions that seek to increase the long-term pursuit of careers in STEM to focus on boosting the development of adolescents' math and science motivational beliefs during high school (Harackiewicz et al., 2012).

Parent STEM Support and Adolescents' Math and Science Motivational Beliefs

This article examined the extent to which parents' STEM support at the beginning of high school related to adolescents' concurrent

Table 3

Significant UV Paths Difference Across the Intersection of Gender and College Generation Status

SEM path that varied by group	Female first-generation college students ($n = 1,590$) *M* (*SD*)	Male first-generation college students ($n = 1,220$) *M* (*SD*)	Female continuing-generation college students ($n = 3,850$) *M* (*SD*)	Male continuing-generation college students ($n = 3,450$) *M* (*SD*)	Statistical significance ($\Delta\chi^2$)	Significant comparisons
Covariances						
Ninth science UV ↔ ninth math UV	0.72 (0.05)^{***b}	0.57 (0.08)^{***a}	0.36 (0.05)^{***a}	0.46 (0.04)^{***a}	75.030***	M-FG, F-CG, M-CG < F-FG
Changes in science ↔ changes in math UV	0.52 (0.06)^{***b}	0.15 (0.09)^{**a}	0.36 (0.04)^{***a}	0.41 (0.04)^{***ab}	21.827***	F-CG, M-CG < F-FG
Paths from utility values to STEM major choice						
Ninth math UV → STEM major	−0.001 (0.038)^{a}	−0.06 (0.078)^{a}	0.02 (0.033)^{ab}	0.15 (0.049)^{**b}	12.204**	F-FG, M-FG < M-CG
Changes in math UV → STEM major	0.04 (0.032)^{ab}	−0.03 (0.072)^{a}	−0.03 (0.030)^{a}	0.12 (0.037)^{**b}	12.468**	M-FG, F-CG < M-CG
Ninth science UV → STEM major	0.10 (0.035)^{**a}	0.32 (0.111)^{**b}	0.20 (0.033)^{***ab}	0.15 (0.050)^{**ab}	11.519**	F-FG < M-FG
Changes in science UV → STEM major	0.00 (0.031)^{a}	0.16 (0.068)^{b}	0.14 (0.025)^{***b}	0.20 (0.034)^{***b}	16.262**	F-FG < M-FG, F-CG, M-CG

Note. Within rows, means sharing a letter in superscripts are not significantly different at $p < .01$. Source: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09). UV = utility value; SEM = structural equation modeling; F-FG = female first-generation college students; M-FG = male first-generation college students; F-CG = female continuing-generation college students; M-CG = male continuing-generation college students; STEM = science, technology, engineering, and mathematics.
** $p < .01$. *** $p < .001$.

math and science motivational beliefs and the changes in those beliefs. We found that parents' STEM support as adolescents transitioned to high school, including doing science projects together, typically was positively related to adolescents' science motivational beliefs in ninth grade, which in turn positively predicted their STEM college majors (Jiang et al., 2020). Our findings align with prior correlational and experimental studies that parents' STEM support could reinforce adolescents' confidence, trigger their interest, and help them learn the value of studying science (e.g., Harackiewicz et al., 2012; Simpkins et al., 2020; Simpkins, Price, et al., 2015). However, we did not find an association between ninth-grade parental STEM support and the changes in adolescents' math and science motivational beliefs from ninth to 11th grade. Parental support at one time point might be insufficient to prepare adolescents for their development throughout high school. Adolescents are expected to benefit when parents continually adapt and provide support based on adolescents' changing experiences with new courses and teachers, the challenges they face in STEM, and their changing interests and goals (Starr et al., 2022). Few studies have considered how parents adapt their STEM support to help adolescents overcome challenges and foster their evolving interests. Future studies could examine how parents' continuing support and adaptive responses to adolescents' experiences relate to the changes in adolescents' math and science motivations.

The Intersection of Gender and College Generation Status

Our findings affirmed the value of the intersectionality approach (Else-Quest & Hyde, 2016) and confirmed that female first-generation college students who were often neglected in STEM literature may experience double oppression from gender stereotypes in STEM and lack of family science capital in STEM (Archer et al., 2015). Because men have more power in STEM (Stewart-Williams & Halsey, 2021) and first-generation college students face inequality in cultural capital regarding college education and science capital in STEM (Archer et al., 2015), female first-generation college students were experiencing multiple marginalization in STEM with the lowest level of parental support, math and science ability self-concepts, and less likely to choose a STEM major. Future interventions targeting this particular group might address both obstacles in STEM in terms of gender and family resources (that vary by college generation status), as targeting only one of these areas might not adequately support this group in STEM (Dika & D'Amico, 2016; Harackiewicz et al., 2016; Wilson & Kittleson, 2013). Though we focus on additive processes of oppression, additional unique processes (e.g., multiplicative) that are contributing to their marginalization should be examined (Cole, 2009).

Our results also highlight the importance of examining the rich variability within each gender group (Hyde, 2014). Male first-generation college students were lower on nearly all of the indicators than male continuing-generation college students. The same pattern emerged for several indicators among female students. Our results demonstrate the importance of examining the within gender variability with the context of other social factors since not all female students or male students are the same in terms of the privilege and oppression they experience in STEM. Also, aligned with the intersectionality approach (Cole, 2009; Else-Quest & Hyde, 2016), although female continuing-generation college students and male first-generation college students face different obstacles in STEM, we found they often had similar math and science motivational beliefs. However, their STEM major choices were significantly different favoring male first-generation college students than female continuing-generation college students. Gender-related processes (e.g., gender stereotypes) may play a bigger role in STEM major choice than motivational beliefs. Future intersectionality studies, particularly qualitative studies, are needed to understand power and inequalities in adolescents' STEM motivation and choices at the intersection of gender and college generation status.

In contrast to the more consistent mean-level differences across the four groups, we found only subtle differences in the relations between the focal variables. The associations for two out of three motivational beliefs were not different across four groups, which means the predictors and correlates of adolescents' math and science ability self-concepts and intrinsic values were largely similar for groups at the intersection of gender and first-generation college status. Among the few exceptions, we found that math and science motivational utility values consistently and positively predicted the STEM college majors for male continuing-generation college students compared to other groups. Utility values might be stronger predictors of STEM college majors for male continuing-generation college students because they experience the least amount of discrimination and structural barriers, have more freedom to choose their majors, and base that decision more on what they think will be important for their future (Pascarella et al., 2004; Wigfield et al., 2015). Other groups might weigh more heavily on other factors in their decision-making processes such as costs (e.g., tuition, lack of fit with the stereotype), family priorities, and identity (Bui, 2002).

The descriptive analysis at the intersection of gender and college generation status results aligned with prior literature demonstrated that first-generation college students are more likely to be Latinx and Black students and from low-income families (Lohfink & Paulsen, 2005; Pascarella et al., 2004). Because there were racial/ethnic disparities not accounted for by college gen status or other indicators of social class, we controlled for race/ethnicity throughout our analyses. Our results aligned with prior literature that Asian students tended to have higher math and science motivational beliefs and were more likely to choose a STEM major than White students (Hsieh et al., 2021). However, future research could consider the intersection of race/ethnicity and college generation status to gain a deeper understanding of the nuanced experiences at the intersection of multiple identities in STEM education (Harackiewicz et al., 2016).

Limitations and Future Directions

This article extended the literature by examining the individual and contextual factors that are associated with adolescents' math and science motivation and STEM college majors. However, limitations need to be taken into account when interpreting the results. Although quantitative data have the advantage of testing longitudinal relations and subgroup differences, it provides less insight into the details of the developmental processes. For example, why adolescents' math and science ability self-concepts decreased, whereas their utility values increased warrants further unpacking. Qualitative studies are needed to understand the nuances of parental support; for example, asking parents to describe their conversations while helping children with their science projects would provide a better picture of why these supports help adolescents in STEM (Pomerantz et al., 2007).

We examined the relations between parents' STEM support in ninth grade and the changes in adolescents' math and science motivation from ninth to 11th grade. These models were designed based on theories that parental support predicts adolescents' current and subsequent motivational beliefs (Hill & Tyson, 2009; Wigfield et al., 2015). Such parent effects, however, do not negate the existence of child effects where, in this case, adolescents' motivational beliefs influence parents' STEM support. Theories and existing empirical work suggest effects in both directions are possible, but the evidence in elementary school has been more consistent concerning parent effects than child effects (Simpkins, Fredricks, et al., 2015; Wigfield et al., 2015). Child effects may be more prominent during adolescence and need to be systematically tested. In addition, we used a measure of parenting at one time point; however, parents do not provide support only at one time point. They support their children throughout their life. The continuity of parental support should be examined to understand the bidirectional effects and the extent to which parents' continued support predicted more positive changes in adolescents' motivational beliefs. Lastly, parents reported their support. Though using parent report of their support reduces shared method variance compared to when adolescents report on both parent support and their motivational beliefs, situated expectancy-value theory argues that adolescents are active agents and their interpretation of their environment is what influences their motivational beliefs (Wigfield et al., 2015). Adolescents may have different interpretations of parents' support (e.g., being overbearing and limiting autonomy) when parents have good intentions (Pomerantz et al., 2007). Future studies should collect data from both parents and adolescents concerning parent support to take into account these issues.

We examined the disparities in adolescents' math and science motivational beliefs and STEM choices at the intersection of gender and college generation status. Adolescents were categorized into these groups based on their selection of demographic categories and not based on the extent to which they identify with these groups. Future studies could gather identity data to learn more about adolescents' social identities.

Another limitation of this article is that the motivational belief measures ask about participants' beliefs about their math and science classes and not about math or science in general. Thus, the changes in beliefs may be more tied to changes in math and science high school courses than their feelings about math and science more generally. Although these beliefs might be highly correlated, they could be different for some, due to unique experiences in their math and science classes (e.g., a particularly hard class, a teacher they struggle with). Future studies are needed to examine adolescents' motivational beliefs on math and science generally to confirm the results of this article.

Conclusion

This article provided important insights for practitioners and policymakers to pay attention to adolescents' motivational beliefs at the beginning of high school as well as how their motivational beliefs develop during high school. We found that not all math and science motivational beliefs decreased during high school, specifically adolescents' ability self-concepts decreased, their utility values increased, and their intrinsic values were stable in science and decreased in math. Our results suggest math and science are complementary domains that support the development of each other, which aligns with tenets of dimensional comparison theory (Möller & Marsh, 2013). We found that parental support at the beginning of high school was more strongly related to adolescents' ninth-grade science motivational beliefs rather than their math motivational beliefs or changes in their beliefs. Another significant contribution of this article is that we found mean-level differences at the intersection of gender and college generation status that can be traced back to the beginning of high school, including parental support, math and science motivational beliefs, and are carried forward to whether they declare a STEM major 7 years later in college. However, the process-level differences in the relations between focal variables were rare, suggesting that interventions on parenting or motivation might have similar effects for all groups. Also, this article draws attention to a group that might experience acute marginalization in STEM, namely female first-generation college students. Extra support for adolescents who belong to this group could help narrow gaps in math and science.

References

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. https://doi.org/10.1002/sce.21092

Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015). "Science capital": A conceptual, methodological, and empirical argument for extending Bourdieusian notions of capital beyond the arts. *Journal of Research in Science Teaching*, *52*(7), 922–948. https://doi.org/10.1002/tea.21227

Bettencourt, G. M., Manly, C. A., Kimball, E., & Wells, R. S. (2020). STEM degree completion and first-generation college students: A cumulative disadvantage approach to the outcomes gap. *The Review of Higher Education*, *43*(3), 753–779. https://doi.org/10.1353/rhe.2020.0006

Bourdieu, P. (1986). The forms of capital. In J. G. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241–258). Greenwood Press.

Bui, K. V. T. (2002). First-generation college students at a four-year university: Background characteristics, reasons for pursuing higher education, and first-year experiences. *College Student Journal*, *36*(1), 3–12.

Cataldi, E. F., Bennett, C. T., Chen, X., & Simone, S. A. (2018). *First-generation students: College access, persistence, and postbachelor's outcomes*. National Center for Education Statistics, U.S. Department of Education.

Chen, X., & Carroll, C. (2005). *First-generation student in postsecondary education: A look at their college transcripts (NCES No. 2005-171)*. National Center for Education Statistics, U.S. Department of Education. http://nces.ed.gov/pubs2005/2005171.pdf

Cole, E. R. (2009). Intersectionality and research in psychology. *American Psychologist*, *64*(3), 170–180. https://doi.org/10.1037/a0014564

Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A Black feminist critique of antidiscrimination doctrine, feminist theory, and antiracist politics. *University of Chicago Legal Forum*, *140*, 139–167.

Degol, J. L., Wang, M. T., Ye, F., & Zhang, C. (2017). Who makes the cut? Parental involvement and math trajectories predicting college enrollment. *Journal of Applied Developmental Psychology*, *50*, 60–70. https://doi.org/10.1016/j.appdev.2017.03.007

Dika, S. L., & D'Amico, M. M. (2016). Early experiences and integration in the persistence of first-generation college students in STEM and non-STEM majors. *Journal of Research in Science Teaching*, *53*(3), 368–383. https://doi.org/10.1002/tea.v53.3

Dotterer, A. M., McHale, S. M., & Crouter, A. C. (2009). The development and correlates of academic interests from childhood through adolescence. *Journal of Educational Psychology*, *101*(2), 509–519. https://doi.org/10.1037/a0013987

Douglas, D., & Attewell, P. (2017). School mathematics as gatekeeper. *The Sociological Quarterly*, *58*(4), 648–669. https://doi.org/10.1080/00380253.2017.1354733

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. https://doi.org/10.1080/00461520902832368

Eccles, J. S., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology*, *61*, Article 101859. https://doi.org/10.1016/j.cedpsych.2020.101859

Else-Quest, N. M., & Hyde, J. S. (2016). Intersectionality in quantitative psychological research: II. Methods and techniques. *Psychology of Women Quarterly*, *40*(3), 319–336. https://doi.org/10.1177/0361684316647953

Else-Quest, N. M., Mineo, C. C., & Higgins, A. (2013). Math and science attitudes and achievement at the intersection of gender and ethnicity. *Psychology of Women Quarterly*, *37*(3), 293–309. https://doi.org/10.1177/0361684313480694

Enders, C. K. (2010). *Applied missing data analysis*. Guilford Press.

Engle, J., & Tinto, V. (2008). *Moving beyond access: College success for low-income, first-generation students*. Pell Institute for the Study of Opportunity in Higher Education.

Fong, C. J., Kremer, K. P., Cox, C. H. T., & Lawson, C. A. (2021). Expectancy-value profiles in math and science: A person-centered approach to cross-domain motivation with academic and STEM-related outcomes. *Contemporary Educational Psychology*, *65*, Article 101962. https://doi.org/10.1016/j.cedpsych.2021.101962

Gibbons, M. M., & Borders, L. D. (2010). Prospective first-generation college students: A social-cognitive perspective. *The Career Development Quarterly*, *58*(3), 194–208. https://doi.org/10.1002/j.2161-0045.2010.tb00186.x

Gottfried, A. E., Marcoulides, G. A., Gottfried, A. W., & Oliver, P. H. (2009). A latent curve model of parental motivational practices and developmental decline in math and science academic intrinsic motivation. *Journal of Educational Psychology*, *101*(3), 729–739. https://doi.org/10.1037/a0015084

Gottfried, A. E., Marcoulides, G. A., Gottfried, A. W., & Oliver, P. H. (2013). Longitudinal pathways from math intrinsic motivation and achievement to math course accomplishments and educational attainment. *Journal of Research on Educational Effectiveness*, *6*(1), 68–92. https://doi.org/10.1080/19345747.2012.698376

Gottfried, A. E., Preston, K. S. J., Gottfried, A. W., Oliver, P. H., Delany, D. E., & Ibrahim, S. M. (2016). Pathways from parental stimulation of children's curiosity to high school science course accomplishments and science career interest and skill. *International Journal of Science Education*, *38*(12), 1972–1995. https://doi.org/10.1080/09500693.2016.1220690

Grimm, K. J., An, Y., McArdle, J. J., Zonderman, A. B., & Resnick, S. M. (2012). Recent changes leading to subsequent changes: Extensions of multivariate latent difference score models. *Structural Equation Modeling*, *19*(2), 268–292. https://doi.org/10.1080/10705511.2012.659627

Grimm, K. J., Ram, N., & Estabrook, R. (2016). *Growth modeling: Structural equation and multilevel modeling approaches*. Guilford Press.

Guo, J., Parker, P. D., Marsh, H. W., & Morin, A. J. S. (2015). Achievement, motivation, and educational choices: A longitudinal study of expectancy and value using a multiplicative perspective. *Developmental Psychology*, *51*(8), 1163–1176. https://doi.org/10.1037/a0039440

Guo, J., Wang, M. T., Ketonen, E. E., Eccles, J. S., & Salmela-Aro, K. (2018). Joint trajectories of task value in multiple subject domains:

From both variable- and pattern-centered perspectives. *Contemporary Educational Psychology*, *55*, 139–154. https://doi.org/10.1016/j.cedpsych.2018.10.004

Häfner, I., Flunger, B., Dicke, A. L., Gaspard, H., Brisson, B. M., Nagengast, B., & Trautwein, U. (2018). The role of family characteristics for students' academic outcomes: A person-centered approach. *Child Development*, *89*(4), 1405–1422. https://doi.org/10.1111/cdev.12809

Harackiewicz, J. M., Canning, E. A., Tibbetts, Y., Priniski, S. J., & Hyde, J. S. (2016). Closing achievement gaps with a utility-value intervention: Disentangling race and social class. *Journal of Personality and Social Psychology*, *111*(5), 745–765. https://doi.org/10.1037/pspp0000075

Harackiewicz, J. M., Rozek, C. S., Hulleman, C. S., & Hyde, J. S. (2012). Helping parents to motivate adolescents in mathematics and science: An experimental test of a utility-value intervention. *Psychological Science*, *23*(8), 899–906. https://doi.org/10.1177/0956797611435530

Hill, N. E., & Tyson, D. F. (2009). Parental involvement in middle school: A meta-analytic assessment of the strategies that promote achievement. *Developmental Psychology*, *45*(3), 740–763. https://doi.org/10.1037/a0015362

Hsieh, T., Liu, Y., & Simpkins, S. D. (2019). Changes in United States Latino/a high school students' science motivational beliefs: Within group differences across science subjects, gender, immigrant status, and perceived support. *Frontiers in Psychology*, *10*, Article 380. https://doi.org/10.3389/fpsyg.2019.00380

Hsieh, T., Simpkins, S. D., & Eccles, J. S. (2021). Gender by racial/ethnic intersectionality in the patterns of Adolescents' math motivation and their math achievement and engagement. *Contemporary Educational Psychology*, *66*, Article 101974. https://doi.org/10.1016/j.cedpsych.2021.101974

Hyde, J. S. (2014). Gender similarities and differences. *Annual Review of Psychology*, *65*(1), 373–398. https://doi.org/10.1146/annurev-psych-010213-115057

Ingels, S. J., Pratt, D. J., Herget, D. R., Burns, L. J., Dever, J. A., Ottem, R., Rogers, J. E., Jin, Y., & Leinwand, S. (2011). *High School Longitudinal Study of 2009 (HSLS:09). Base-year data file documentation (NCES 2011-328).* National Center for Education Statistics, U.S. Department of Education. https://nces.ed.gov/surveys/hsls09/hsls09_data.asp

Jacobs, J. E., Lanza, S., Osgood, D. W., Eccles, J. S., & Wigfield, A. (2002). Changes in children's self-competence and values: Gender and domain differences across grades one through twelve. *Child Development*, *73*(2), 509–527. https://doi.org/10.1111/1467-8624.00421

Jiang, S., Simpkins, S. D., & Eccles, J. S. (2020). Individuals' math and science motivation and their subsequent STEM choices and achievement in high school and college: A longitudinal study of gender and college generation status differences. *Developmental Psychology*, *56*(11), 2137–2151. https://doi.org/10.1037/dev0001110

Kazak, A. E. (2018). Editorial: Journal article reporting standards. *American Psychologist*, *73*(1), 1–2. https://doi.org/10.1037/amp0000263

Lohfink, M. M., & Paulsen, M. B. (2005). Comparing the determinants of persistence for first-generation and continuing-generation students. *Journal of College Student Development*, *46*(4), 409–428. https://doi.org/10.1353/csd.2005.0040

Marsh, H. W., Lüdtke, O., Nagengast, B., Trautwein, U., Abduljabbar, A. S., Abdelfattah, F., & Jansen, M. (2015). Dimensional comparison theory: Paradoxical relations between self-beliefs and achievements in multiple domains. *Learning and Instruction*, *35*, 16–32. https://doi.org/10.1016/j.learninstruc.2014.08.005

Master, A., Meltzoff, A. N., & Cheryan, S. (2021). Gender stereotypes about interests start early and cause gender disparities in computer science and engineering. *Proceedings of the National Academy of Sciences*, *118*(48), Article e2100030118. https://doi.org/10.1073/pnas.2100030118

McArdle, J. J. (2009). Latent variable modeling of differences and changes with longitudinal data. *Annual Review of Psychology*, *60*, 577–605. https://doi.org/10.1146/annurev.psych.60.110707.163612

McArdle, J. J., & Grimm, K. J. (2010). Five steps in latent curve and latent change score modeling with longitudinal data. In K. van Montfort, J. Oud, & A. Satorra (Eds.), *Longitudinal research with latent variables* (pp. 245–274). Springer-Verlag.

Möller, J., & Marsh, H. W. (2013). Dimensional comparison theory. *Psychological Review*, *120*(3), 544–560. https://doi.org/10.1037/a0032459

Moote, J., Archer, L., DeWitt, J., & MacLeod, E. (2021). Who has high science capital? An exploration of emerging patterns of science capital among students aged 17/18 in England. *Research Papers in Education*, *36*(4), 402–422. https://doi.org/10.1080/02671522.2019.1678062

Musu-Gillette, L. E., Wigfield, A., Harring, J. R., & Eccles, J. S. (2015). Trajectories of change in students' self-concepts of ability and values in math and college major choice. *Educational Research and Evaluation*, *21*(4), 343–370. https://doi.org/10.1080/13803611.2015.1057161

Muthén, L. K., & Muthén, B. O. (2012). *Mplus user's guide* (7th ed.).

Nagy, G., Watt, H. M. G. G., Eccles, J. S., Trautwein, U., Lüdtke, O., & Baumert, J. (2010). The development of students' mathematics self-concept in relation to gender: Different countries, different trajectories? *Journal of Research on Adolescence*, *20*(2), 482–506. https://doi.org/10.1111/j.1532-7795.2010.00644.x

National Science Board. (2020). *Science and engineering indicators 2020: The state of U.S. Science and Engineering* (NSB-2020-1). National Science Foundation. https://ncses.nsf.gov/pubs/nsb20201/.

Pascarella, E. T., Pierson, C. T., Wolniak, G. C., & Terenzini, P. T. (2004). First-generation college students. *The Journal of Higher Education*, *75*(3), 249–284. https://doi.org/10.1080/00221546.2004.11772256

Petersen, J. L., & Hyde, J. S. (2017). Trajectories of self-perceived math ability, utility value and interest across middle school as predictors of high school math performance. *Educational Psychology*, *37*(4), 438–456. https://doi.org/10.1080/01443410.2015.1076765

Pomerantz, E. M., Moorman, E. A., & Litwack, S. D. (2007). The how, whom, and why of parents' involvement in children's academic lives: More is not always better. *Review of Educational Research*, *77*(3), 373–410. https://doi.org/10.3102/003465430305567

Próspero, M., & Vohra-Gupta, S. (2007). First generation college students: Motivation, integration, and academic achievement. *Community College Journal of Research and Practice*, *31*(12), 963–975. https://doi.org/10.1080/10668920600902051

Puente, K., Starr, C. R., Eccles, J. S., & Simpkins, S. D. (2021). Developmental trajectories of science identity beliefs: Within-group differences among Black, Latinx, Asian, and White students. *Journal of Youth and Adolescence*, *50*(12), 2394–2411. https://doi.org/10.1007/s10964-021-01493-1

RTI International. (2021). *First-generation college graduates: Race/ethnicity, age, and use of career planning services*. NASPA. https://firstgen.naspa.org/files/dmfile/FactSheet-011.pdf

Rubach, C., Lee, G., Starr, C. R., Gao, Y., Safavian, N., Dicke, A. L., Eccles, J. S., & Simpkins, S. D. (2022). Is there any evidence of historical changes in gender differences in American High School Students' Math Competence-Related Beliefs from the 1980s to the 2010s? *International Journal of Gender, Science and Technology*, *14*(2), 55–126. https://genderandset.open.ac.uk/index.php/genderandset/article/view/1322

Satorra, A., & Bentler, P. M. (2001). A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika*, *66*(4), 507–514. https://doi.org/10.1007/BF02296192

Shapka, J. D., Domene, J. F., & Keating, D. P. (2006). Trajectories of career aspirations through adolescence and young adulthood: Early math achievement as a critical filter. *Educational Research and Evaluation*, *12*(4), 347–358. https://doi.org/10.1080/13803610600765752

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2005). Parents' socializing behavior and children's participation in math, science, and computer out-of-school activities. *Applied Developmental Science*, *9*(1), 14–30. https://doi.org/10.1207/s1532480xads0901_3

Simpkins, S. D., Estrella, G., Gaskin, E., & Kloberdanz, E. (2018). Latino parents' science beliefs and support of high school students' motivational beliefs: Do the relations vary across gender and familism values? *Social Psychology of Education*, *21*(5), 1203–1224. https://doi.org/10.1007/s11218-018-9459-5

Simpkins, S. D., Fredricks, J. A., & Eccles, J. S. (2012). Charting the Eccles' expectancy-value model from mothers' beliefs in childhood to youths' activities in adolescence. *Developmental Psychology*, *48*(4), 1019–1032. https://doi.org/10.1037/a0027468

Simpkins, S. D., Fredricks, J. A., Eccles, J. S., & Huston, A. C. (2015). The role of parents in the ontogeny of achievement-related motivation and behavioral choices. *Monographs of the Society for Research in Child Development*, *80*(2), i–169.

Simpkins, S. D., Liu, Y., Hsieh, T., & Estrella, G. (2020). Supporting Latino high school students' science motivational beliefs and engagement: Examining the unique and collective contributions of family, teachers, and friends. *Educational Psychology*, *40*(4), 409–429. https://doi.org/10.1080/01443410.2019.1661974

Simpkins, S. D., Price, C. D., & Garcia, K. (2015). Parental support and high school students' motivation in biology, chemistry, and physics: Understanding differences among Latino and Caucasian boys and girls. *Journal of Research in Science Teaching*, *52*(10), 1386–1407. https://doi.org/10.1002/tea.21246

Snodgrass Rangel, V., Vaval, L., & Bowers, A. (2020). Investigating underrepresented and first-generation college students' science and math motivational beliefs: A nationally representative study using latent profile analysis. *Science Education*, *104*(6), 1041–1070. https://doi.org/10.1002/sce.21593

Starr, C. R., Tulagan, N., & Simpkins, S. D. (2022). Black and Latinx adolescents' STEM motivational beliefs: A systematic review of the literature on parent stem support. *Educational Psychology Review*, *34*(4), 1877–1917. https://doi.org/10.1007/s10648-022-09700-6

Stephens, N. M., Townsend, S. S. M., Markus, H. R., & Phillips, L. T. (2012). A cultural mismatch: Independent cultural norms produce greater increases in cortisol and more negative emotions among first-generation college students. *Journal of Experimental Social Psychology*, *48*(6), 1389–1393. https://doi.org/10.1016/j.jesp.2012.07.008

Stewart-Williams, S., & Halsey, L. G. (2021). Men, women and STEM: Why the differences and what should be done? *European Journal of Personality*, *35*(1), 3–39. https://doi.org/10.1177/0890207020962326

Sy, S. R., Fong, K., Carter, R., Boehme, J., & Alpert, A. (2011). Parent support and stress among first-generation and continuing-generation female students during the transition to college. *Journal of College Student Retention: Research, Theory & Practice*, *13*(3), 383–398. https://doi.org/10.2190/CS.13.3.g

Vogt, W. P. (Ed.) (2005). *Dictionary of statistics & methodology* (Vols. 1-0). SAGE Publications. https://doi.org/10.4135/9781412983907

Wan, S., Lauermann, F., Bailey, D. H., & Eccles, J. S. (2021). When do students begin to think that one has to be either a "math person" or a "language person"? A meta-analytic review. *Psychological Bulletin*, *147*(9), 867–889. https://doi.org/10.1037/bul0000340

Wang, M. T., Degol, J., & Ye, F. (2015). Math achievement is important, but task values are critical, too: Examining the intellectual and motivational factors leading to gender disparities in STEM careers. *Frontiers in Psychology*, *6*, Article 36. https://doi.org/10.3389/fpsyg.2015.00036

Wang, M. T., & Degol, J. L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review*, *29*(1), 119–140. https://doi.org/10.1007/s10648-015-9355-x

Watt, H. M. G. (2006). The role of motivation in gendered educational and occupational trajectories related to maths. *Educational Research and Evaluation*, *12*(4), 305–322. https://doi.org/10.1080/13803610600765562

Watt, H. M. G., Hyde, J. S., Petersen, J., Morris, Z. A., Rozek, C. S., & Harackiewicz, J. M. (2017). Mathematics—A critical filter for STEM-related career choices? A longitudinal examination among Australian and U.S. adolescents. *Sex Roles*, *77*(3–4), 254–271. https://doi.org/10.1007/s11199-016-0711-1

Wigfield, A., Eccles, J. S., Fredricks, J. A., Simpkins, S., Roeser, R. W., & Schiefele, U. (2015). Development of achievement motivation and engagement. In M. E. Lamb & R. M. Lerner (Eds.), *Handbook of child psychology and developmental science: Socioemotional processes* (pp. 657–700). Wiley. https://doi.org/10.1002/9781118963418.childpsy316

Wilson, R. E., & Kittleson, J. (2013). Science as a classed and gendered endeavor: Persistence of two white female first-generation college students within an undergraduate science context. *Journal of Research in Science Teaching*, *50*(7), 802–825. https://doi.org/10.1002/tea.21087

Received March 29, 2023
Revision received November 2, 2023
Accepted November 4, 2023 ■