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The Development and the Parental Socialization Process of Adolescents' Math and Science Motivation

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The Development and the Parental Socialization Process of Adolescents' Math and Science Motivation

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Education

by

Su Jiang

Dissertation Committee:
Professor Sandra Simpkins, Chair
Chancellor's Professor Emerita Deborah Vandell
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2022

DEDICATION

To

my family

for making my dreams come true

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VITA
Su Jiang

Education

2017-2022	**University of California, Irvine** Ph.D., School of Education Specialization: Human Development in Context
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2011-2013	**New York University** M.S., Graduate School of Arts & Science Specialization: Bioinformatics
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Publications

PB4 **Jiang, S.**, Simpkins, S. D. (under review). The predictors and correlates of the changes in adolescents' math and science motivational beliefs during high school: A latent change score study. *Journal of Educational Psychology*.

PB3 Yu, M. V. B., Hsieh, T. Y., Lee, G., **Jiang, S.**, Pantano, A., & Simpkins, S. D. (2022). Promoting Latinx adolescents' math motivation through competence support: Culturally responsive practices in an afterschool program context. *Contemporary Educational Psychology*, *68*, 102028.

PB2 **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

PB1 Ma, T. L., **Jiang, S.**, Simpkins, S. D., Vandell, D., & Zarrett, N. (2020). Brief Report: Patterns of Children's Prosocial Behaviors in Middle Childhood Predicting Peer Relations During Early Adolescence. *Journal of Adolescence*, *78*, 1-8.

Working Papers

WP2 **Jiang, S.,** & Simpkins, S. D., Parent and child factors that predict parents' school-based involvement and STEM-specific support during high school.

WP1 Gülseven, Z., **Jiang, S.,** Simpkins, S. D., Vandell, D. Out-of-school time during middle childhood and adolescence: Are they related to changes in academic and social well-being? *Child Development.*

Poster Presentations

PP8 **Jiang, S.**, Simpkins, S. D. (2022, March) The predictors and outcomes of the changes in adolescents' math and science motivational beliefs during high school: A latent change score study. Poster accepted at the Society for Research on Adolescence Biennial Meeting, New Orleans, LA

PP7 **Jiang, S.**, Simpkins, S. D., Zarrett, N., & Vandell, D. (2020, March). *Examining the consistency and disparities of adolescents' self-control skills reported by teachers, mothers, and fathers.* Paper presented at the Society for Research on Adolescence Biennial Meeting, San Diego, CA. (Conference canceled.)

PP6 **Jiang, S.** & Simpkins, S. D. (2020, March). *Examining the profiles of parental support at home and school and their relations to adolescents' science motivational beliefs.* Poster accepted at the Society for Research on Adolescence Biennial Meeting, San Diego, CA. (Conference canceled.)

PP5 **Jiang, S.** & Simpkins, S. D. (2020, April). *The role of math and science motivational beliefs in supporting STEM outcomes in high school and college.* Poster presented at the American Educational Research Association Annual Meeting, San Francisco, CA. (Conference canceled.)

PP4 **Jiang, S.** & Simpkins, S. D. (2020, April). *The longitudinal relations between adolescents' math and science motivation and their relations to STEM outcomes.* Poster presented at the American Educational Research Association Annual Meeting, San Francisco, CA. (Conference canceled.)

PP3 **Jiang, S.**, Ma, T. L., Simpkins, S. D., Vandell, D., & Zarrett, N. (2019, March). Comparing Profiles of Mother Rated and Teacher Rated Prosocial Behaviors: The Role of Gender and Ethnicity. Poster presented at the Society for Research in Child Development Biennial Meeting, Baltimore, MA.

PP2 **Jiang, S.** & Simpkins, S. D. (2019, March). Pattern-Centered Analysis of Latino Adolescents' Math and Science Motivational Beliefs and the Relation to Science Engagement. Poster presented at the Society for Research in Child Development Biennial Meeting, Baltimore, MA.

PP1 Ma, T. L., **Jiang, S.**, Simpkins, S. D., Vandell, D., & Zarrett, N. (2019, March). Profiles of children's prosocial behaviors and their longitudinal associations with peer aggression, bullying, and victimization. Poster presented at the Society for Research in Child Development Biennial Meeting, Baltimore, MA.

Research Experiences

2017-now **Simpkins Research Lab**

Graduate Student Researcher

- Conducting independent research using advanced quantitative methods (e.g., growth mixture modeling, latent change score modeling, latent class/profile analysis) and publishing papers for related grant of NSF, Templeton grant, and Mott grant
- Assisting in grant proposal writing for Templeton Grant on adolescents' characteristic development
- Designing and updating Simpkins Research Lab website
- Mentoring undergraduate researchers in data recording and data coding

2016-2017 **Simpkins Research Lab**

Research Assistant

- Record, organize, and clean longitudinal data for Dr. Simpkins's NSF grant research

- Conducted literature review on motivation development of adolescents for Dr. Simpkins's NSF AISL grant proposal
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Teaching Experiences

2020 Summer	**Teaching Assistant** for The Adolescent Learner (EDUC 361) at UCI
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2018 Fall	**Teaching Assistant** for Theories of Development and Learning Applied to Education (EDUC 40) at UCI
2015-2016	**Science Teacher** of 9th grade biology at Alexander Hamilton High School, Los Angeles, CA
2014-2015	**Science Student Teacher** of 9th grade biology at Los Angeles High School of the Arts, Los Angeles, CA
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Mentoring Experiences

2018 - present **Mentor** for undergraduate research assistants at University of California Irvine
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- Mentored first-generation immigrant Chinese students on adjusting to high school and transition to American educational system

2015 Summer **Coordinator** of Summer Camp Program, Columbia University, New York, NY
- Coordinated meetings and conversations between Columbia University professors and immigrant high school students on topics of college education and career choice

Services

2021	**Reviewer** for Journal of Sex Roles
2021	**Student Representative** for 2021 UCI School of Education Admission Committee
2021	**Conference reviewer** for SRA
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2019	**Student Coordinator** for School of Education 2019 Recruitment Weekend
2019	**Student Journal Referee** for Child Development
2018	**Student Journal Referee** for Journal of Applied Developmental Psychology
2018	**Student Journal Referee** for Merrill-Palmer Quarterly
2018	**Student Journal Referee** for Journal of Youth and Adolescence
2018	**Student Journal Referee** for Child Development
2018	**Student Volunteer** for School of Education 2018 Recruitment Weekend

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2018	**Activate to Captivate** Public Speaking Certificate Program

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ABSTRACT OF THE DISSERTATION

The Development and the Parental Socialization Process of Adolescents' Math and Science Motivation
by
Su Jiang
Doctor of Philosophy in Education
University of California, Irvine, 2022
Professor Sandra Simpkins, Chair

Understanding the development of adolescents' math and science motivational beliefs is critical in supporting the sustainable development of science, technology, engineering, and mathematics (STEM) in the U.S. Drawing on Eccles' situated expectancy-value theory (Eccles & Wigfield, 2020), this dissertation examine the development of adolescents' math and science motivational beliefs and parental socialization process related to adolescents' math and science motivation during adolescence. Data were from the national representative longitudinal dataset of the High School Longitudinal Study (HSLS) of 2009 for both papers.

Paper 1 examined the change in adolescents' math and science motivational beliefs from 9th grade to 11th grade using the Latent Change Score model. In this model, I examined how math and science motivational beliefs develop during high school and how math and science motivational beliefs are interrelated while they develop together. Paper 1 found that not all types of math and science motivational beliefs declined during high school as found in prior literature. And math and science motivational beliefs supported the development of each other during high school. Paper 1 also found that not only adolescents' 9th grade math and science motivations but the development of their math and science motivations predicted their later STEM choice. This study confirmed the mean-level differences in adolescents' math and science motivation, parental support, and college major choice at the intersection of gender and college generation status; however, the process level differences were subtle among the groups.

Paper 2 examined the parent- and child-level predictors of parents' academic support. This paper examined two parent-level factors (i.e., parents' educational expectations for children and parents' STEM efficacy beliefs) and two child-level factors (i.e., children's STEM interest and math achievement) to understand what predicts parents' school-based involvement and STEM-specific support at 9th grade. Paper 2 found that parents' beliefs and children's math achievement were both positive predictors of parents' school-based involvement and STEM-specific support. Parents were more likely to provide more STEM-specific support to adolescents who were more interested in STEM. Additionally, this study found that parents of female and male continuing-generation college students would provide more parental support and have higher beliefs about adolescents compared to female and male first-generation college students.

Both papers provided insights for policymakers and practitioners to focus on the development of adolescents' math and science motivation as well as the parental socialization of STEM motivation during high school.

CHAPTER 1

Overarching Introduction to the Dissertation

Science, technology, engineering, and mathematics (STEM) fields build the foundation for the sustained growth and stability of the U.S. economy (US Congress Joint Economic Committee, 2014). STEM workers play a critical role in keeping the U.S. internationally competitive in discovery and technology innovation. A diverse talent pool of Americans with strong STEM knowledge and skills is essential to meet the current demand for STEM workers with the rapid innovation in STEM globally (National Research Council, 2011; National Science Board, 2020). Understanding what leads to the pursuit of STEM education and STEM careers is essential in supporting the sustainable development of STEM in the U.S.

High school is an essential time for students' academic pathways to STEM majors and careers (Maltese & Tai, 2011; Taningco et al., 2008). Understanding the development and the precursors of high school students' math and science motivation is important in understanding their STEM-related choices. Previous studies have found that students who have higher math and science motivational beliefs are more likely to pursue a STEM major in college and a STEM career later in life (Guo et al., 2015; Robnett & Leaper, 2013; Seo et al., 2019; Wang et al., 2015; Watt et al., 2012). However, we know little about how the change in math and science motivational beliefs relate to later STEM choices. Theories also suggest that parents are one of the main socializers of students' motivational beliefs that parents' academic support would positively predict adolescents' STEM motivation and choices (Wigfield et al., 2015). Research largely on white, middle-class families found that parents who have stronger beliefs, such as efficacy beliefs, are more likely to provide more parents' academic support, which in turn are related to students' higher math and science motivational beliefs and better STEM outcomes

(Catsambis, 2001; Kirk et al., 2011; Simpkins et al., 2012; Simpkins, Fredricks, et al., 2015). However, little of the parent academic support literature focused on the marginalized groups such as female and first-generation college students.

National reports have shown that groups of students who do not fit the mainstream STEM stereotype, including female and first-generation college students, are underrepresented in most STEM fields (Cataldi et al., 2018; National Science Board, 2018; National Science Foundation, 2019). According to the situated expectancy-value theory, individuals' social categories, such as being a female or first-generation college student, affect students' motivational beliefs and outcomes (Eccles & Wigfield, 2020). While most studies examined adolescents' social categories such as gender and college generation status independently, scholars have argued that systems of oppression and privilege associated with these social groups do not function in isolation (Crenshaw, 1989; Hyde, 2014).

This dissertation investigates how high school students' math and science motivational beliefs change and the parental socialization process of those beliefs. Given that math and science motivational beliefs are often studied separately in STEM literature, this study fills a gap in the literature by examining the interrelatedness of math and science motivational beliefs as they simultaneously develop in high school and their associations with whether adolescents declare a STEM major in college. Moreover, this dissertation studies group inequalities in adolescents' math and science motivational beliefs as well as parents' beliefs and supportive behaviors at the intersection of gender and first-generation college status.

Importance of Adolescence and Emerging Adulthood

Life course theory underscores the importance of looking at human development prenatally to death (Elder Jr. & Rockwell, 1979). Life course theory emphasizes person-context interactions, as well as the social structures and pathways through life. Context is studied in life course theory by looking at the developing person and their interactions with social environments while considering the historical time and the timing in that person's life. Trajectories and transitions are key elements in life course theory to establish development by changing individuals' social status, social roles, and social development. In this dissertation, I examined adolescents' development during high school and the transition from high school to college. This dissertation covers two developmental periods theorized to have a prolonged influence on individuals' life paths: adolescence and emerging adulthood.

Scholars have argued it is critical to study students' academic pathways to STEM majors and careers during adolescence and emerging adulthood (Arnett, 2007; Maltese & Tai, 2011; Taningco et al., 2008). Adolescents have more autonomy in high school than in earlier developmental periods to make academic choices that are consequential for STEM college opportunities, such as not taking math or science courses or which courses to take (Maltese & Tai, 2011). According to Erikson's theory (1993), adolescence is the primary time when individuals explore their identity in society. During adolescence, individuals develop a sense of self and struggle with questions such as "Who am I" and "What do I want to do with my life?" Students who do not fit in the mainstream stereotype of STEM, including female and first-generation college students, often disidentify from math- and science-related careers during adolescence (Taningco et al., 2008; Wilson & Kittleson, 2013). The situated expectancy-value theory also suggests that adolescence is the time when students solidify their competence-related beliefs (i.e., can I do the task?) and values (i.e., do I want to do the task?) (Wigfield et al., 2015). Students' competence-related beliefs and values developed during adolescence turn into life choices and outcomes during early adulthood (Eccles & Wigfield, 2002). Indeed, students who have higher math and science motivational beliefs during high school are more likely to enroll in a STEM major and pursue a STEM career (Guo et al., 2015; Robnett & Leaper, 2013).

Arnett (2007) expanded Erikson's work and suggested that individuals continue to explore their identity and associated educational and occupational choices into emerging adulthood, which spans 18-25 years of age. Arnett characterized emerging adulthood as the age of identity exploration, instability, self-focus, feeling in between, and possibilities (Arnett, 2014). Individuals consider various life possibilities and make enduring life decisions during emerging adulthood that have implications for their future career, marriage, and life paths. Students learn to make critical decisions for themselves and accept responsibility for their choices and actions during emerging adulthood. Individuals who form coherent identities across adolescence and emerging adulthood are theorized to have a more structured plan for their future when facing the uncertainty of choices (Schwartz et al., 2005). Though emerging adulthood is a distinct developmental period, Arnett (2000) agrees with life course theory (Elder Jr. & Rockwell, 1979) that developmental processes and decisions during emerging adulthood are, in part, driven by prior experiences in adolescence. At the same time, Arnett characterizes emerging adulthood as a unique period filled with exploration and instability, thus, raising questions on how adolescents' motivational processes predict emerging adulthood choices. Therefore, it is critical to understand the extent to which adolescents' motivational beliefs relate to decisions during emerging adulthood, such as college major choice.

The Overarching Theoretical Framework: Situated Expectancy-Value Theory

Eccles' situated expectancy-value theory stems from Atkinson's (1957) and Bandura's (1997) model that links individuals' expectancy-related and subjective task value beliefs to their achievement-related performance, persistence, and choices (Eccles & Wigfield, 2020). The theoretical concept map of this dissertation is presented in Figure 1. Eccles' situated expectancy-value theory posits that individuals' expectancy of success in a specific task (i.e., ability self-concept) and the values they attach to the subject (i.e., subjective task value) are the most immediate predictors of their task-specific achievement, persistence, and choices (Eccles & Wigfield, 2002). Ability self-concept in Eccles' situated expectancy-value theory is commonly defined as the self-evaluation of one's general ability in a specific domain. Subjective task value captures individuals' desire to do different tasks. The situated expectancy-value theory distinguishes different components of subjective task value, including intrinsic value (liking or enjoyment), utility value (the instrumental value of the tasks for helping to fulfill personal goals), attainment value (the link between the task and one's sense of self, identity, and core personal values), and cost (what may be given up by making a specific choice) (Eccles & Wigfield, 2002; Wigfield et al., 2015). The current dissertation focuses on two promotive subjective task values: intrinsic value and utility value, which were theorized to be critical in relation to adolescents' achievements and choices (Eccles & Wigfield, 2002; Wigfield et al., 2015).

As shown on the right side of the figure, situated expectancy-value theory (Eccles & Wigfield, 2002, 2020) argues that adolescents' domain-specific self-concept of ability and subjective task values directly predict their academic achievement and choices. Prior literature supported the situated expectancy-value theory with relative findings. Within math, students' self-concept of ability and subjective task value are important predictors of their math outcomes during adolescence, including their math achievement (Simpkins et al., 2006; Wang et al., 2015; Watt et al., 2006), math course-taking in high school (Guo et al., 2015; Nagy et al., 2006; Simpkins et al., 2006; Wang, 2012; Watt, 2006). Although studied to a lesser extent than math, similar relations have emerged in science (Andersen & Ward, 2014; Guo et al., 2018; Jiang et al., 2020; Simpkins et al., 2006). In addition, emerging findings suggest that adolescents' math and science motivational beliefs are both positive indicators of their STEM outcomes during emerging adulthood, including STEM major choices (Guo et al., 2015) and STEM career choices (Jiang et al., 2020; Wang et al., 2015; Watt et al., 2012). However, less work exists on math and science motivational beliefs predicting these processes in emerging adulthood (path a in Figure 1). Given Arnett's (2000, 2014) characterization of emerging adulthood as less stable, explorative, and a time to consider various possibilities, more research needs to examine the extent to which math and science motivational beliefs and achievements in adolescence predict their STEM choices in emerging adulthood.

The situated expectancy-value theory has a submodel that describes the parenting process of adolescents' motivational beliefs. In the parent socialization model of the situated expectancy-value theory, Eccles and colleagues (2020) argue that parents are primary socializers who shape children's domain-specific motivation through their domain-specific supportive behaviors (Wigfield et al., 2015). As presented in Figure 1, parents' academic support in specific domains are critical to children's motivation development in that domain by providing resources at home and experiences outside of the home that encourages children to pursue their interests and find their competence (path b in Figure 1; Wigfield et al., 2015). Several other theoretical frameworks address the relations between parents' academic support and adolescents' academic outcomes. Using Epstein's (1987) framework, Hill and Tyson (2009) discussed the multidimensionality of parents' general academic support. They identified three types of commonly used parental support: *school-based involvement* (e.g., parent-teacher conferences), *home-based involvement* (e.g., helping with homework), and *academic socialization* (e.g., conversations about school and college). Among the three types of parent support, Hill and Tyson (2009) highlighted the importance of school-based involvement and academic socialization in relation to students' academic outcomes. The two theories of the Eccles' parent socialization model (Eccles & Wigfield, 2020) and Hill and Tyson's (2009) parental support framework focus on two dimensions of parents' academic support: Hill and Tyson's (2009) model emphasizes parents' general involvement in adolescents' education at school and the situated expectancy-value theory focuses more on the domain-specific support parents provide. Therefore, synthesizing the two parental support theoretical framework, this dissertation focused on two types of parents' academic supportive behaviors that are important in supporting adolescents' math and science motivational beliefs: parents' school-based involvement (e.g., school-based involvement such as attending parent-teacher conferences) and parents' STEM-specific support (e.g., co-activity such as taking students to museums).

Moving further to the left side of Figure 1, the parent socialization model of the situated expectancy-value theory posits that parents' beliefs about their efficacy, parents' expectations for their children, and child indicators (e.g., children's achievement) are all related to parents' academic support (path c in Figure 1; Wigfield et al., 2015). Parents are likely to provide more support if they expect their children to go further in education and have higher STEM efficacy beliefs in themselves (Briley et al., 2014; Fan & Williams, 2010; Green et al., 2007; Hoover-Dempsey et al., 2001; Shumow et al., 2011). Hoover-Dempsey and Sandler's (1997) parental involvement framework also argues that parents' decisions to get involved in children's education not only depend on their own beliefs but also depends on the demands and opportunities for involvement from children (Hoover-Dempsey & Sandler, 1997). Prior literature often has the assumption that the stronger direction of influence is parents to children rather than the opposite, but little literature existed to examine how children shaped parents' behaviors. Therefore, in this dissertation, I studied the precursors of parents’ academic support using both parent- and child-level indicators. I focused on two kinds of parental beliefs that are associated with parents' behaviors in supporting their children: parents' efficacy beliefs on their ability to help children and parents' educational expectations for their children. To look at child effects on parent supportive behaviors, I included two child STEM indicators of math achievement and STEM interest in studying parents' academic support in general and STEM.

Group Differences

As shown in Figure 1, the situated expectancy-value theory suggests that group differences in adolescents' motivational beliefs and outcomes arise because of the socializers' behaviors, contextual factors, and the broader cultural milieu (Eccles & Wigfield, 2020; Wigfield et al., 2015). Gender-related processes and college generation status are two central components of adolescents' cultural milieu.

Gender differences. According to the situated expectancy-value model (Eccles & Wigfield, 2020; Wigfield et al., 2015), gender role expectations and stereotypes are an aspect of adolescents' cultural milieu and affect parents and adolescents’ beliefs and behaviors, which in turn influence adolescents' achievement and choices. Gender role expectations and stereotypes influence adolescents' math and science motivational beliefs and STEM outcomes through the processes of gender role socialization, the internalization of gender role expectations and stereotypes, and the absence of same-sex role models. For example, stereotypes have been shown to shape socializers' behaviors, such as parents providing more supportive behaviors in science for boys than girls (Simpkins, Price, et al., 2015).

Previous literature has shown that females are less privileged and more likely to drop out of the STEM pipeline (Dika & D’Amico, 2016; Harackiewicz et al., 2016; Jacobs et al., 2002).

Female adolescents tend to have lower math and science ability self-concept and subjective task values compared to male adolescents in high school (Beghetto, 2007; Dai, 2001; Else-Quest et al., 2013; Guo et al., 2015; Nagy et al., 2010; Simpkins, Fredricks, et al., 2015; exceptions see Jacobs et al., 2002). Female students are also less likely to choose STEM majors or careers than male students (Guo et al., 2015; Parker et al., 2012, 2014; Robnett & Leaper, 2013; Wang et al., 2015), even though they have similar if not higher math achievement in high school (Else-Quest et al., 2013; Hyde, 2014; Lindberg et al., 2010). The existing studies that examined gender as a moderator in the relations between math and science motivational beliefs and students' academic outcomes have yielded mixed findings that some found motivational beliefs is a stronger predictor and some found the opposite (Guo et al., 2015; Simpkins et al., 2012; Simpkins, Fredricks, et al., 2015; Wang, 2012; Watt et al., 2012). Even though the evidence in the existing literature is mixed, examining the process differences is critical in understanding females' underrepresentation in STEM.

College generation differences. First-generation college students, who are the first in their family to go to college, tend to have different STEM-related experiences because of the disparities in their proximal environments, such as families and schools, compared to continuing-generation college students (Bui, 2002). First-generation college students, in general, have fewer parental educational resources, have lower college aspirations, and face more difficulty in terms of their college academic achievement, attendance, and graduation compared to continuing-generation college students (Gibbons & Borders, 2010; Harackiewicz et al., 2016; Jiang et al., 2020; Stephens et al., 2012; Wilson & Kittleson, 2013). Among college students, first-generation college students typically have lower achievement in college biology classes (Harackiewicz et al., 2016; Tibbetts et al., 2016) and are less likely to take higher-level math college courses compared to continuing-generation students (Chen & Carroll, 2005).

Even less is known about the extent to which there are process-level differences based on college generation status. The relations between motivational beliefs and STEM outcomes could be different for first- and continuing-generation college students due to the differences in family resources and social support (Garriott et al., 2013; Gibbons & Borders, 2010). For example, it is possible that the adolescents' beliefs and achievements may be weaker predictors of emerging adults' college majors for first- compared to continuing-generation college students as college might expose first-generation college students to a wide variety of educational and occupational choices that they may not have been familiar with. Thus, there may be more exploration of possibilities and instability in educational choices from adolescence to emerging adulthood for first- compared to continuing-generation college students (Arnett, 2000). In contrast, other work suggests that first-generation college students' motivational beliefs could be a stronger predictor of STEM outcomes than their peers because they need higher motivational beliefs to overcome the challenges they face in STEM (Harackiewicz et al., 2016). Given the scarcity of the literature, it is important to examine the process-level differences for first- and continuing-generation college students.

The Intersection of Gender and College Generation Status.

A growing literature argues that studying demographic differences such as gender in isolation could neglect the within-group differences and argue for combining multiple social identities in studying differences across groups (Crenshaw, 1989; Hyde, 2014). For example, the experience of parents' STEM-specific support during high school could be very different for first-generation college females compared to continuing-generation college females. Scholars are increasingly considering the intersection of social categories when studying students' math and science motivation and how parents support students' math and science motivation (Else-Quest et al., 2013; Simpkins, Price, et al., 2015). However, most of these studies focused on the intersection of gender and race/ethnicity. This dissertation is among the first to our knowledge to test the intersection of gender and college generation status because college generation status differences cover more disparities in education level, income level, and work status than race/ethnicity differences.

The literature on the mean-level differences based on gender and college generation status provides evidence that both female and first-generation college students are often marginalized in STEM. Therefore, I argue that belonging to both social groups would exacerbate the marginalization of a single social group making the female first-generation college students the most marginalized group and male continuing-generation students the most privileged group. And, male first-generation college students and female continuing-generation college students are hypothesized to be in the middle in terms of their parents' beliefs and support, as well as adolescents’ motivational beliefs, and STEM outcomes. Prior studies have found that male students are more likely to have higher math and science motivational beliefs (Beghetto, 2007; Else-Quest et al., 2013; Simpkins, Price, et al., 2015). However, male first-generation students could face more difficulty building high math and science motivational beliefs due to their lack of parental resources in higher education compared to male continuing-generation students. Identifying as a female first-generation college student may aggregate oppressive processes of both gender and college generation status and potentially is associated with a lower level of STEM outcomes and parents' support. Given that little work examines the differences between first-generation and continuing-generation college students, even less is known about these differences at the intersection of gender and college generation status. The few existing studies focused on general academic and parenting processes highlighted the potential within-group differences among males and females. For example, among a group of female college freshmen, parents of first-generation college students provided less emotional support and informational support for their daughters than parents of continuing-generation college students (Sy et al., 2011). Examining the intersection of gender and college generation status is helpful to address if marginalization due to gender or college generation status has equal effects on adolescents' parental support, motivational beliefs, and STEM outcomes.

Due to the differences in family resources and social support between first- and continuing-generation college male and female students (Garriott et al., 2013; Gibbons & Borders, 2010), motivational beliefs could function differently for the four groups of students when predicting outcomes None of the prior studies, to our knowledge, has tested the process differences across college generation status, let alone the intersection of gender and college generation status. However, it is important to understand whether motivational beliefs function similarly in these groups of students. Suppose motivational beliefs are more important for female first-generation college students in predicting their STEM major choices, interventions targeting first-generation college female students' math and science motivational beliefs in high school would help support first-generation college female students' STEM outcomes (Harackiewicz et al., 2016; Tibbetts et al., 2016). Therefore, this dissertation tested the mean-level differences in math and science motivational beliefs, STEM major choice, parents' beliefs, and parents' academic support. In addition to mean-level differences, I examined the process-level differences at the intersection of gender and college generation status in focal constructs' relations.

Overview of the Dissertation Studies

Drawing on Eccles' situated expectancy-value theory (Eccles & Wigfield, 2020), this dissertation examined the development of adolescents' math and science motivational beliefs during high school, the parenting precursors, and the associations with their later college major for four groups: female first-generation college students, male first-generation college students, female continuing-generation college students, and male continuing-generation college students.

As shown in Figure 1, paper 1 examined the changes in adolescents' math and science motivational beliefs from 9^{th} grade to 11^{th} grade. Drawing on the situated expectancy-value theory (Eccles & Wigfield, 2020), this paper examined the changes in adolescents' math and science motivational beliefs from 9^{th} to 11^{th} grade and the interrelationship of math and science motivational beliefs as they develop in high school, as well as how they relate to adolescents' STEM major choice seven years later. Meanwhile, this paper also focused on how parents' academic support is associated with the development of adolescents' math and science motivational beliefs in high school. Another main focus of this paper is examining differences at the intersection of gender and college generation status in the (a) means of adolescents' math and science motivational beliefs and college major choice, and parental support; and (b) the relations between those constructs.

Paper 2 examined the parent and adolescent predictors of parents' academic support (see Figure 1). According to the parental socialization model (Wigfield et al., 2016) and Hoover-Demspey and Sandlers' parenting model (1997), parents' decisions to provide general and STEM-specific support depend on both their own beliefs and child indicators. Therefore, at the parent level, I examined how parents' STEM-specific efficacy beliefs and parents' educational expectations predict parents' academic support in general and STEM. At the adolescent level, I examined how adolescents' math achievement and STEM interest predicted parents' academic support. And finally, paper 2 examined the mean-level and process-level differences in all of these indicators at the intersection of gender and college generation status.

This dissertation consisted of two studies that jointly examine how adolescents' STEM motivational beliefs develop in high school and the correlates and outcomes associated with the development of adolescents' STEM motivational beliefs. Data for all two studies were drawn from the High School Longitudinal Study (HSLS) of 2009, which is a longitudinal study from the U.S. National Center for Education Statistics (NCES) that recruited a nationally representative sample of 9th graders across the U.S. (Ingels et al., 2011). HSLS was designed to investigate "the paths into and out of science, technology, engineering, and mathematics (STEM) fields of study and careers; and the educational and social experiences that are related to these shifts in plans or paths," which strongly aligns with the propose of this dissertation (Ingels et al., 2011, page iii). HSLS data were collected through a stratified, two-stage random sample design with primary sampling units defined as schools. HSLS selected a random sample of 940 schools from 10 states in the first stage. In the second stage, students were randomly selected from the sampled schools within strata defined by race/ethnicity. Approximately 28 students within each school were selected, and a total of 21,440 students participated in the base-year study. Four waves of data were collected from 2009 to 2016: base-year (9th grade, collected in fall 2009), first follow-up (11th grade, spring 2012), 2013 update (right after high school, summer & fall 2013), and second follow-up (three years post high school, 2016). Each study uses a specific sub-sample of the data to best match the aims of each study.

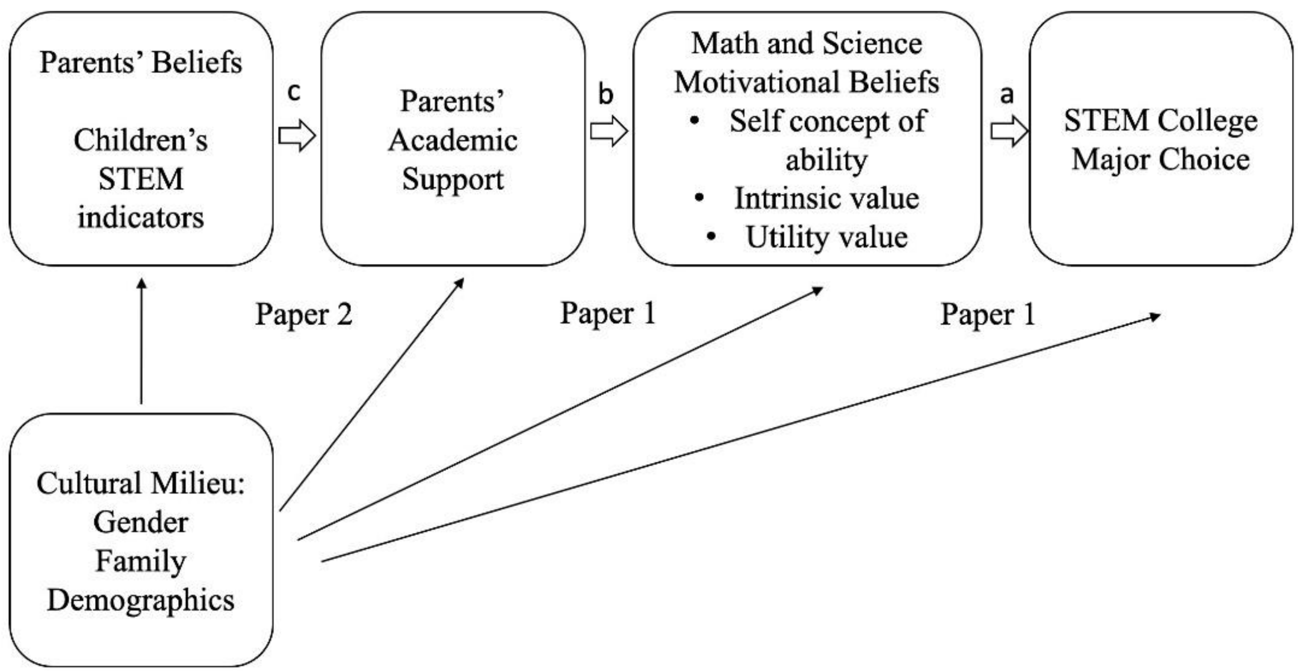

Figure 1. The theoretical concept map of the dissertation.

CHAPTER 2

The antecedents and correlates of the changes in adolescents' math and science motivational beliefs during high school

Abstract

Understanding what leads to the pursuit of a STEM major in college is critical in supporting a competitive STEM workforce. Drawing on the situated expectancy-value theory, this paper examined the developmental process of adolescents' math and science motivational beliefs and the parental socialization process of STEM motivation. In addition, we examined the mean-level differences in adolescents' motivation, parental support, and STEM choice, and the process-level differences of the relations among these focal variables at the intersection of gender and college generation status (first-generation vs. continuing-generation college students). Using the national representative dataset of the High School Longitudinal Study (N = 12,070; M_{age} = 14; 54% female students), this paper found that not all math and science motivational beliefs declined during high school; instead, science interest remained stable, and math and science utility value increased. We also found that not only adolescents' 9^{th} grade math and science motivations but the development of their math and science motivations predicted their later STEM choice. This study confirmed the mean-level differences in adolescents' math and science motivation, parental support, and college major choice at the intersection of gender and college generation status; however, the process level differences were subtle among the groups. This study provided insights for policymakers and practitioners to focus on the development of adolescents' math and science motivation as well as the parental socialization of STEM motivation during high school.

Keywords: motivational beliefs, STEM, gender, first-generation college students, math and science

The antecedents and correlates of the changes in adolescents' math and science motivational beliefs during high school

A diverse talent pool of individuals with solid science, technology, engineering, and mathematics (STEM) knowledge and skills is essential (National Science Board, 2020) for the sustained growth of the U.S. economy (U.S. Congress Joint Economic Committee, 2014). However, because STEM fields are often stereotyped as masculine and intelligent domains, subgroups of adolescents, including female and first-generation college students, often are marginalized in most STEM fields (Cataldi et al., 2018; National Science Board, 2020). Though much of the existing research identifies which groups have been marginalized and the numerous barriers they face, there is little information on what individual and contextual factors promote marginalized adolescents' STEM success. Describing the factors that support marginalized adolescents' motivation to pursue STEM is needed to help reverse some of these dismal trends.

This paper investigated how adolescents' math and science motivational beliefs change in high school and the parental socialization process of those beliefs. Given that math and science motivational beliefs are often studied separately, the first goal of this study is to fill a gap in STEM literature by examining the interrelatedness of math and science motivational beliefs as they simultaneously develop in high school and their associations with whether adolescents declare a STEM major in college. The second goal of this study extends the existing parenting literature by testing how parents' supportive behaviors predict the changes in adolescents' math and science motivational beliefs and the extent to which those indicators and processes vary by gender and adolescents' college generation status.

The Development of Math and Science Motivational Beliefs

Eccles' situated expectancy-value theory posits that individuals' motivational beliefs, specifically their beliefs about their abilities in a domain (i.e., ability self-concept) and the values they attach to the domain (i.e., subjective task value), influence their achievement, persistence, and choices in that domain (Eccles, 2009; Eccles & Wigfield, 2020). Ability self-concept in expectancy-value theory is defined as the perceived competence in their ability to succeed in a specific domain. Subjective task value captures individuals' desire to do different tasks. The current study focuses on two promotive subjective task values: intrinsic value and utility value. Intrinsic value was conceptualized as the enjoyment one expects to gain from doing a task, and utility value is the importance of the task to one's future plan. Findings from several studies support the positive 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 science (Andersen & Ward, 2014; Guo et al., 2018; Jiang et al., 2020). However, this robust literature is largely predicated on indicators of adolescents' motivational beliefs measured at a single time point and in a single domain. Despite that, this and other motivation theories argue adolescents' motivational beliefs in math and science develop and influence each other over time (Eccles & Wigfield, 2020; Möller & Marsh, 2013).

The 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). Though with some exceptions (Hsieh et al., 2019; Puente et al., 2021), adolescents' academic 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). Yet, only a few studies have examined how changes in adolescents' math and science motivational beliefs during high school predict later STEM outcomes (Gottfried et al., 2013; Guo et al., 2018; Musu-Gillette et al., 2015). This nascent literature suggests that although the level of adolescents' motivation at any one point in time is predictive of their later STEM outcomes, the changes in their motivation matter as well. For example, Musu-Gillette and colleagues (2015) found that adolescents with consistently high math motivational beliefs and those whose beliefs demonstrated slow declines were more likely to choose a STEM college major or career than those who experienced fast declines. However, only math motivation is examined in this paper, and little is known about the relations between the change in science motivation to STEM outcomes.

Though these motivational processes are often analyzed separately by subject, such as examining motivational processes in math separately from science, 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). As for complementary domains, such as math and science, the theory suggests that they should have small negative or even positive effects on each other; however, the relations between complementary domains are less examined in the literature. Scholars have argued that math is the gatekeeper to later advanced math and science courses in high school that math motivation and performance are associated with later science motivation and performance (Douglas & Attewell, 2017; Watt et al., 2017). Emerging studies suggest that adolescents' math and science motivational beliefs are both positive indicators of their STEM major choices (Guo et al., 2015; Jiang et al., 2020), however, math and science motivational beliefs were related to STEM outcomes in different ways. For instance, using the same data as the current study, Jiang and colleagues (2020) found that adolescents' math motivational beliefs predicted adolescents' STEM college major through associations with their high school STEM course-taking and GPA, whereas science motivational beliefs directly predicted their STEM college major.

Parent Supportive Behaviors in Relation to Math and Science Motivation

Theories and prior literature have demonstrated that parents play an essential role in supporting children's academic motivation, achievement, and choices (Hill & Tyson, 2009; Wigfield et al., 2015). Some theories, including Hill and Tyson's (2009) parent support model, focus on how parents are involved in children's education at their school, helping them with schoolwork at home and through academic conversations. Other theories, including the parent socialization model of the situated expectancy-value theory (Eccles & Wigfield, 2020), describe how parents cultivate children's motivational beliefs and skills in specific domains like math and science through a variety of strategies (e.g., encouragement, co-activity, provision of opportunities). Though these two theories vary in terms of whether they focus on parents' general educational involvement compared to parent socialization in an effort to cultivate children's motivation in particular domains, existing research in these two distinct pieces of the literature suggests that both types of parent support should promote adolescents' motivation in academic domains like math and science.

Parents' school-based involvement in education has been broadly conceptualized as parents' school-based efforts to support their children's academic learning (Grolnick & Slowiaczek, 1994). Hill and Tyson's (2009) model and several meta-analyses have shown that parents' involvement in school settings is associated with children's grades and test scores overall

(Castro et al., 2015; Jeynes, 2005). Additionally, parents' school-based involvement is positively associated with adolescents' motivational beliefs in math and science in middle school and high school (Gottfried et al., 2009; Liou et al., 2019; Mujtaba et al., 2018; Shumow et al., 2011). Though this literature suggests that parent involvement in children's education matters, researchers have yet to consider if these general strategies still matter once you consider the domain-specific strategies parents employ to cultivate adolescents' motivational beliefs in math and science.

In the parent socialization model of the situated expectancy-value theory, Eccles and colleagues (2020) argue that parents are the primary socializers who shape children's domain-specific motivation through their domain-specific supportive behaviors, including modeling, co-participation, and encouraging (Wigfield et al., 2015). Parents' math- and science-specific supportive behaviors are positively related to adolescents' math and science motivational beliefs (Häfner et al., 2018; Simpkins et al., 2015, 2018, 2020). The two distinct pieces of literature on parent involvement in children's education and parent socialization of children's math and science motivation each suggest that the one type of parent support matters, but few studies have examined both to study which one might matter more and if either of these parent supports help buffer against the typical declines in adolescents' math and science motivational beliefs in high school.

The Intersection of Gender and College Generation Status.

According to situated expectancy-value theory, these motivational processes and individuals are situated within immediate contexts, such as families, and within the broader societal context, which is broadly described as the cultural milieu (Wigfield et al., 2015).

Gender-related processes and college generation status are two central components of adolescents' cultural milieu.

Gender can shape adolescents' motivational development and processes through gender-role socialization, the internalization of gender-role stereotypes, and processes of gender identity development (Simpkins et al., 2015; Wigfield et al., 2015). A robust literature demonstrates that female adolescents tend to have lower math and science ability self-concepts, intrinsic and utility values (Else-Quest et al., 2013; Guo et al., 2015; Nagy et al., 2010; exceptions see Jacobs et al., 2002) and are less likely to choose STEM majors or aspire toward STEM careers than male adolescents (Guo et al., 2015; Parker et al., 2012; Wang et al., 2015). However, recently researchers have pointed out that gender differences and similarities should be examined in context with other social categories and cannot be fully understood in isolation (Hyde, 2014). Researchers have yet to test if gender differences emerge within other groups systematically and the extent of marginalization and privilege due to gender versus other social categories are equally predictive. For example, even though males are privileged in math and science, it is unclear if this privilege advantages continuing- and first-generation male college students equally. Describing such nuances in gender differences is necessary to effectively support diverse individuals in STEM as boys and girls are very diverse groups.

First-generation college students, who are the first in their family to obtain a college degree, are more likely to be members of an underrepresented racial or ethnic group and from a low-income family (Garriott et al., 2013). First-generation college students, on average, have lower math and science motivational beliefs (Jiang et al., 2020; Snodgrass Rangel et al., 2020), are less likely to declare a STEM major (Chen & Carroll, 2005), tend to experience more obstacles on the way to pursue a college degree in STEM due to the lack of family resources compared to their counterparts (Bui, 2002; Gibbons & Borders, 2010).

Because gender and college generation status are theorized to work through two different mechanisms (i.e., gender stereotypes and expectation versus family resources, respectively), we expected their effects in terms of oppression or privilege were additive. Being both female and a first-generation college student may exacerbate the marginalization of being a member of one social group making the female first-generation college students the most marginalized group and male continuing-generation college students the most privileged group. Though male first-generation college students and female continuing-generation college students theoretically may experience different barriers and challenges in STEM, adolescents in these two groups could be similar in terms of their modest motivation to pursue STEM. Examining the intersection of gender and college generation status is helpful to address if marginalization due to gender or college generation status has equal effects.

Yet, 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 for their daughters than parents of female continuing-generation college students (Sy et al., 2011). Though scholars have also argued that individual strengths (e.g., motivational beliefs) and support may be more instrumental for adolescents marginalized in STEM, given the number of challenges and obstacles they face (Stephens et al., 2012; Wilson & Kittleson, 2013), this hypothesis has largely gone untested. We tested potential mean-level and process-level differences in this study to help address this gap in the literature.

The Current Study

Drawing on the situated expectancy-value theory (Eccles & Wigfield, 2020), this paper examined the changes in adolescents' math and science motivational beliefs from 9^{th} to 11^{th} grade and the interrelationship of math and science motivational beliefs as they develop in high school, as well as how they relate to adolescents' STEM major choice seven years later. We expected that adolescents' math and science motivational beliefs would decline from 9th to 11th grade based on prior literature. We expected that the development of math and science motivational beliefs would be related to each other, such that having higher math motivational beliefs in 9^{th} grade would be related to higher science motivational beliefs in 9^{th} grade and smaller declines over time in their science motivational beliefs; we expected the same relations when science predicted math. We hypothesized that adolescents whose parents were involved more in school and provided more STEM-specific support would have higher math and science motivational beliefs in 9^{th} grade and have smaller declines in their math and science motivational beliefs from 9^{th} to 11^{th} grade. We also expected that adolescents who had higher math or science motivational beliefs in 9^{th} grade and smaller declines in their math and science motivational beliefs from 9^{th} to 11^{th} grade were more likely to choose a STEM major.

Another main focus of this paper is examining (a) the mean-level differences in adolescents' math and science motivational beliefs, parental support, and college major choice; and (b) the process-level differences in the relations between these constructs at the intersection of gender and college generation status. We hypothesized that male continuing-generation college students would have the highest level of parental support, the highest math and science motivational beliefs, and would be most likely to declare a STEM college major, whereas female first-generation college students would have the lowest means on these indicators. Male first-generation college students and female continuing-generation college students are 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 9th graders across the U.S. 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 21,440 adolescents participated in the base-year study.

The analytic sample included 12,070[1] adolescents (17% Hispanic, 11% African American, 10% Asian, 53% Caucasians, and 9% other race/ethnicity) who were enrolled or had ever enrolled in college by February 2016. We excluded those who did not enroll in college as of February 2016 as they did not report their college major (*n* = 13,140) as this study focused on college-going adolescents and whether they declared a STEM college major. In 9th grade, adolescents in the analytic sample were on average 14.39 years old, 54% female adolescents, 28% were first-generation college students, and from families with median income between $55,000 and $75,000. Within the analytic sample, 16% were female first-generation college

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

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). The analytic sample included adolescents who had higher math and science motivational beliefs in 9th and 11th grade though the effect sizes were small (*d* = .01 - .27), higher 9th grade math achievement (*d* = .67), higher high school English GPA (*d* = .81), higher parent education levels (*d* = .57), and family incomes (*d* = .45) than the excluded sample (see a full comparison in Supplementary Table S1). The data used in this study were approved under IRB protocol at the XXX, under the project title: XXX and IRB protocol number: HS#:2018–4349.

Measures

HSLS surveyed adolescents in 9th and 11th grade (in 2009 and 2011, respectively) about their math and science motivational beliefs. Parents' academic support variables were collected through parent surveys in 9th grade. College enrollment information was gathered in 2016, which was three years after high school. A complete list of items used for math and science motivational beliefs, the STEM outcome, and control variables is provided in Table S2.

Motivational beliefs. Adolescents reported their math and science motivational beliefs (i.e., ability self-concept, intrinsic value, and utility value) using the same items in 9th and 11th grade. Measurement invariance was tested and confirmed the scales evidenced configural, weak, and strong measurement invariance (Grimm et al., 2016) across time (i.e., 9th and 11th grade) and across the four groups defined by gender and college generation status (i.e., female first-generation college students, male first-generation college students, female continuing-generation college students, and male continuing-generation college students) (See Tables S3&S4).

Ability self-concept. The items measuring ability self-concept align with situated expectancy-value theory's definition that adolescents' ability self-concept is the extent to which adolescents feel competent in their ability to succeed in a specific domain (Eccles & Wigfield, 2020). Four items were used to measure adolescents' ability self-concept in each domain at 9^{th} and 11^{th} grade (α = .90, .89 for math and .88, .92 for science in 9^{th} and 11^{th} grade, respectively; 1 = *strongly disagree,* 4 = *strongly agree*; e.g., "You are certain that you can master the skills being taught in this course").

Intrinsic value. Situated expectancy-value theory conceptualized intrinsic value as the enjoyment one garners from doing tasks (Eccles & Wigfield, 2020). Three items were reported by adolescents on their 9^{th} and 11^{th} grade intrinsic value in math and in science (α = .78, .80 for math and .81, .83 for science in 9^{th} and 11^{th} grade, 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 to their future plan (Eccles & Wigfield, 2020). Adolescents reported their 9^{th} and 11^{th} grade utility value in math and in science using three items in each domain (α = .77, .81 for math and .74, .82 for science in 9^{th} and 11^{th} grade, respectively; 1 = *strongly disagree*, 4 = *strongly agree;* e.g., "will be useful for a future career").

College STEM major. Adolescents reported their major or field 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 three years after high school. Adolescents' 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 STEM and non-STEM fields (Ingels et al., 2011). STEM major choice was a dichotomous variable of whether adolescents' first or second major field was math, science, engineering or technology, including majors such as biological and biomedical sciences, agriculture and related science, computer and information sciences, engineering, math and statistics, economics as defined by National Center for Education Statistics (NCES) (for a full list of STEM majors, see Table S2).

Parent academic support. Two broad indicators of parent academic support were examined in this paper: parents' school-based involvement and parents' STEM-specific support.

Parent school-based involvement. The items measuring parent school-based involvement aligned with Hill and Tyson's (2009) school-based involvement framework, which includes items such as communicating with teachers and volunteering for the school. The parent report school-based involvement scale was captured by the sum of the six dichotomous items in 9^{th} grade (1 = *Yes*, 0 = *No;* e.g., "attended a general school meeting such as an open house or a back-to-school night). Prior studies have examined parents' general school-based supportive behaviors using similar items (Fan & Williams, 2010).

Parent STEM-specific support. Aligned with the situated expectancy-value theory (Eccles & Wigfield, 2020), the items measuring parents' STEM-specific support reflected parents' specific supportive behaviors in STEM domains. Parents' STEM-specific 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 9th-grader] with a school science fair project"). Prior studies have used similar items to construct parents' STEM-specific support composite scores when studying parental processes in STEM (Simpkins et al., 2005, 2015).

The intersection of gender and college generation status. Adolescents' first-generation college status was a parent-reported dichotomous variable indicating that none of the adolescents' parents had earned an associate's degree, bachelor's degree, or higher (1 = *first-generation college student*, 0 = *continuing-generation college student*). Adolescents reported their gender in 9th grade (1 = *female*, 0 = *male*). 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.

Covariates. Family income, adolescents' race/ethnicity, adolescents' 9th grade math achievement, and high school English GPA were incorporated as covariates in the models given their relations with the focal indicators (Else-Quest et al., 2013; Simpkins et al., 2015). Family income is the overall family income from all sources in 2008 (1 = *less than or equal to $15,000*, 13 = *greater than $235,000*). Adolescents' 9th grade math achievement was a norm-referenced measurement of achievement that captured an estimate of adolescents' achievement relative to the population (Ingels et al., 2011). It was rescaled to a mean of 50 and a standard deviation of 10. Adolescents' high school English GPA was the cumulative English GPA adolescents got throughout high school from transcript data collected shortly after high school (0 = *D*, 4 = *A*).

Plan of Analysis

This paper examined (a) within-domain changes, (b) within- and cross-domain relations in math and science motivational beliefs from 9th to 11th grade, and (c) the associated predictors and outcomes (see the conceptual model in Figure 2). We estimated three latent change score models (McArdle, 2009) -- one for each of the three motivational beliefs (i.e., ability self-concept, intrinsic value, and utility value) to avoid multicollinearity issues. Each model captured the changes in adolescents' math and science motivational beliefs. Adolescents' motivational beliefs were specified in the models as latent variables using the items described earlier by the marker variable factor identification. The analyses centered on structural equation models were estimated in Mplus v8.0 (Muthén & Muthén, 2012). Models were weighted to account for the nonresponse rate in the sampling process. Strata and primary sampling unit (i.e., schools) variables were used to correct the standard errors based on the stratified design of the data. Models were estimated using the robust maximum likelihood (MLR) estimator, which provides a robust estimation for non-normally distributed data, such as our dichotomous STEM college major indicator when having a complex sample design.

The 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' values at Time 1 (Grimm et al., 2012). Compared to other time-sequence analyses (e.g., latent growth 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 a few as two time points, which is the case for adolescents' motivational beliefs in the HSLS dataset; other models require three and more time points.

We estimated bivariate LCS models to capture the relations between average change in adolescents' math and science motivational beliefs from 9th to 11th grade (Grimm et al., 2016). In the bivariate LCS models, we estimated the mean of the change score (Δ), which represents the difference between adolescents' motivational beliefs in 9th grade and 11th grade (e.g., ΔMath Motivational Beliefs in Figure 2). We also estimated how adolescents' motivational beliefs in the same domain in 9th grade were related to the change scores (Δ) (see paths a and f in Figure 2; Grimm et al., 2012). The stability path (auto-regression between latent scores) and the path from the latent score at 11th grade to the latent change score were fixed at 1 to meet model identification requirements (McArdle & Grimm, 2010). Based on the literature, we hypothesized that adolescents' math and science motivational beliefs would decline over time (Gottfried et al., 2009; Guo et al., 2018). In addition to the paths that capture the change within each domain, our bivariate LCS models included relations across domains. Specifically, we tested the extent to which changes in adolescents' math and science motivational beliefs from 9^{th} to 11^{th} grade were correlated (path i in Figure 2) and the extent to which adolescents' motivational beliefs in one domain in 9^{th} grade predicted changes in their beliefs in the other domain from 9^{th} to 11^{th} grade (paths b and e in Figure 2).

Under the second hypothesis, we expected that adolescents' math and science motivational beliefs in 9^{th} grade would be positively associated with their STEM college majors. Additionally, we expected that the smaller declines in adolescents' math and science motivational beliefs from 9^{th} to 11^{th} grade would be positively associated with their STEM college major. The outcome of college major choice was included in the latent change score model and regressed on the change score (paths d and g in Figure 2) and the 9^{th} grade score (paths c and h in Figure 2) of adolescents' math and science motivational beliefs in each of the three models.

We also examined the extent to which parents' school-based involvement and STEM-specific support in 9^{th} grade were associated with adolescents' 9^{th} grade math and science motivational beliefs and the changes in their beliefs over time. Based on prior literature, we hypothesized that adolescents whose parents exhibited higher school-based involvement and STEM-specific support would have higher math and science motivational beliefs in 9^{th} grade and have smaller declines over time. Parents' school-based involvement and STEM-specific support were included in the latent change score model to predict 9^{th} grade motivational beliefs and the change of motivational beliefs. Family income, adolescent race/ethnicity, 9^{th} grade math achievement, and high school English GPA were included as controls in all of the latent change score models, and they predicted each of the focal indicators in Figure 2.

Lastly, we expected that there would be mean-level differences in focal variables in Figure 2 and process-level differences in the nature of relations between these indicators at the intersection of gender and first-generation college status. For mean-level differences, we estimated ANOVA tests for continuous variables and chi-square test for categorical variables in STATA, version 14.2 (StataCorp, 2015). For process-level differences, we conducted the 4-group multi-group analysis using the following three steps. First, we freely estimated the relational paths in Figure 2 across groups (except for the paths that were constrained to 1 for model estimation requirements). Second, as an omnibus test, we constrained all relational paths shown in Figure 2 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 $\chi 2$ difference test (Satorra & Bentler, 2001), as it is the recommended approach for models with MLR estimator (Muthén & Muthén, 2012).

Robustness Check

The proportion of missing values varied between 7% - 15% for math and science motivational beliefs in 9^{th} and 11^{th} grade, 11% for STEM major choice in college, and 21% for parental support. Missing data were handled with Full-Information-Maximum-Likelihood (FIML) because this approach yields less biased estimates than traditional approaches such as listwise or pairwise deletion (Enders, 2010).

Because of the longitudinal nature and the missing data, we conducted two sets of robustness checks. First, we reran the full latent change score model described earlier using a more limited subsample of adolescents who had complete data in college (n = 8,260) to test the robustness of results estimating outcomes for participants who dropped out of the study. The second set of robustness checks was estimated because we had to drop a number of adolescents who did not attend college from our main analyses. These analyses 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. Rather, it included all of the relations in high school, including the changes in students' motivation and the parental correlates.

Transparency and Openness

We report 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 dataset, although a public dataset of HSLS with suppression of some of the original data could be found: https://nces.ed.gov/surveys/hsls09. Materials and analysis code for this study are available by emailing the corresponding author. Data were analyzed using STATA version 14.2 (StataCorp, 2015) and Mplus version 8.0 (Muthén & Muthén, 2012). This study's design and its analysis were not pre-registered.

Results

Descriptive Statistics

Adolescents' math and science motivational beliefs in 9th grade on average ranged from 2.85 to 3.15; and it ranged from 2.64 to 3.28 in 11th grade on a one to four scales. Within each subject, adolescents' math and science motivational beliefs (i.e., ability self-concept, intrinsic value, and utility value) were moderately correlated in 9th grade and 11th grade (*r* = .36 -.58). Across subjects, adolescents' math and science motivational beliefs were weakly to moderately correlated in 9th grade and 11th grade (*r* = .10 - .43). The same motivational belief across the two years had small correlations (*r* = .22 - .37). Parents' school-based involvement and STEM-specific support had a small association (*r* = .28). Means, standard deviations, and correlations of focal variables are presented in Table 1.

To test our first three hypotheses, we estimated latent change score models including parent support as predicts and STEM college major choices as outcomes separately for the three types of adolescents' math and science motivational beliefs (i.e., ability self-concept, intrinsic value, and utility value). The fit of these three structural equation models was good to excellent. The latent change score model with math and science ability self-concept showed excellent model fit, χ^2 (234) = 1283.504, $p < .001$, CFI = .967, RMSEA = .022, SRMR = .041. Items in the self-concept model evidenced significant loadings for both latent variables of math ability self-concept: β = .69 - .86, $p < .001$; and science ability self-concept: β = .72 - .89, $p < .001$. The math and science intrinsic value model fit the data well, χ^2 (138) = 1395.171, $p < .001$, CFI = .895, RMSEA = .031, SRMR = .063. Factor loadings were statistically significant for math intrinsic value: β = .66 – .77, $p < .001$; and science intrinsic value: β = .68 – .81, $p < .001$. The LCS model with math and science utility values was also a good fit to the data, χ^2 (138) = 1392.672, $p < .001$, CFI = .909, RMSEA = .031, SRMR = .063 Factor loadings were statistically significant for math utility value: β = .56 – .83, $p < .001$; and science utility value: β = .66 – .87, $p < .001$. Next, we discuss the latent change score models with predictors and outcomes based on our research questions. Due to account for the large sample size of this study, to adjust to the number of tests conducted for this study, and to avoid Type I error, the significant level was set at $p < .01$.

Changes in Adolescents' Math and Science Motivational Beliefs from 9th to 11th Grade

We expected that adolescents' math and science motivational beliefs would decline from 9th to 11th grade for the first hypothesis. We examined this hypothesis using three separate models for different types of motivational beliefs to examine each motivational belief's unique developmental patterns and avoid issues of multicollinearity.

Adolescents' ability self-concepts. The focal path coefficients are shown in Figure 3. The mean change of adolescents' math and science motivational beliefs were both significant and negative: $\Delta\mu = -.215$, $p < .001$ for math and $\Delta\mu = -.063$, $p = .001$ for science with significant variances, indicating adolescents' math and science ability self-concepts, on average, declined from 9th to 11th grade. Within each domain, adolescents' 9th 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' 9th grade ability self-concepts positively predicted subsequent changes in the other domain; for example, adolescents' 9th grade math ability self-concepts positively predicted the changes in their science beliefs from 9th to 11th grade (math predicting science: $\beta = .09$, $p < .001$; science predicting math: $\beta = .10$, $p < .001$). These findings suggest that adolescents with higher math 9th 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' 9th 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 value. The focal path coefficients are shown in Figure 4. Adolescents' math intrinsic value demonstrated significant declines from 9th to 11th grade, $\Delta\mu$ = -.291, p < .001, but their science intrinsic value did not significantly change over time, $\Delta\mu$ = -.034, p = .095. Both intrinsic values demonstrated significant variances. Similar to adolescents' ability self-concept, adolescents' 9th grade math and science intrinsic value were negatively related to subsequent changes within that same domain (math: β = -.66, p < .001; science: β = -.60, p < .001), but positively related to changes in the other domain (math predicting science: β = .09, p < .001; science predicting math: β = .17, p < .001). Finally, the changes in adolescents' math and science intrinsic value were significantly and positively related (r = .19, p < .001).

Adolescents' utility value. The focal path coefficients are shown in Figure 5. Unlike, adolescents' ability self-concept and intrinsic values which typically declined from 9th to 11th, adolescents' math and science utility values both significantly increased, $\Delta\mu$ = .291, p < .001 for math and $\Delta\mu$ = .232, p < .001 for science, and had significant variances. Similar to the two other motivational beliefs, adolescents' 9th grade science utility values were negatively related to subsequent changes within same domain (β = -.51, p < .001), and positively related to subsequent changes in math (β = .11, p < .001). However, for math, utility value negatively related to subsequent change in same domain (β = -.59, p < .001), but not significantly predicted change in science (β = .06, p = .04). Finally, the changes in adolescents' math and science utility values were significantly and positively related (r = .38, p < .001).

Math and Science Motivational Beliefs Predicting STEM Major Choice

We hypothesized that having higher math and science motivational beliefs in 9th grade and smaller declines in the change of math and science motivational beliefs from 9th to 11th would positively predict adolescents declaring a STEM major in college. We examined this hypothesis by testing the latent change score model with the outcome of college major choice and regressed college major choice on both the change scores (paths d and g in Figure 2) and the two 9th grade scores (paths c and h in Figure 2) in math and science. As shown in Figure 3, adolescents' math and science ability self-concepts in 9th grade and the changes in adolescents' math and science ability self-concepts from 9th to 11th grade all positively predicted their STEM major choice in college (β = .12 and β = .15 for math and science ability self-concept in 9th grade respectively, and β = .11 and β = .09 for change, $p < .001$). This means that students who had higher math and science ability self-concepts and students who had a more positive change in math and science ability self-concepts from 9th to 11th grade are more likely to pursue a STEM degree. Similarly, as shown in Figure 4, adolescents' math and science intrinsic values at 9th grade and the changes in adolescents' math and science intrinsic values from 9th to 11th grade all significantly and positively predicted adolescents' STEM major choice in college (β = .12 and β = .14 for math science ability intrinsic values in 9th grade respectively, and β = .10 and β = .13 for change, $p < .001$). However, for utility value (Figure 5), only 9th grade and the changes of adolescents' science utility values significantly and positively predicted adolescents' STEM major choice (β = .20 and β = .19 respectively, $p < .001$); 9th grade and the changes of adolescents' math utility values did not significantly predict college major choice. In summary, both 9th grade and the changes in adolescents' math and science ability self-concepts and intrinsic values positively predicted their STEM major choice in college. And only science utility values but not math utility values was positively related to STEM major choice in college.

Parent Supportive Behaviors and Adolescent STEM Motivational Beliefs

We examined the relations between parent supportive behaviors, including both parents' school-based involvement and parents' STEM-specific support, and adolescents' math and science motivational beliefs in 9th grade and the changes in those beliefs from 9th to 11th grade by testing the latent change score models with two parental support indicators (see Figure 2). We hypothesized that adolescents whose parents evidenced higher school-based involvement and STEM-specific support would have higher math and science motivational beliefs in 9th grade and have smaller declines in their math and science motivational beliefs from 9th to 11th grade. In the ability self-concept model shown in Figure 3, parents' STEM-specific support was significantly and positively related to adolescents' math and science ability self-concepts in 9th grade ($\beta = .06$, $p < .01$, and $\beta = .08$, $p < .001$ respectively). In the intrinsic value model (Figure 4), parents' STEM-specific support was significantly and positively related to adolescents' science intrinsic values in 9th grade ($\beta = .09$, $p < .001$), but not math intrinsic values in 9th grade. In the utility value model, parents' STEM-specific support significantly predicted adolescents' science utility values in 9th grade ($\beta = .10$, $p < .001$) but not math utility values. In summary, parents' school-based involvement generally was not related to adolescents' math and science motivational beliefs, whereas parents' STEM-specific support was positively related to 9th grade science motivational beliefs.

The Intersection of Gender and College Generation Status

We examined the mean-level differences in adolescents' math and science motivational beliefs as well as the process-level differences in the relations between math and science motivational beliefs with predictors and outcomes at the intersection of gender and college generation status. We hypothesized that male continuing-generation college students would have the highest level of parental support, the highest math and science motivational beliefs, and will be most likely to declare a STEM college major, whereas female first-generation college students would be the lowest on these indicators. Mean-level ANOVA and chi-square analysis results

(Table 2) showed that parents of continuing-generation college students reported higher school-based and STEM-related support in 9^{th} grade than parents of first-generation college students. Within first-generation and continuing-generation college students, parents of sons provided more STEM-specific support in 9^{th} grade than parents of daughters. Aligned with our hypotheses, male continuing-generation college students had the highest math and science ability self-concepts in 9^{th} and 11^{th} grade and were more likely to choose STEM majors in college, whereas female first-generation college students had the lowest and were less likely to choose STEM major, and the other two groups were in the middle. The difference in adolescents' math and science intrinsic value across the four groups was mostly subtle and insignificant. As for utility value, male adolescents often scored higher than female adolescents within first-generation and continuing-generation college groups.

Process-level differences in the relations between focal variables were tested by examining if the paths of the latent change score model were significantly different across the four groups defined by first- and continuing-generation female and male college students. We conducted multi-group analysis on each of the latent change score models and constrained the paths shown in Figures 3 to 5 to see whether the paths were significantly different across the four groups. When we constrained all focal paths to be equal across the four groups, we found that the math and science ability self-concept model and intrinsic value models were not significantly different, $\Delta \chi^2 (60) = 69.375$, $p = .19$; $\Delta \chi^2 (60) = 69.197$, $p = .19$, 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 value in 9^{th} grade and the change score from 9^{th} to

11th were significant and positive across the four groups. Though different in scale, the correlations were the strongest for female first-generation and continuing-generation college students, *r* = .72 and .57, respectively. The paths from math and science utility value in 9th grade and the changes from 9th to 11th grade to STEM major choices were significantly different across the four groups. Ninth grade and the changes in math utility value only significantly related to later STEM major choice for male continuing-generation college students and no other groups. Science utility values in 9th were significantly related to STEM major choice for all groups, but the relation was significantly weaker in scale for female first-generation college students. The changes in science utility value were significantly related to STEM major choice for most of the groups except for first-generation college students. Overall, mean-level differences were found for parental support, math and science ability self-concept, and STEM major choice 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 Check Analysis

We conducted two robustness check analyses to test the robustness of the results. For the first robustness check, we re-estimated the three models in Figures 2 - 4 for participants who had data in the last round of data collection (n = 8,260). And for the second robustness check, we re-estimated 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 analysis results were very similar to the main analysis (Figure S1-S6). Paths that were different between the main and robustness check analyses were at the $p < .05$ level, which was not reported as significant in this study.

Discussion

Taking a developmental perspective, this paper examined the dual change processes of adolescents' math and science motivational beliefs from 9^{th} to 11^{th} grade and how their beliefs were related to parental support and their STEM college major choice seven years later. This paper extended the literature by examining the relations between math and science motivational beliefs as they develop together during high school. While prior literature on parent involvement in school and parent support of youth's math and science motivation both suggest that each of these types of parent support were effective (e.g., Castro et al., 2015; Simpkins et al., 2015), this study examined both to examine which one might matter more and if these supports help buffer against the typical declines in adolescents' math and science motivational beliefs in high school. Little research, to our knowledge, has examined the disparities in math and science motivation, parental support, and STEM choice at the intersection of gender and college generation status. This paper fills the gap in the literature by examining the mean-level differences in parental support, math and science motivational beliefs in 9^{th} and 11^{th} grade, and STEM major choice, as well as the process-level differences in the relations between focal variables.

The Changes in Math and Science Motivational Beliefs

Previous studies have found that adolescents' motivational beliefs in academic domains (e.g., math, English; e.g., Dotterer et al., 2009; Wigfield et al., 2015) typically decline during high school, with exceptions in domains such as biology that sometimes demonstrate increases (Hsieh et al., 2019). Our results confirmed that math and science ability self-concepts and math intrinsic values tended to decline during high school, but science intrinsic values remained stable, and math and science utility values increased during high school. It is possible that even though adolescents get less confident in math and science, they place more importance on math and science towards the end of high school when they need to think about graduation and college, where math and science grade is essential. Our results suggest that different types of motivational beliefs did not develop in a similar way; rather, they could change in opposite directions during high school. These findings highlight the need to examine specific motivational beliefs when studying the development of math and science motivational beliefs since they are theoretically distinct and serve different functions (Eccles & Wigfield, 2020).

We found that adolescents' math and science motivational beliefs were interconnected, such that having high motivational beliefs in one domain helped slow declines or supported increases in the other domain (Eccles, 2009; Möller & Marsh, 2013). This result supported the dimensional comparison theory that motivational beliefs of math and science are complementary domains that positively affect each other during high school. Some scholars argue that math is the gateway domain to future science learning and choice (Shapka et al., 2006; Watt et al., 2017). Our results supported this idea and extended that the relation between math and science is not unidirectional but rather reciprocal, where science ability self-concepts and values could also support the development of math motivational beliefs during high school.

Another major contribution of this paper is that we found that not only did the level of adolescents' 9th grade math and science motivational beliefs predict the odds they would select STEM as a college major, but the changes in their math and science motivational beliefs from 9th to 11th grade also predicted these odds after controlling for math score and English GPA. Adolescents who had smaller declines in their math and science ability self-concept and intrinsic value or larger increases in their science utility values were more likely to choose a STEM major compared to their peers; these relations emerged even after accounting for the level of adolescents' beliefs in 9th grade. These findings underscore examining the developmental changes in adolescents' math and science motivational beliefs and their correlations.

Interventions that follow adolescents throughout high school may be more effective in supporting adolescents' STEM major choice than interventions at one time point. Another interesting finding of this paper is that only science utility value predicted college major choice. This finding aligned with prior literature that science utility value directly predicted STEM major choice while math utility value predicted STEM major choice through high school GPA and courses (Jiang 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 Supportive Behaviors in Relation to Adolescent STEM Motivation

This paper examined how parents' school-based involvement and parents' STEM-specific support related to adolescents' 9^{th} grade math and science motivational beliefs and the changes in adolescents' math and science motivational beliefs from 9^{th} to 11^{th} grade. We found that compared to parents' school-based involvement, parents' STEM-specific support, including doing science projects together, was more likely to be positively related to adolescents' science motivational beliefs at 9^{th} grade, which in turn positively predicted STEM major choice. Parents' STEM support is more predictive could be due to that it aligns more with the academic socialization type of parental support (e.g., discussing a program or article about math, science, or technology), which was found to be more predictive than school-based involvement (Hill & Tyson, 2009). Our findings align with prior literature of both correlational studies and experimental studies that parents' STEM-specific support could support adolescents' confidence, trigger their interest, and help them learn the value of studying science (e.g., Harackiewicz et al., 2012; Simpkins et al., 2015, 2020). However, we found cross-sectional links between parents'

STEM-specific support and adolescents' math and science motivational beliefs, but not longitudinal links. This could be because that support from more socializers would be more helpful as adolescents' math and science develop. Prior research has found that adolescents who were supported by multiple people, such as teachers and peers, were more likely to have a positive change in science motivation in high school (Simpkins et al., 2020). We also found that parents' STEM-specific support was related more consistently to science than math. Because three of the four categories in STEM, namely science, technology, and engineering, all fall within the broad domain of science. Thus, parents' STEM-specific support falls more into the broad domain of science versus the broad domain of math. Given the importance of science motivational beliefs on STEM major choice, our results suggest that future interventions could consider targeting parents' STEM-specific support and getting parents involved in STEM-specific activities to support adolescents' STEM choices (Harackiewicz et al., 2012).

The Intersection of Gender and College Generation Status

To understand and promote marginalized adolescents' STEM success, this study examined the development of math and science motivational beliefs at the intersection of gender and college generation status. Our findings suggest that the mechanism of gender and college generation status on adolescents' math and science ability self-concepts was addictive, meaning that being both female and first-generation college student would aggregate the marginalization of being a member of either social group making female first-generation adolescents the most marginalized in math and science. Our results highlight the importance of examining gender differences within the social context of other social categories. For example, we found consistent gender differences for parents' STEM-specific support, math and science ability self-concept, and STEM major choice within the groups of first-generation and continuing-generation college students. However, these gender differences did not consistently hold for parents' school-based involvement and math and science intrinsic value and utility value. For parents' school-based involvement and math and science intrinsic value and utility value, the lack of parent social capital of college-going experience could play a more important role than gender role stereotype, so gender differences were not salient in these indicators (Sandefur et al., 2006). Our results demonstrated the importance of examining gender differences within the context of other social factors to fully understand gender differences in adolescents' STEM motivation and choice.

We found subtle differences across the four groups in the relations between focal variables. Two out of three motivational beliefs models were not different across four groups, which supports that the relations between parental support, math and science motivational beliefs, and outcomes might function similarly for groups at the intersection of gender and first-generation college status. Among the few exceptions, we found that math and science motivational beliefs consistently and positively predicted STEM major choice for male continuing-generation college students compared to other groups. When male continuing-generation college students made their college major choice using their math and science utility value, other groups might consider 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). Male continuing-generation college students theoretically may also experience the least amount of discrimination and structural barriers; thus, their utility value might be more predictive because they have fewer constraints (Pascarella et al., 2017; Wigfield et al., 2015). More research is needed for marginalized groups of female and first-generation adolescents to understand their high school and college experience and their reasons for pursuing or not pursuing STEM.

Limitations and Future Directions

This paper extended the literature by examining the individual and contextual factors that promote marginalized adolescents' math and science motivation and STEM choice. However, limitations need to be taken into account when interpreting the results. Although quantitative data has the advantage of testing longitudinal relations and group differences, it provides less insight into actual developmental processes. Qualitative research is needed to obtain a more comprehensive picture of the development of math and science motivational beliefs and STEM choice. For example, what contextual factors led to increased utility value and decreased ability self-concept. More social contextual factors need to be considered, such as peer relations, school climate, and teacher relations. Moreover, qualitative studies are needed to understand the nuance in how parents implement parental support—for example, asking parents to describe their experiences with teachers and their conversations while helping children with their science projects would provide a better picture of how parents interact with adolescents in STEM (Pomerantz et al., 2007).

We examined the disparities in 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 the group they belonged to and not based on the extent to which they identified with these groups. Future studies could gather self-identified data on gender and college generation status to learn more about adolescents' social identities. With adolescents' identities on these social factors, adolescents could be grouped into more accurate social groups.

Conclusion

This study examined the dual change process of math and science motivational beliefs during high school. We found that not all math and science motivational beliefs declined during high school (utility value increased). Our results suggest math and science are complementary domains that support the development of each other. Another significant contribution is that this paper is among the first to examine math and science motivational beliefs at the intersection of gender and college generation status. We found mean-level differences among these students that can be traced back to the beginning of high school, including parental support, math and science motivational beliefs, that then are carried forward to whether they declare a STEM major seven years later in college. However, the process-level differences in the relations between focal variables were rarer, suggesting that interventions on parenting or motivation might have similar effects. This paper 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. Also, this paper 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.

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Tables and figures

Table 1

Descriptive Statistics and Correlations among Key Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
9th grade parent indicators															
1. Parent school-based involvement	-														
2. Parent STEM-specific support	.28***	-													
9th grade motivational beliefs															
3. Math self-concept of ability	.03*	.08***	-												
4. Math utility value	-.02	.04**	.36***	-											
5. Math intrinsic value	.03*	.06***	.46***	.46***	-										
6. Science self-concept of ability	.03*	.10***	.40***	.17***	.19***	-									
7. Science utility value	.02	.08***	.19***	.41***	.28***	.37***	-								
8. Science intrinsic value	.02	.09***	.17***	.23***	.28***	.46***	.52***	--							
11th grade motivational beliefs															
9. Math self-concept of ability	.02	.06***	.37***	.17***	.20***	.25***	.13***	.14***	-						
10. Math utility value	.00	.06***	.23***	.31***	.22***	.13***	.19***	.15***	.40***	-					
11. Math intrinsic value	.01	.06***	.26***	.23***	.30***	.15***	.17***	.21***	.56***	.46***	-				
12. Science self-concept of ability	.03**	.10***	.21***	.10***	.11***	.30***	.13***	.16***	.29***	.17***	.15***	-			
13. Science utility value	.01	.08***	.17***	.18***	.16***	.25***	.34***	.24***	.25***	.43***	.25***	.38***	-		
14. Science intrinsic value	.03*	.08***	.11***	.12***	.15***	.17***	.19***	.22***	.15***	.17***	.22***	.58***	.44***	-	
15. STEM college major	-.01	.07***	.18***	.09***	.10***	.20***	.14***	.13***	.23***	.18***	19***	.18***	.24***	.17***	--
M	3.30	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	.23
SD	1.73	1.45	.66	.62	.70	.63	.62	.71	.71	.59	.74	.73	.64	.75	.42
Skewness	-.15	-.04	-.35	-.54	-.45	-.22	-.33	-.47	-.30	-.56	-.22	-.29	-.39	-.41	1.28
Kurtosis	2.11	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.

*$p < .05$. **$p < .01$. ***$p < .001$.

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Table 2

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

Indicator	Female first-generation college students (F-FG) (n = 1,590) *M(SD)*	Male first-generation college students (M-FG) (n = 1,220) *M(SD)*	Female continuing-generation college students (F-CG) (n = 3,580) *M(SD)*	Male continuing-generation college students (M-CG) (n = 3,450) *M(SD)*	Statistical significance (ANOVA F-test or Chi-square results)	Significant comparisons
9th grade parent indicators						
School-based Involvement	2.91 (1.71)^{a}	2.91 (1.70)^{a}	3.76 (1.60)^{b}	3.79 (1.62)^{b}	172.72***	F-FG, M-FG < F-CG, M-CG
STEM-specific support	2.78 (1.50)^{a}	2.97 (1.51)^{b}	3.13 (1.40)^{c}	3.44 (1.40)^{d}	83.97***	F-FG < M-FG < F-CG < M-CG
9th grade motivational beliefs						
Math self-concept of ability	2.90 (.63)^{a}	3.06 (.61)^{c}	2.98 (.63)^{b}	3.13 (.61)^{d}	58.58***	F-FG < F-CG <M-FG < M-CG
Math utility value	3.19 (.58)^{a}	3.24 (.59)^{a}	3.08 (.61)^{b}	3.17 (.61)^{a}	26.26***	F-CG < F-FG, M-FG, M-CG
Math intrinsic value	2.95 (.66)^{a}	2.90 (.68)^{a}	2.92 (.66)^{a}	2.92 (.67)^{a}	1.20	
Science self-concept of ability	2.78 (.60)^{a}	2.91 (.61)^{b}	2.86 (.61)^{b}	3.06 (.60)^{c}	86.23***	F-FG < M-FG, F-CG < M-CG
Science utility value	2.96 (.60)^{a}	2.94 (.61)^{a}	2.95 (.59)^{a}	2.96 (.61)^{a}	0.48	
Science intrinsic value	2.91 (.67)^{ab}	2.91 (.70)^{ab}	2.90 (.69)^{a}	2.96 (.70)^{b}	4.11**	F-CG < M-CG
11th grade motivational beliefs						
Math self-concept of ability	2.71 (.71)^{a}	2.89 (.69)^{c}	2.78 (.71)^{b}	2.98 (.66)^{d}	69.62***	F-FG < F-CG <M-FG < M-CG
Math utility value	3.29 (.57)^{ac}	3.34 (.58)^{ab}	3.27 (.58)^{c}	3.35 (.58)^{b}	12.48***	F-FG, F-CG < M-FG, M-CG
Math intrinsic value	2.68 (.75)^{a}	2.71 (.76)^{a}	2.69 (.73)^{a}	2.74 (.72)^{a}	2.76	
Science self-concept of ability	2.78 (.69)^{a}	2.89 (.69)^{b}	2.80 (.74)^{a}	3.01 (.69)^{c}	64.58***	F-FG, F-CG < M-FG, < M-CG
Science utility value	3.10 (.61)^{ab}	3.06 (.63)^{a}	3.11 (.62)^{b}	3.14 (.64)^{b}	5.95***	M-FG < F-CG, M-CG
Science intrinsic value	2.91 (.73)^{ab}	2.87 (.74)^{a}	2.88 (.78)^{a}	2.95 (.76)^{b}	4.79**	M-FG < F-CG, M-CG
STEM outcomes						
STEM college major	.11 (.32)^{a}	.27 (.44)^{c}	.18 (.39)^{b}	.34 (.48)^{d}	$^{+}$386.89***	F-FG < F-CG <M-FG < M-CG

Note. Within rows, means with dissimilar superscripts are significantly different at $p < .05$. $^{+}$denotes chi-square test results.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 3

Significant Utility Value Paths Difference across the Intersection of Gender and College Generation Status

SEM path that varied by group	Female first-generation college students (F-FG) (n = 1,590) *M(SD)*	Male first-generation college students (M-FG) (n = 1,220) *M(SD)*	Female continuing-generation college students (F-CG) (n = 3,850) *M(SD)*	Male continuing-generation college students (M-CG) (n = 3,450) *M(SD)*	Statistical significance ($\Delta\ \chi^2$)	Significant comparisons
Correlations						
9th grade science utility value WITH 9th grade math utility value	.72(.05)^{***b}	.57(.08)^{***a}	.36(.05)^{***a}	.46(.04)^{***a}	98.72***	M-FG, F-CG, M-CG < F-FG
Changes in science utility value WITH changes in math utility value	.52(.06)^{***b}	.15(.09)^{**a}	.36(.04)^{***a}	.41(.04)^{***ab}	21.82***	F-CG, M-CG < F-FG
Paths from values to college major choice						
9th grade math utility value TO STEM college major	-.001(.038)^{a}	-.06(.078)^{a}	.02(.033)^{ab}	.15(.049)^{**b}	12.204**	F-FG, M-FG < M-CG
Changes in math utility value TO STEM college major	.04(.032)^{ab}	-.03(.072)^{a}	-.03(.030)^{a}	.12(.037)^{**b}	12.468**	M-FG, F-CG < M-CG
9th grade science utility value TO STEM college major	.10(.035)^{**a}	.32(.111)^{**b}	.20(.033)^{***ab}	.15(.050)^{**ab}	11.519**	F-FG < M-FG
Changes in science utility value TO STEM college major	.00(.031)^{a}	.16(.068)^{*b}	.14(.025)^{***b}	.20(.034)^{***b}	16.262**	F-FG < M-FG, F-CG, M-CG

Note. Within rows, means with dissimilar superscripts are significantly different at $p < .05$.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

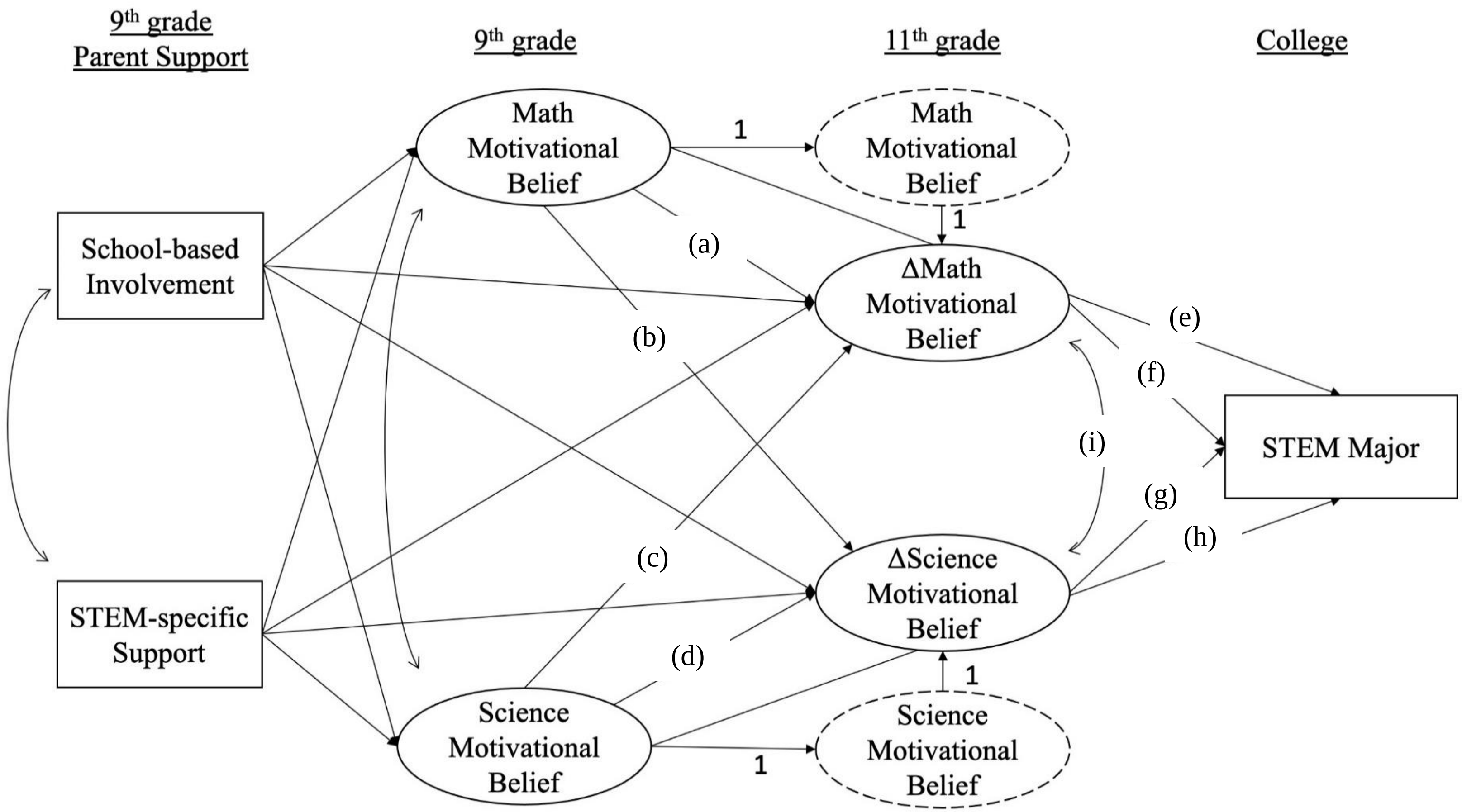

Figure 2. The concept map of the multivariate Latent Change Score model between math and science motivational beliefs. Model controlled for family income, students' ethnicity, 9th grade math achievement, and high school English GPA.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

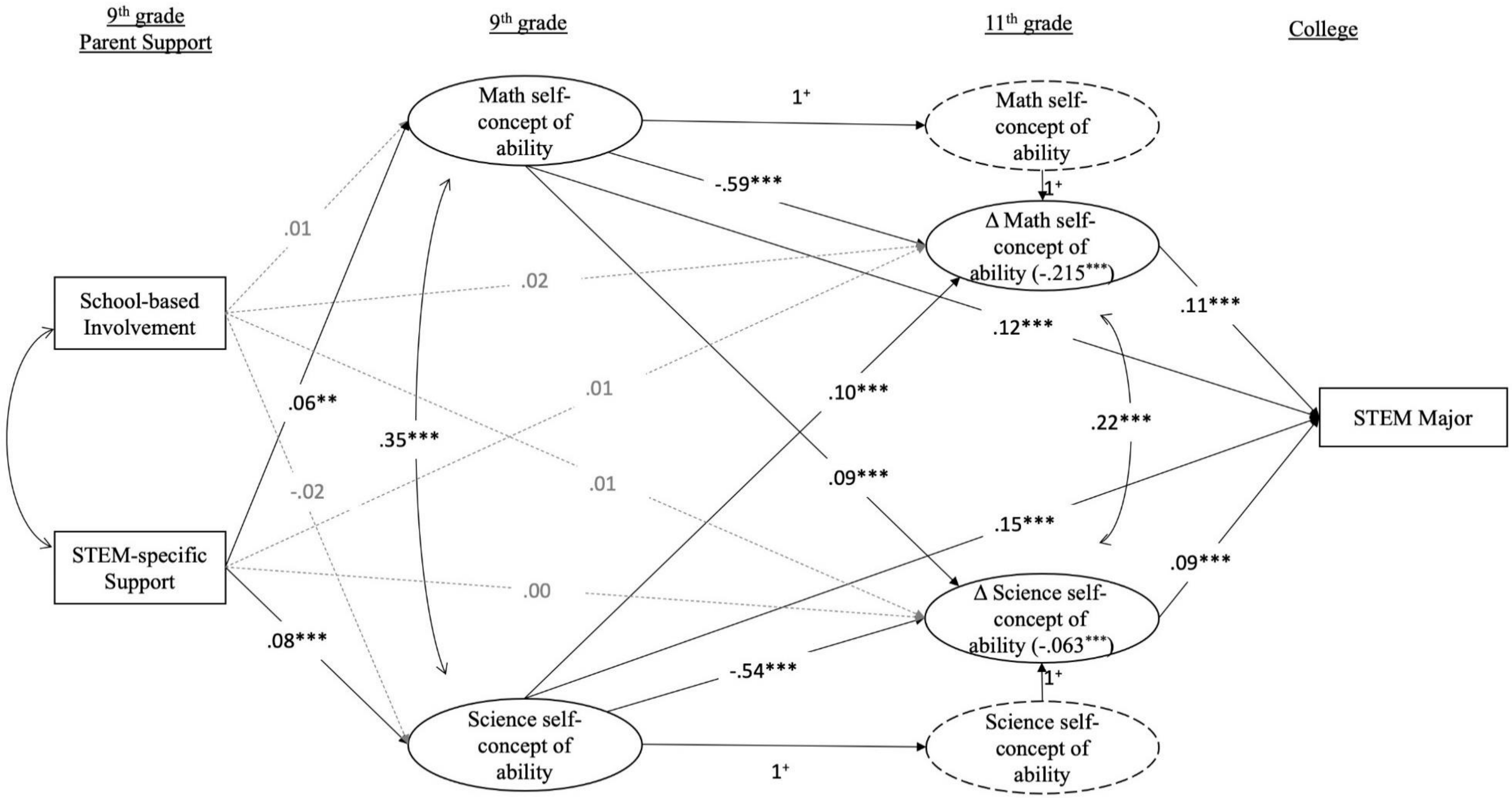

Figure 3. Standardized coefficients of the predictive paths in the multivariate Latent Change Score model between math and science self-concept of ability with predictors and outcomes. Dotted grey lines were nonsignificant paths. +denoted that paths were fixed to 1. Model controlled for family income, students' ethnicity, 9th grade math achievement, and high school English GPA.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
$*p < .05$. $**p < .01$. $***p < .001$.

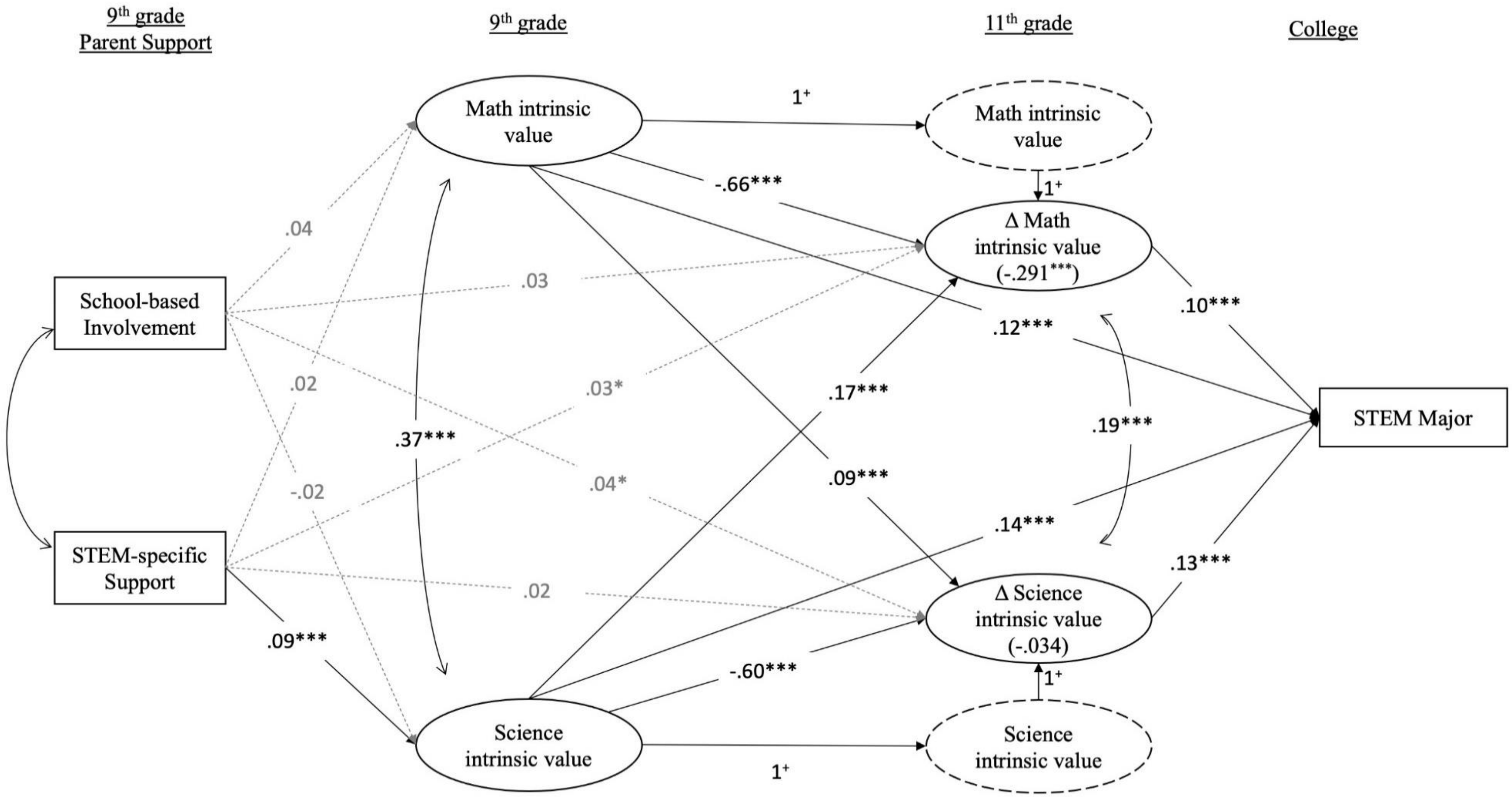

Figure 4. Standardized coefficients of the predictive paths in the multivariate Latent Change Score model between math and science intrinsic value with predictors and outcomes. Dotted grey lines were nonsignificant paths. +denoted that paths were fixed to 1. Model controlled for family income, students' ethnicity, 9th grade math achievement, and high school English GPA.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
*$p < .05$. **$p < .01$. ***$p < .001$.

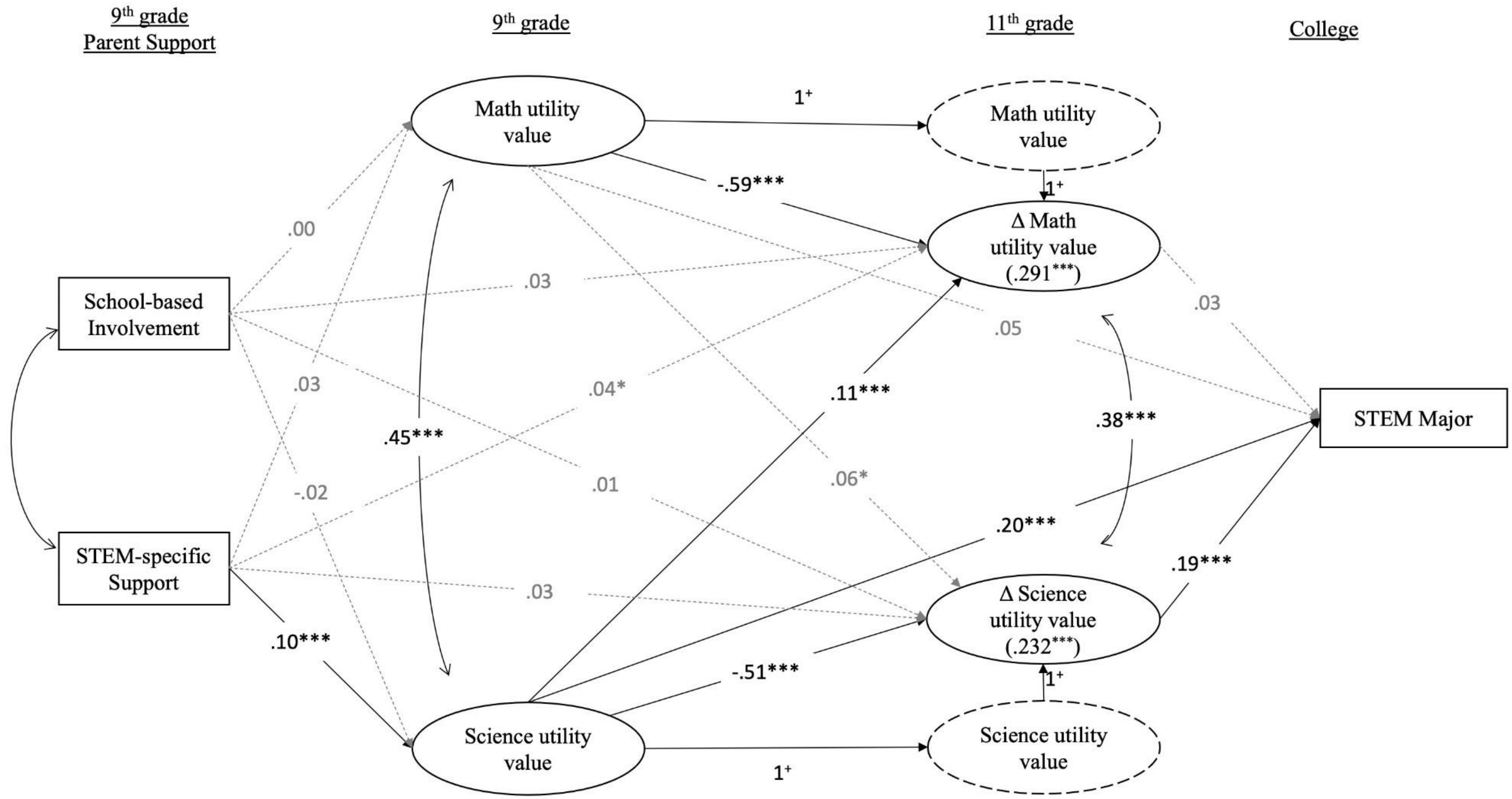

Figure 5. Standardized coefficients of the predictive paths in the multivariate Latent Change Score model between math and science utility value with predictors and outcomes. Dotted grey lines were nonsignificant paths. $^+$denoted that paths were fixed to 1. Model controlled for family income, students' ethnicity, 9th grade math achievement, and high school English GPA.

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

*p < .05. **p < .01. ***p < .001.

Supplemental Materials

Table S1

Comparisons between Analytic and Excluded Samples

Measurements	Analysis sample N	Mean	SD	Min	Max	Excluded sample N	Mean	SD	Min	Max	*t*-test or Chi-square test	Effect size
9th grade parent indicators												
School-based involvement	9480	3.54	1.68	0.00	6.00	6010	2.92	1.75	0.00	6.00	22.11***	.36
STEM-specific support	9570	3.17	1.44	0.00	6.00	6050	2.93	1.47	0.00	6.00	10.01***	.16
9th grade motivational beliefs												
Math self-concept of ability	11030	3.01	0.64	1.00	4.00	8060	2.83	0.70	1.00	4.00	18.60***	.27
Math utility value	10980	3.15	0.61	1.00	4.00	8000	3.14	0.64	1.00	4.00	0.47	.01
Math intrinsic value	11040	2.91	0.67	1.00	4.00	8070	2.79	0.73	1.00	4.00	11.94***	.17
Science self-concept of ability	10330	2.91	0.62	1.00	4.00	7240	2.76	0.65	1.00	4.00	15.48***	.24
Science utility value	10260	2.95	0.60	1.00	4.00	7200	2.87	0.64	1.00	4.00	7.54***	.12
Science intrinsic value	10330	2.92	0.69	1.00	4.00	7260	2.80	0.72	1.00	4.00	10.72***	.16
11th grade motivational beliefs												
Math self-concept of ability	11220	2.84	0.70	1.00	4.00	8880	2.69	0.72	1.00	4.00	14.91***	.21
Math utility value	11210	3.30	0.58	1.00	4.00	8920	3.25	0.60	1.00	4.00	6.96***	.10
Math intrinsic value	11230	2.70	0.73	1.00	4.00	8900	2.57	0.75	1.00	4.00	12.59***	.18
Science self-concept of ability	11170	2.87	0.72	1.00	4.00	8800	2.74	0.73	1.00	4.00	12.83***	.18
Science utility value	11180	3.11	0.63	1.00	4.00	8910	2.98	0.65	1.00	4.00	13.65***	.19
Science intrinsic value	11180	2.90	0.76	1.00	4.00	8830	2.79	0.75	1.00	4.00	10.07***	.14
Covariates												
Female	12070	0.54	0.50	0.00	1.00	13080	0.44	0.50	0.00	1.00	241.78***	.05[a]
Caucasian	12070	0.57	0.50	0.00	1.00	11170	0.48	0.50	0.00	1.00	167.36***	.01[a]
Hispanic	12070	0.14	0.35	0.00	1.00	11170	0.20	0.40	0.00	1.00	143.34***	-.04[a]
African American	12070	0.09	0.29	0.00	1.00	11170	0.14	0.34	0.00	1.00	96.00***	-.03[a]
Asian	12070	0.10	0.30	0.00	1.00	11170	0.08	0.28	0.00	1.00	14.66***	-.08[a]

Other ethnicities	12070	0.10	0.30	0.00	1.00	11170	0.10	0.29	0.00	1.00	0.07	.01[a]
First-generation college students	10110	0.28	0.45	0.00	1.00	6810	0.54	0.50	0.00	1.00	944.44***	-.24[a]
Parent highest education	10160	3.63	1.53	1.00	7.00	6820	2.78	1.37	1.00	7.00	36.60***	.57
Family income	10160	5.17	3.13	1.00	13.00	6790	3.83	2.72	1.00	13.00	28.71***	.45
Math achievement in 9th grade	12070	54.01	9.51	24.10	82.19	9380	47.37	9.54	24.02	79.53	50.62***	.67
High school English GPA	11500	2.91	0.78	0.00	4.00	10270	2.20	0.97	0.00	4.00	59.73***	.81

Note. Effect sizes are Cohen's *d* for continuous variables: small effect .10, moderate effect .30, large effect .80. Independent sample *t*-tests were used for continuous variables, and Chi-square tests were used for dichotomous variables. The Ns were rounded to the nearest ten according to the IES restricted-use data guidelines.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
[a]indicates effect sizes that are phi coefficients: small effect .10, moderate effect .30, large effect .50.
$*p < .05$. $**p < .01$. $***p < .001$.

Table S2

Items of the Focal Measures

Constructs	Items
Self-concept of ability	How much do you agree or disagree with the following statements about your [fall 2009/spring 2012] [math/science] course? (Strongly agree, Agree, Disagree, or Strongly disagree) 1. You are confident that you can do an excellent job on tests in this course 2. You are certain that you can master the skills being taught in this course 3. You are confident that you can do an excellent job on assignments in this course 4. You are certain that you can understand the most difficult material presented in the textbook used in this course
Utility value	How much do you agree or disagree with the following statements about the usefulness of your [fall 2009/spring 2012] [math/science] course? What students learn in this course (Strongly agree, Agree, Disagree, or Strongly disagree) 1. is useful for everyday life. 2. will be useful for college. 3. will be useful for a future career.
Intrinsic value	How much do you agree or disagree with the following statements about your [fall 2009/spring 2012] [math/science course]? (Strongly agree, Agree, Disagree, or Strongly disagree) 1. You are enjoying this class very much 2. You think this class is a waste of your time 3. You think this class is boring
Parent school-based involvement	Since the beginning of this school year (2009-2010), have you or other adults in your household...(Yes, No) attended a general school meeting such as an open house or a back-to-school night? attended a meeting of the parent-teacher organization or association? gone to a regularly scheduled parent-teacher conference with [your 9th grader]'s teacher? attended a school or class event such as a play, dance, sports event or science fair because of [your 9th grader]?

	served as a volunteer in [your 9th grader]'s classroom or elsewhere in the school? participated in fundraising for the school?
Parent STEM-specific support	During the last 12 months, which of the following activities have you or another family member done with [your 9th grader]? (Check all that apply.) Visited a zoo, planetarium, natural history museum, transportation museum, or a similar museum Worked or played on a computer together Built or fixed something such as a vehicle or appliance Attended a school science fair Helped [your 9th grader] with a school science fair project Discussed a program or article about math, science, or technology
College STEM majors	What was your major or field of study for your [bachelor's degree/associate's degree/ [first/second/third etc.] certificate/degree or certificate] from [college/trade school attended]? STEM major included majors as follows: Agriculture, Agriculture Operations, and Related Sciences Natural Resources and Conservation Computer and Information Sciences and Support Services Engineering Engineering Technologies/Technicians Biological and Biomedical Sciences Mathematics and Statistics Multi/Interdisciplinary Studies Military Technologies and Applied Science Physical Sciences Science Technologies/Technicians
Gender	What is your sex? Male Female
Ethnicity	Are you Hispanic or [Latino/Latina]? Yes

	No
	[In addition to learning about your Hispanic background, we would also like to know about your racial background.] Which of the following choices describe your race? You may choose more than one. (Check all that apply.)
	White
	Black or African American
	Asian
	Native Hawaiian or other Pacific Islander
	American Indian or Alaska Native
Parents' highest education	What is the highest level of education [you have/parent #1 has] completed?
	Less than high school
	High school diploma or GED
	Associate's degree
	Bachelor's degree
	Master's degree
	Educational Specialist diploma
	Ph.D., M.D., law degree, or other high level professional degree
	What is the highest level of education [parent #2] has completed?
	Less than high school
	High school diploma or GED
	Associate's degree
	Bachelor's degree
	Master's degree
	Educational Specialist diploma
	Ph.D., M.D., law degree, or other high level professional degree
Family income	Income is a key family characteristic that factors into many research questions including how family finances affect students' ability to go to college. This information is critically important to the success of this study and will be kept completely confidential.
	What was your total household income from all sources prior to taxes and deductions in calendar year 2008? Please include all income such as income from work, investments and alimony.
	* We understand that you may not be able to provide an exact number for your family's income. However, it would be extremely helpful if you would indicate which of the following ranges best

estimates your total household income from all sources prior to taxes and deductions in calendar year 2008. Please include all income such as income from work, investments and alimony.
$15,000 or less
$15,001 - $35,000
$35,001 - $55,000
$55,001 - $75,000
$75,001 - $95,000
$95,001 - $115,000
$115,001 - $135,000
$135,001 - $155,000
$155,001 - $175,000
$175,001 - $195,000
$195,001 - $215,000
$215,001 - $235,000
More than $235,000

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Table S3

Time Invariance Tests of Math and Science Motivational Beliefs from 9th grade to 11th grade

Model tested	χ2	*df*	*p*	RMSEA	RMSEA 90% CI	CFI	ΔCFI
Self-concept of ability							
Configural invariance	5891.641	90	.000	.053	[.052; .054]	.971	—
Weak invariance	6037.013	96	.000	.052	[.051; .053]	.971	.000
Strong invariance	6402.751	102	.000	.052	[.051; .053]	.969	.002
Intrinsic value							
Configural invariance	3993.256	42	.000	.064	[.062; .066]	.951	—
Weak invariance	4058.537	46	.000	.062	[.060; .063]	.950	.001
Strong invariance	4531.355	50	.000	.062	[.061; .064]	.955	.005
Utility value							
Configural invariance	6259.211	42	.000	.080	[.079; .082]	.932	—
Weak invariance	6433.195	46	.000	.078	[.076; .079]	.930	.002
Strong invariance	8618.884	50	.000	.082	[.080; .084]	.922	.008

Note. The criteria for passing measurement invariance is ΔCFI < .01 (Cheung & Rensvold, 2002).
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Table S4

Group Invariance Tests of Math and Science Motivational Beliefs in 9th and 11th grade across the four groups at the intersection of gender and generation college status

Model tested	χ2	*df*	*p*	RMSEA	RMSEA 90% CI	CFI	ΔCFI
Self-concept of ability							
Configural invariance	4761.763	360	.000	.054	[.053; .056]	.971	—
Weak invariance	4888.932	396	.000	.052	[.051; .054]	.970	.001
Strong invariance	5481.362	432	.000	.053	[.052; .054]	.966	.003
Utility value							
Configural invariance	4961.992	168	.000	.083	[.081; .085]	.929	—
Weak invariance	5064.130	192	.000	.078	[.077; .080]	.928	.001
Strong invariance	5321.975	216	.000	.076	[.074; .077]	.925	.003
Intrinsic value							
Configural invariance	3054.784	168	.000	.064	[.062; .066]	.954	—
Weak invariance	3217.700	192	.000	.062	[.060; .064]	.952	.002
Strong invariance	3737.499	216	.000	.063	[.061; .065]	.944	.008

Note. The criteria for passing measurement invariance is ΔCFI < .01 (Cheung & Rensvold, 2002).

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

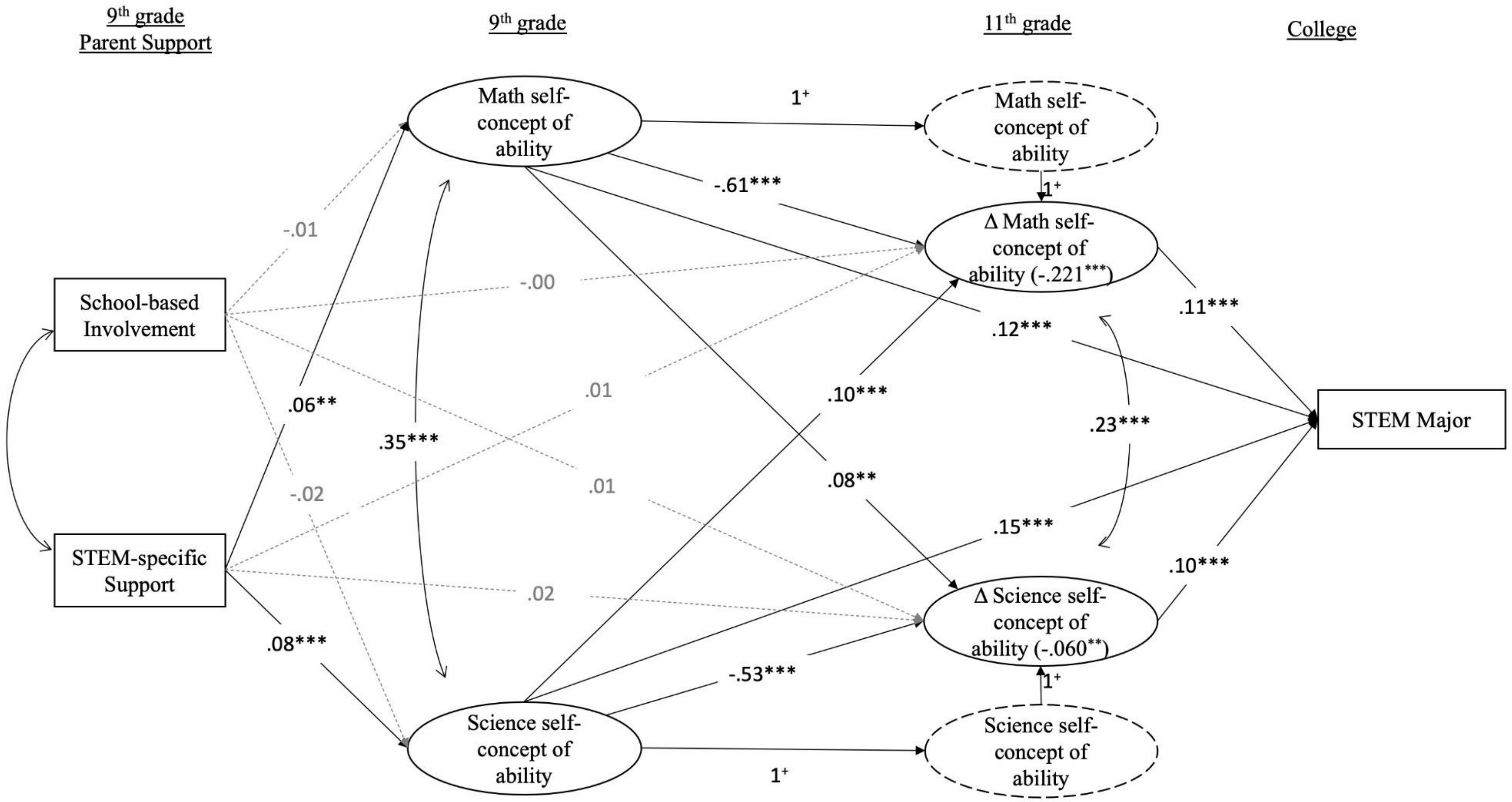

Figure S1. *n* = 8,260. Standardized coefficients of the predictive paths in the multivariate Latent Change Score model between math and science self-concept of ability with predictors and outcomes. Dotted grey lines were nonsignificant paths. $^{+}$denoted that paths were fixed to 1. Model controlled for family income, students' ethnicity, 9th grade math achievement, and high school English GPA. SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
**p* < .05. ***p* < .01. ****p* < .001.

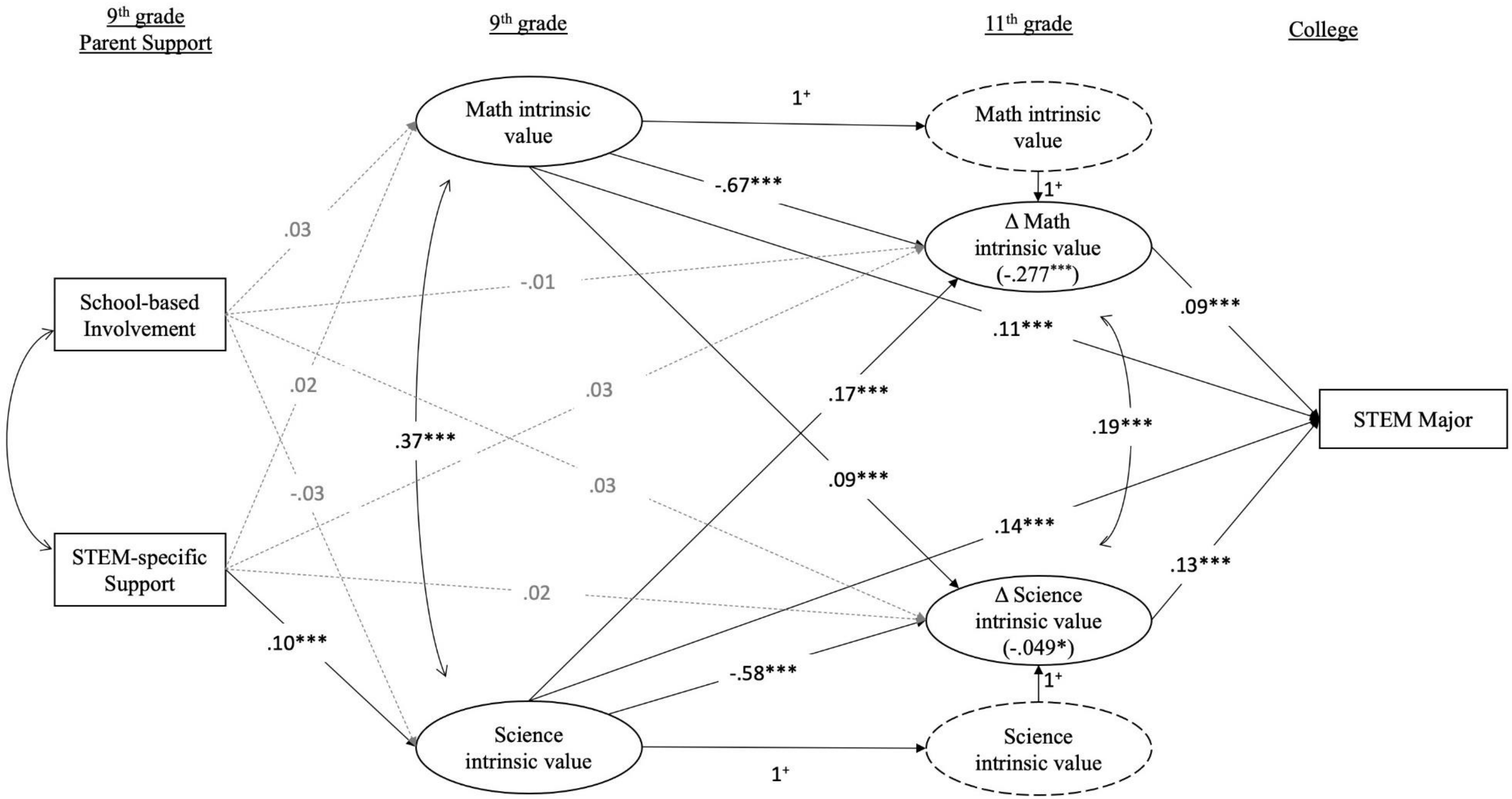

Figure S2. n = 8,260. Standardized coefficients of the predictive paths in the multivariate Latent Change Score model between math and science intrinsic value with predictors and outcomes. Dotted grey lines were nonsignificant paths. $^{+}$denoted that paths were fixed to 1. Model controlled for family income, students' ethnicity, 9th grade math achievement, and high school English GPA.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

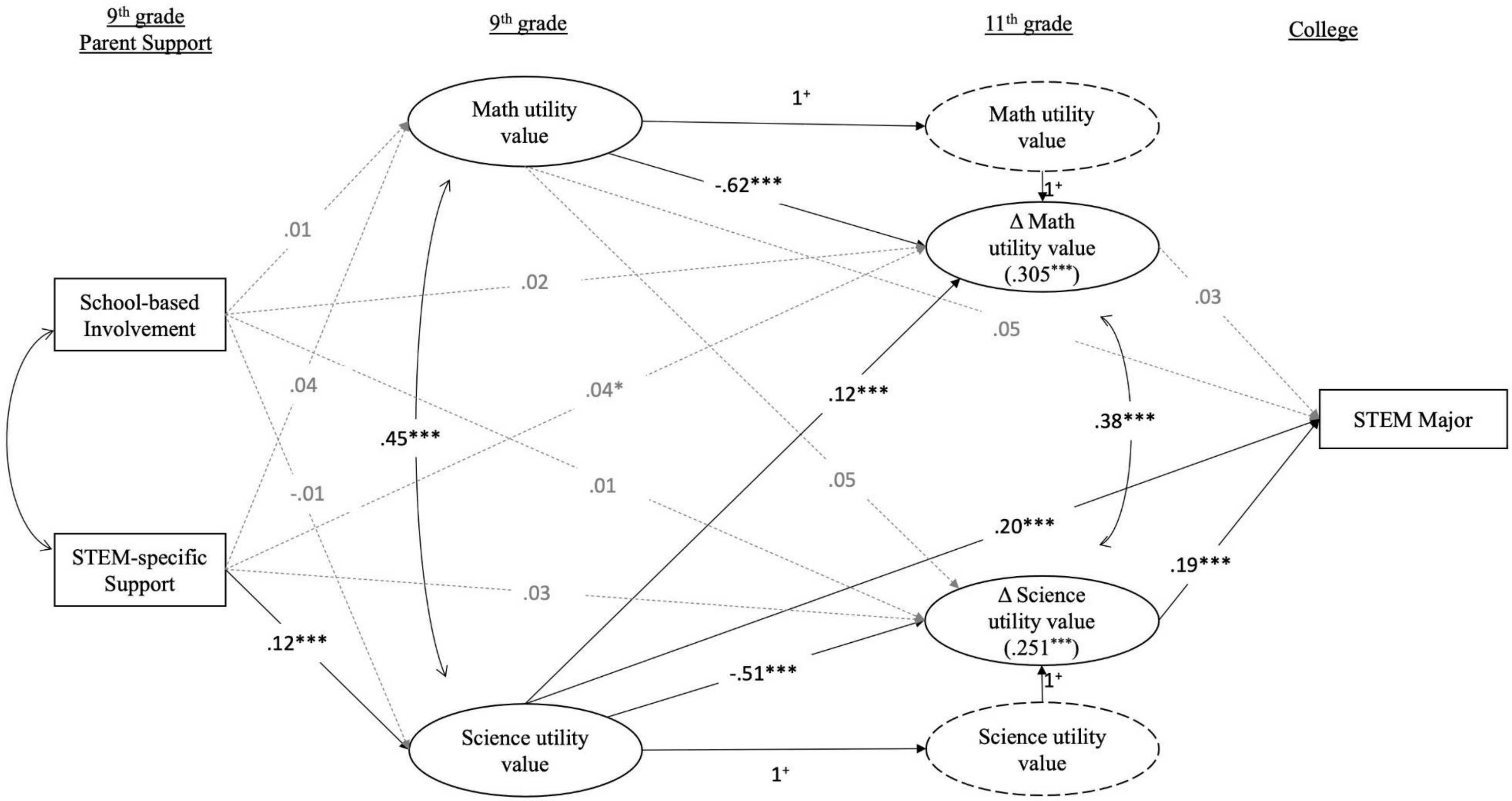

Figure S3. $n = 8{,}260$. Standardized coefficients of the predictive paths in the multivariate Latent Change Score model between math and science utility value with predictors and outcomes. Dotted grey lines were nonsignificant paths. $^{+}$denoted that paths were fixed to 1. Model controlled for family income, students' ethnicity, 9th grade math achievement, and high school English GPA.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

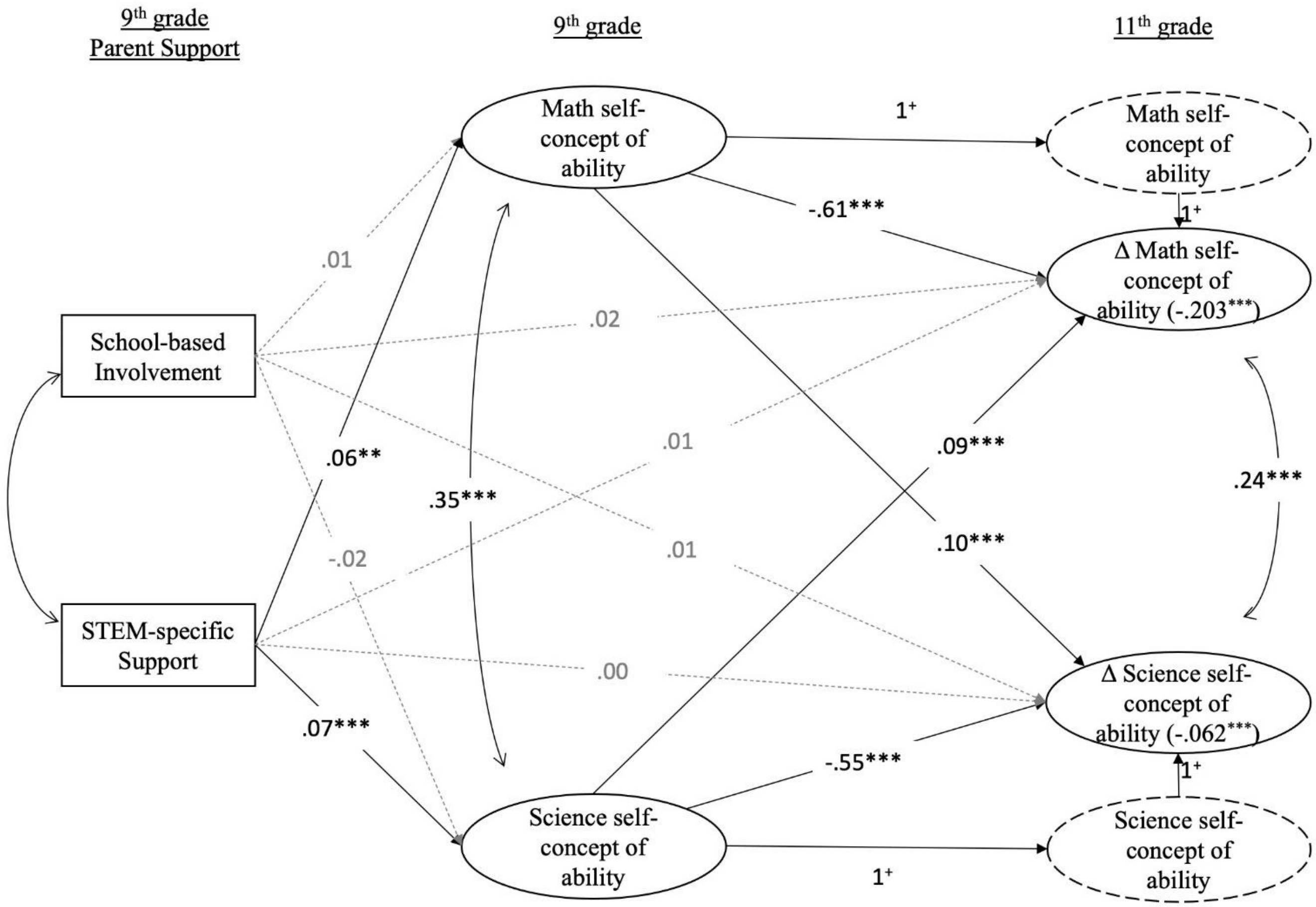

Figure S4. n = 20,930. Standardized coefficients of the predictive paths in the multivariate Latent Change Score model between math and science self-concept of ability with predictors and outcomes. Dotted grey lines were nonsignificant paths. $^{+}$denoted that path were fixed to 1. Model controlled for family income, students' ethnicity, 9th grade math achievement, and high school English GPA. SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
*p < .05. **p < .01. ***p < .001.

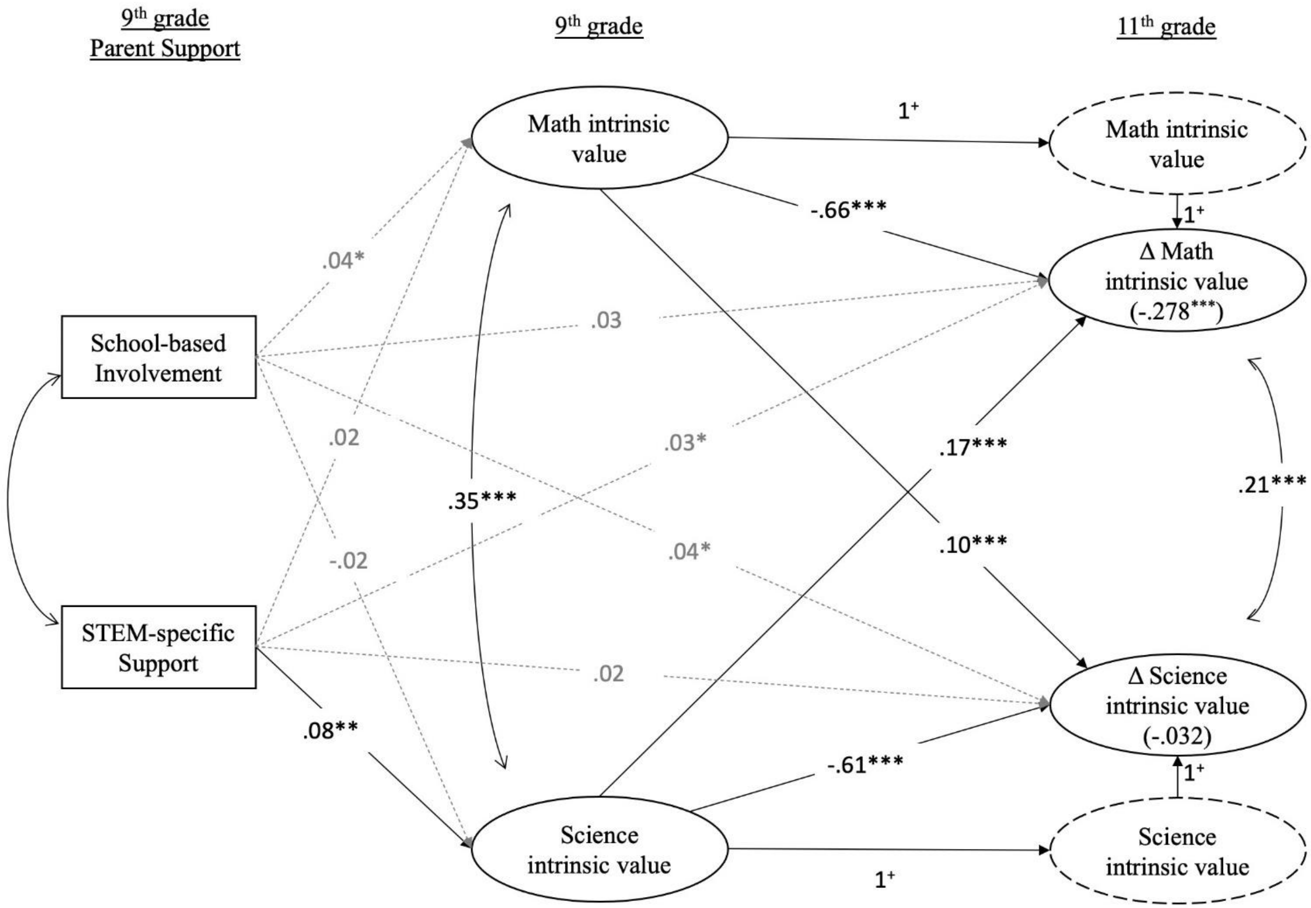

Figure S5. *n* = 20,930. Standardized coefficients of the predictive paths in the multivariate Latent Change Score model between math and science intrinsic value with predictors and outcomes. Dotted grey lines were nonsignificant paths. $^{+}$denoted that path were fixed to 1. Model controlled for family income, students' ethnicity, 9th grade math achievement, and high school English GPA.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
**p* < .05. ***p* < .01. ****p* < .001.

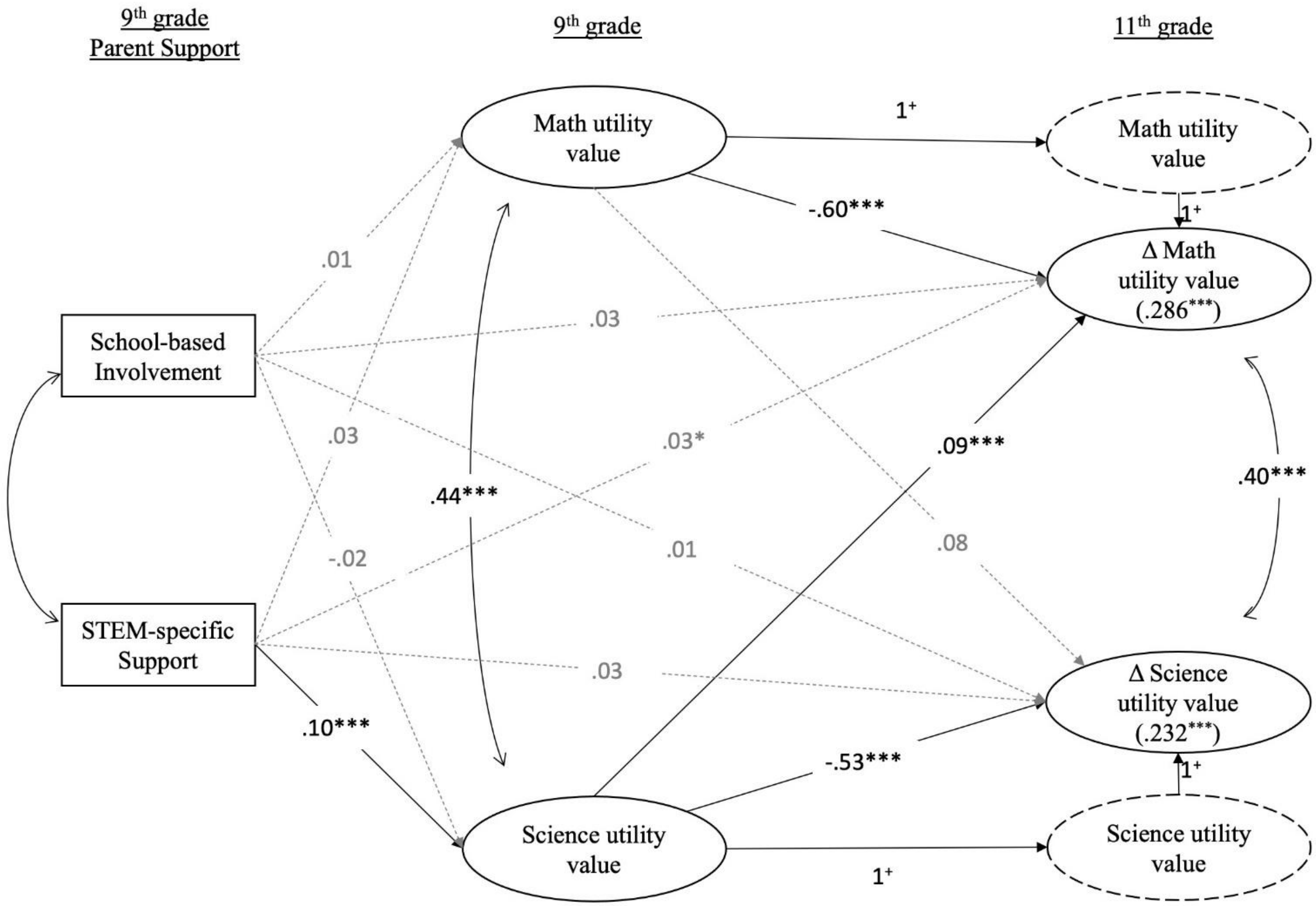

Figure S6. n = 20,930. Standardized coefficients of the predictive paths in the multivariate Latent Change Score model between math and science utility value with predictors and outcomes. Dotted grey lines were nonsignificant paths. $^{+}$denoted that path were fixed to 1. Model controlled for family income, students' ethnicity, 9th grade math achievement, and high school English GPA.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
*$p < .05$. **$p < .01$. ***$p < .001$.

CHAPTER 3

Paper 2

Parent and child factors that predict parents' school-based involvement and STEM-specific support during high school

Abstract

Parents play an essential role in supporting children's educational outcomes, including their attainment, motivation, and choices (Eccles & Wigfield, 2020; Hill & Tyson, 2009). According to Hoover-Dempsey and Sandler's (1997) model of parental involvement and the parent socialization model of situated expectancy-value theory (Eccles & Wigfield, 2020), parents' school-based involvement and STEM-specific support are shaped by both parents' beliefs about themselves and children's achievement and interests. Using the national representative dataset of the High School Longitudinal Study (HSLS; M_{age} = 14, 50% female, 57% Caucasians, 16% Hispanics, 10% African Americans, 8% Asians, and 10% Others), this paper examined two parent-level factors (i.e., parents' educational expectations for children and parents' STEM efficacy beliefs) and two child-level factors (i.e., children's STEM interest and math achievement) to understand what predicts parents' school-based involvement and STEM-specific support at 9th grade. We found that parents' beliefs and children's math achievement were both positive predictors of parents' school-based involvement and STEM-specific support. Parents were also more likely to provide more STEM-specific support to adolescents who were more interested in STEM. Additionally, this study found that parents of female and male potential continuing-generation college students would provide more parental support and have higher beliefs about adolescents compared to female and male potential first-generation college students. This study provided insights for policymakers and practitioners to focus on the reasons behind the parental socialization of STEM motivation during high school.

Keywords: parental support, STEM support, parent beliefs, gender, first-generation college students

Parent and child factors that predict parents' school-based involvement and STEM-specific support during high school

Developing a globally competitive workforce in science, technology, engineering, and mathematics (STEM) fields is critical for sustainable economic growth in our societies (US Congress Joint Economic Committee, 2014). Females and first-generation college students have historically been underrepresented in STEM majors and occupations, and are more likely to turn away from STEM early in high school (Cataldi et al., 2018). Researchers have found that parents are essential in supporting adolescents in STEM during this critical time (Eccles & Wigfield, 2020; Harackiewicz et al., 2012; Hill & Tyson, 2009; Simpkins et al., 2020; Simpkins, Fredricks, et al., 2015). Though research suggests parent support in STEM and school is a more general matter, we know very little about why some parents provide more support than others. For example, do parents provide more STEM support to their sons than daughters? Or, do parents provide more STEM support when they expect their child to earn a college degree? It is critical to understand the precursors of parent support, especially for students who have been marginalized and do not fit the mainstream STEM stereotype, including female and first-generation college students (National Science Foundation, 2021).

Literature on the determinants of parents' academic support is sparse and focuses on parental factors (e.g., Fan & Williams, 2010; Šimunović & Babarović, 2020). Back in the 1960s, Bell (1968) argued that children's behaviors and adjustments affect parenting. Even though adolescence is a developmental period characterized by independence, autonomy, and solidifying one's identity, very little work during adolescence and in STEM has considered child effects on parenting (Bell, 1968; Briley et al., 2014; Simpkins, Fredricks, et al., 2015). For example, do parents provide more STEM support when their adolescents are more interested in STEM? In other words, are parents responsive to adolescents' developing interests? Also, do they adjust their parenting if the adolescent is struggling in STEM? These questions remain unanswered in the literature. This paper examined both parent and child factors that predict parental support in general education and in STEM.

Theoretical Frameworks

Several theories and models suggest parent academic support is critical for youth's academic achievement (Eccles & Wigfield, 2020; Hill & Tyson, 2009). According to Hill and Tyson (2009), parents' school-based involvement and academic socialization are essential predictors of child academic outcomes. Two of these theories also describe the precursors of parents' academic support. Specifically, Hoover-Dempsey and Sandler (1997) theorized that parents' involvement in children's education depends on both parent-level and child-level factors, including parents' sense of efficacy to help their child succeed in school and the invitations and opportunities for parents receive to get involved. The parent socialization model of the situated expectancy-value theory (Eccles & Wigfield, 2020) aligns with Hoover-Dempsey and Sandler's (1997) parental involvement framework and posits that parents' beliefs such as parents' educational expectations for children and their efficacy beliefs in particular domains (e.g., math efficacy beliefs) influence the extent to which they provide academic support in that domain. In addition, situated expectancy-value theory suggests that parents' long-term expectations for their children's education, children's beliefs (e.g., children's interest), and children's achievement also determine the extent to which parents support their child in particular domains (e.g., math, science; Wigfield et al., 2015). This paper examined the precursors of parents' academic support suggested by both theories to test both parent- and child-level predictors. We focused on two parental beliefs: parents' efficacy beliefs about their ability to help children in math and science and parents' educational expectations for their children. We also included two child STEM indicators: youth's STEM interest and math achievement. Inclusion of parent- and child-level predictors will help address the long-standing debate on the extent to which there are child effects in parenting (Bell, 1968).

Parents' efficacy beliefs describe their perception of their competencies in a specific subject (Eccles & Wigfield, 2020). Prior studies have found that parents' efficacy beliefs for helping their children to succeed in school are positively related to the level of parental involvement in *general* academic learning (Green et al., 2007; Hoover-Dempsey et al., 2001; Shumow et al., 2011; Shumow & Lomax, 2002; Simpkins et al., 2012; Tazouti & Jarlégan, 2019), resulting in better child academic outcomes (Coleman & Karraker, 1998; Jones & Prinz, 2005). However, the studies on parents' efficacy beliefs focus on parents' general efficacy beliefs and parents' general academic support. Little work exists concerning how parents' math- and science-specific efficacy beliefs relate to their support in math and science (Šimunović & Babarović, 2020). Simpkins and colleagues (2012) studied the relations between parents' math-specific beliefs when youths were in Grade 1, 2, and 4 and parents' math-specific support when youths were in Grade 2, 3, and 5. They found that mothers' math-specific beliefs positively predicted their math-specific supportive behaviors. More literature is needed to understand how parents' STEM-specific efficacy beliefs predicted their STEM-specific support.

According to the parent socialization model of situated expectancy-value theory and (Eccles & Wigfield, 2020), parents' educational expectations for their children shape students' expectations, achievement, and future plans (Briley et al., 2014; Fan & Williams, 2010; Froiland & Davison, 2016; Jeynes, 2005; Lazarides et al., 2016; Rodríguez et al., 2017; Simpkins et al., 2006). According to theory, these associations between parents' educational expectations and child academic outcomes are mediated by parents' supportive behaviors (Eccles & Wigfield, 2002). However, little work exists on whether parents' expectations are associated with their academic support in terms of either adolescents' general education or STEM specifically. One of the exceptions is work from Davis-Kean (2005), who found that parents' educational expectations for 8-to-12-year-old children were positively related to parents' general academic support, including reading to children (i.e., how often parents read to children) and other co-activities (i.e., involves in activities in board games, sports, computers, and arts and crafts). For parents' STEM-specific support, Shumow and Schmidt (2014) found that mothers' educational expectations for their children were positively related to parents' supportive behaviors in science at home (e.g., helping with science homework) in 9th grade. More research is needed to examine whether parents' educational expectations for their children translate into their general academic support and STEM-specific support.

The parent socialization model of Eccles' situated expectancy-value theory (Eccles & Wigfield, 2002) and Hoover-Dempsey and Sandler's (1997) parental involvement framework both argue that parents' decisions to get involved in children's education not only depend on their own beliefs but also depends on the demands and opportunities for involvement from children. Students who are more interested in STEM are more likely to instigate involvement in general academics and STEM from their parents. Prior studies have found the positive relations between children's beliefs and parents' supportive behaviors in reading, sports, and music (Shumow et al., 2011; Simpkins, Vest, et al., 2010). For example, Shumow, Lyutykh, and Schmidt (2011) studied students from 12 science classrooms in a single comprehensive high school and found that students' science interest was positively related to parents' academic involvement in school and home. In another study done by Simpkins and colleagues (2010), they examined the association between children's sport- and instrumental music-specific interests and parents' behaviors in sports and instrumental music. They found that children's sports interest in grade 1 predicted a slower increase in fathers' sports-specific supportive behaviors from grade one to six. And children’s interest in music predicted a steep increase in fathers’ supportive behaviors in music from grade one to six. However, few studies have examined how children's beliefs in math and science predicted parents' supportive behaviors, especially in STEM.

The parent socialization model of Eccles' situated expectancy-value theory (Eccles & Wigfield, 2020) posits that parents are responsive to children's academic achievement. Some prior literature on the relations between child achievement and parents' general academic support found that parents are more likely to provide more academic support to children who have higher achievement (Dumont et al., 2014; Simpkins, Price, et al., 2015). For example, using an elementary and middle school sample, Simpkins and colleagues (2015) studied the bidirectional process between parents and children during elementary school. They found that children's athletic, reading, and math abilities as rated by teachers predicted parents' beliefs of children's abilities in those domains, which, in turn, positively predicted parents' behaviors, including parents' encouragement and co-activity in these domains. However, prior studies that found the positive relations between achievement and parents' academic support were often conducted in elementary and middle school (Dumont et al., 2014; Simpkins, Price, et al., 2015). The relations between children's achievement and parents' academic support could differ for high school adolescents. Parents of high achievers in high school could provide less parental academic support since their children are already "doing well" academically and may benefit from more autonomy (Eccles & Midgley, 1989). For example, Sy and colleagues (2013) found that children's reading skills at 39 and 42 months were positively related to parents' academic socialization during middle childhood (i.e., between ages 7 - 12); however, reading skills during middle childhood were *negatively* associated with parents' academic instruction during adolescence (between age 13-17). Also, prior literature has mainly focused on the effects of child reading skills on parents' general academic support. To our knowledge, no previous study has examined how math achievement relates to parents' general academic support and STEM-specific support in high school. However, it is important to understand whether parents would be more supportive of students who are higher achievers in math, and if yes, would they provide more academic or STEM-related support.

Group Differences

The situated expectancy-value theory suggests that group differences in adolescents' and parents' beliefs and behaviors arise because of the broader cultural milieu (Eccles & Wigfield, 2020). Moreover, the theory suggests that these differences might emerge as (a) mean-level differences across groups, such as female potential first-generation college students having lower STEM interests than male potential continuing-generation college students, or as (b) process-level differences, such as parents' educational expectations being a stronger predictor for parents of female potential first-generation college students than male potential continuing-generation college students. Therefore, in this study, I tested mean-level differences as well as process-level differences at the intersection of gender and college generation status (i.e., female potential first-generation college students, male potential first-generation college students, female potential continuing-generation college students, and male potential continuing-generation college students).

Gender differences. According to the situated expectancy-value model (Eccles & Wigfield, 2020), gender role expectations and stereotypes are an aspect of adolescents' cultural milieu and affect parents' and adolescents' beliefs and behaviors. Gender role expectations and stereotypes influence parents' and adolescents' math and science beliefs through the processes of gender role socialization, the internalization of gender role expectations and stereotypes, and the absence of same-sex role models. For example, stereotypes have been shown to shape socializers' behaviors, such as parents providing more supportive behaviors in science for boys than girls (Simpkins, Price, et al., 2015). Parents of sons are more likely to provide more supportive behaviors than parents of daughters in general education (Carter & Wojtkiewicz, 2000; Crowley et al., 2001; Simpkins, Fredricks, et al., 2015); however, they hold higher educational expectations for daughters than sons (Froiland & Davison, 2016).

College generation differences. First-generation college students, who are the first in their family to go to college, tend to have different STEM-related experiences because of the disparities in their proximal environments, such as families and schools, compared to continuing-generation college students (Bui, 2002). First-generation college students, in general, have fewer parental educational resources, have lower college aspirations, and face more difficulty in terms of their college academic achievement, attendance, and graduation compared to continuing-generation college students (Gibbons & Borders, 2010; Harackiewicz et al., 2016; Jiang et al., 2020; Stephens et al., 2012; Wilson & Kittleson, 2013). However, little work exists to test the mean-level differences in parental support and beliefs between potential first- and continuing-generation students in high school.

The Intersection of Gender and College Generation Status

Theories and literature provide evidence that both female and first-generation college students are often marginalized in STEM. Since gender and college generation status are theorized to work through two different mechanisms (i.e., gender stereotypes and expectation versus family resources, respectively), we expected that having both identities would exacerbate the marginalization of a single social identity group making the female potential first-generation college students the most marginalized group and male potential continuing-generation students the most privileged group. And the two groups of male potential first-generation college students and female potential continuing-generation college students are hypothesized to be in the middle in terms of their parents' beliefs and support. Though little research examines STEM-related support and beliefs at the intersection of gender and potential college generation status, the few existing studies support our hypothesis and highlight the within-group differences among males and females. For example, among a group of female college freshmen, parents of female potential first-generation college students provided less emotional support and informational support for their daughters than parents of female potential continuing-generation college students (Sy et al., 2011).

Due to the differences in family resources and social support between male and female potential first- and continuing-generation college students (Garriott et al., 2013; Gibbons & Borders, 2010), parent- and child-level factors could function differently for the four groups of students when predicting parents' supportive behaviors. For example, parents' STEM-specific efficacy might be a stronger predictor of parents' STEM support for potential continuing-generation students than potential first-generation college students. None of the prior studies, to our knowledge, has tested the process differences of how parents made their decisions on supportive behaviors across college generation status, let alone the intersection of gender and college generation status. However, it is important to understand whether the process differences were similar in these groups of students. Suppose parents' beliefs are more important for parents of female potential first-generation college students in predicting their supportive behaviors than other groups. Interventions targeting female potential first-generation college students' parents' beliefs in educational attainment and STEM education would help support female potential first-generation college students' STEM outcomes through their parents' supportive behaviors (Harackiewicz et al., 2016; Tibbetts et al., 2016).

The Current Study

This paper examined the parent and child factors that are related to parents' supportive behaviors based on Eccles' situated expectancy-value theory and Hoover-Dempsey and Sandler's parental involvement framework (Eccles & Wigfield, 2020; Hoover-Dempsey & Sandler, 1997). The two parent factors we examined are parents' STEM-specific efficacy beliefs and parents' educational expectations for children. Based on prior literature, we hypothesized that parents who were more confident in their ability to help their children in STEM and had higher educational expectations for their children would be more involved in children's general education in school and provide more STEM-specific support. The two child-level factors we included are children's STEM-interest and math achievement. We hypothesized that adolescents' math achievement would be negatively related to parents' school-based involvement and STEM-specific support. And parents would provide more school-based involvement and STEM-specific support to adolescents who were more interested in STEM. Second, we also examined the mean-level and process-level differences in all of these indicators at the intersection of gender and college generation status. Among the four groups at the intersection of gender and college generation status, we hypothesized that parents of male potential continuing-generation college students would have the highest level of efficacy in STEM and hold the highest educational expectations for their children, followed by female potential continuing-generation college students and then male and female potential continuing-generation college students. Potential male continuing-generation college students would be the highest on their math achievement and are more interested in STEM, and female potential first-generation college students would be the lowest, whereas the male potential first-generation college students and female potential continuing-generation college students were in the middle. Due to the lack of literature on the process-level differences, we did not have a specific hypothesis for process-level differences. Instead, we explored whether the relations would be different for these four groups.

Method

Data were drawn from the High School Longitudinal Study (HSLS) of 2009. The High School Longitudinal Study of 2009 is a longitudinal study from the U.S. National Center for Education Statistics (NCES) that recruited a nationally representative sample of 9th graders across the U.S. (Ingels et al., 2011). Data were collected through a stratified, two-stage random sample design with primary sampling units defined as schools. The first stage comprised a random sample of 940 schools from 10 states. In the second stage, students were randomly selected from the sampled schools within strata defined by race/ethnicity. Approximately 28 students within each school were selected, and a total of 21,440 students participated in the base-year study.

The analytic sample included 16,990 students whose parents completed the parent survey in 9th grade. In 9th grade, adolescents on average were 14.47 years old, 50% were female students, 38% were potential[2] first-generation college students, and the median family income was between $55,000 and $75,000. The analytic sample comprised Caucasians (57%), Hispanics (16%), African Americans (10%), Asians (8%), and other races (10%, i.e., Native Americans,

[2] Adolescents whose parents did not complete college degrees were called potential first-generation college students because by the time of the data collection, they were not in college yet. Some of them might not enroll in college eventually.

Pacific Islanders, and more than one race). Within the analytic sample, 19% were female potential first-generation college students (*n* = 3,220), 19% were male potential first-generation college students (*n* = 3,270), 31% were female potential continuing-generation college (*n* = 5,170), and 31% were male potential continuing-generation college (*n* = 5,260). Parent surveys were completed by 71% biological mothers, 21% biological fathers, 2% adoptive mothers, 2% grandmothers, and 4% other relatives, including stepmother/stepfather and other guardians. 76% of the responding parent were married, 13% were divorced, 6% were never married, and 5% were separated or widowed. Responding parents consisted of 64% Caucasians, 14% Hispanics, 10% African Americans, 8% Asians, and 4% other races (i.e., Native Americans, Pacific Islanders, and more than one race).

From the full sample of 21,440 participants, I excluded those whose parents did not complete the parent survey (*n* = 4,450). Comparisons of the analytic and the excluded samples are provided in Table 4. The analytic sample included students who had higher math achievement (*d* = .43) than the excluded sample. The differences between the analytic and excluded samples on parental support and beliefs were small to moderate (*d* = .05- .28). Also, families in the analytic sample had higher education levels (*d* = .32) and family incomes (*d* = .31). The analytic sample had fewer potential first-generation college students than what was expected by chance (φ = -.13).

Measures

The means and correlations of the focal variables included in this study are presented in Table 5. A complete list of items used for parent beliefs and support, adolescent indicators, and controls are provided in Appendix A.

Parental beliefs. Parents reported their STEM-specific efficacy beliefs and expectations for their adolescents' educational attainment in 9th grade.

Parents' STEM-specific efficacy. Parents' STEM-specific efficacy was defined as their efficacy in helping their 9th grade students with their STEM homework. Parents' STEM-specific efficacy is the mean of two items: "How confident do you feel about your ability to help [your 9th-grader] with the homework [he/she] has this year in each of the following subjects?" Math and science (α = .99, 1 = *Not at all confident*, 3 = *Very confident*). Previous studies have used similar items to measure parents' efficacy beliefs in children's education (Simpkins et al., 2012).

Parents' educational expectations. Parents reported their expectations for their adolescents' educational attainment: "As things stand now, how far in school do you think [he/she] will actually get?" (1 = *Less than high school*; 10 = *Complete a Ph.D., M.D., law degree or other high level professional degree*). A similar single item measure of parent expectations for adolescents was used in numerous studies (e.g., Froiland & Davison, 2016; Shumow & Schmidt, 2014).

Adolescents' STEM indicators. Adolescents' STEM-specific beliefs of STEM achievement and math achievement were both measured in 9th grade.

STEM interest. Situated expectancy-value theory conceptualized interest as the enjoyment one garners from doing tasks (Eccles & Wigfield, 2020). Adolescents' STEM interest was the mean of six items reported by adolescents on their 9th grade intrinsic value in math and in science (α = .78 for math and .81 for science in 9th grade, respectively; 1 = *strongly disagree*, 4 = *strongly agree;* e.g., "You are enjoying this class very much").

Math achievement. Adolescents' 9th grade math achievement was a norm-referenced Item Response Theory-based standardized assessment of math achievement that captured an estimate of students' math achievement related to the population (9^{th} graders of fall 2009; Ingels et al., 2011). It was rescaled to a mean of 50 and a standard deviation of 10.

Parent academic support. This paper examined two broad indicators of parent academic support: parents' school-based involvement and parents' STEM-specific support.

Parent school-based involvement. The items measuring parent school-based involvement aligned with Hill and Tyson's (2009) school-based involvement framework, including communicating with teachers and volunteering for the school. The parent school-based involvement scale was captured by the sum of the six dichotomous items in 9^{th} grade (1 = *Yes*, 0 = *No;* e.g., "attended a general school meeting such as an open house or a back-to-school night). Prior studies have examined parents' general school-based supportive behaviors using similar items (Fan & Williams, 2010).

Parent STEM-specific support. Aligned with the situated expectancy-value theory (Eccles & Wigfield, 2020), the items measuring parents' STEM-specific support reflected parents' specific supportive behaviors in STEM domains. Parents' STEM-specific support was captured by the sum of the six parent-reported dichotomous items on their supportive behaviors in supporting their adolescent in STEM (1 = *Yes*, 0 = *No;* e.g., "Helped [your 9th-grader] with a school science fair project"). Prior studies have used similar items to construct parents' STEM-specific support composite scores when studying parental processes in STEM (Simpkins et al., 2005; Simpkins, Price, et al., 2015).

The intersection of gender and college generation status. First-generation college status was a parent-report dichotomous variable indicating none of the adolescents' parents had earned an associate's or bachelor's degree or above (1 = *potential first-generation college student*, 0 = *potential continuing-generation college student*). Students reported their gender in

9th grade (1 = *female*, 0 = *male*). Four groups at the intersection of gender and college generation status were created using the two variables: female potential first-generation college students, male potential first-generation college students, female potential continuing-generation college students, and male potential continuing-generation college students.

Covariates. Family income and adolescents' ethnicity were incorporated as covariates in path models. Family income was reported by parents, which indicates adolescents' family income from all sources in 2008 (1 = *less than or equal to $15,000*, 13 = *greater than $235,000*). Adolescents reported their ethnicity in 9th grade student survey.

Plan of Analysis

This paper examined the parent- and child-level predictors of parents' school-based involvement and STEM-specific support. We hypothesized that parents who have higher STEM-specific efficacy beliefs and higher educational expectations for their children would provide more general and STEM-specific support to their adolescents. Parents would also be more involved in adolescents' general education in school and provide STEM-specific support when their adolescents have lower math achievement and higher STEM interests. The conceptual model is presented in Figure 6. A path model was estimated to test the relations between parents' beliefs, adolescents' STEM interest and math achievement, and parents' support in 9th grade. Family income and children's ethnicity were included as controls for the model shown in Figure 6. All models estimated in this study were weighted to account for the nonresponse rate in the sampling process (weight = W1PARENT). Using the TYPE=COMPLEX command, strata and primary sampling unit (i.e., schools) variables were used to correct the standard errors based on the stratified design of the data. Models were estimated using the robust maximum likelihood (MLR) estimator, which provides a robust estimation for non-normally distributed data when having a complex sample design. The proportion of missing values varied between 3%-7% for parent beliefs and child STEM indicators and 9% for parent support indicators. Missing data were handled with Full-Information-Maximum-Likelihood (FIML), which yields less biased estimates than traditional approaches such as listwise or pairwise deletion (Enders, 2010).

The second aim of this study was to examine the mean-level differences in parents' and adolescents' beliefs and parental support as well as differences in the nature of relations among parents' and adolescents' beliefs and parental support at the intersection of gender and first-generation college status. We estimated ANOVA tests for continuous variables and chi-square test for categorical variables in STATA to test mean-level differences. We conducted the 4-group multi-group analysis in SEM using the following three steps to test process-level differences. First, the process-level differences were tested by freely estimating the paths and covariances in Figure 6 across groups. Then, the paths and covariances shown in Figure 6 were constrained to be the same across groups to test whether there were group differences in the overall model. All model comparisons were tested with the Satorra-Bentler scaled $\chi 2$ difference test (Satorra & Bentler, 2001), as it is the recommended approach for models with MLR estimator (Muthén & Muthén, 2012). If the overall test was statistically significant across groups, we would compare each path/correlation across four groups to identify which specific associations varied across which specific groups.

Robustness Check

To examine whether the results were robust for those whose parents did or did not participate in the study, we estimated the path models included the families who did not complete the parent survey (*n* = 21,440). Using this subsample, the path models from parents' beliefs, adolescents' STEM-specific indicators, and parents' academic support were re-estimated.

Results

The first goal of this paper was to examine how parent- and child-level indicators predict parents' supportive behaviors in STEM and general. To test our hypothesis, we estimated the relations using the structural equation model in Mplus 8.0 (Muthén & Muthén, 2012). The model demonstrated excellent fit to the data, χ^2 (10) = 177.432, $p < .001$, CFI = .931, RMSEA = .031, SRMR = .023. The standardized coefficients for the focal paths are shown in Figure 7. The results suggest that parents' academic expectations, parents' efficacy in STEM, and adolescents' math achievement are all predictors of parents' school-based involvement and STEM-specific support. Parents' academic expectations for children was positively related to parents' school-based involvement ($\beta = .04$, $p < .05$) and parents' STEM-specific support ($\beta = .06$, $p < .05$). Also, parents' efficacy in STEM positively predicted parents' school-based involvement ($\beta = .12$, $p < .001$) and parents' STEM-specific support ($\beta = .19$, $p < .001$). Adolescents' math achievement positively predicted parents' school-based involvement ($\beta = .14$, $p < .001$) and parents' STEM-specific support ($\beta = .04$, $p < .01$). Additionally, adolescents' science interest is positively related to parents' STEM-specific support ($\beta = .07$, $p < .001$), but not school-based involvement after controlling for family income and ethnicity.

The second goal of this paper is to examine the group differences among the focal variables. We examined the mean-level differences in parents' and adolescents' STEM-related indicators as well as the process-level differences in the relations among predictors and outcomes at the intersection of gender and college generation status. We hypothesized that male potential continuing-generation college students would have the highest level of parental beliefs and the highest level of child-level STEM indicators. Mean-level ANOVA analysis results were presented in Table 6. Male potential continuing-generation college students had the highest level of STEM beliefs, math achievement, and parental beliefs and support, while female potential continuing-generation college students on similar levels on these indicators except for parents' STEM-specific support. Male and female potential first-generation college students tend to have similar levels of STEM beliefs, math achievement, and parental beliefs and support. And they were significantly lower than male and female potential continuing-generation college students. Parents of male potential continuing-generation college students would provide the highest level of STEM-specific support, and female first-generation college students were having the lowest. And the other two groups were in the middle. Aligned with prior literature, parents tend to have higher educational expectations for female potential first-generation and continuing-generation college students compared to male potential first-generation and continuing-generation college students. Overall, male and female potential continuing-generation college students tend to have significantly higher STEM-related indicators than male and female potential first-generation college students.

The process-level difference in the relations between focal variables was conducted to test whether the paths of the model with predictors and outcomes function differently for potential first- and continuing-generation female and male adolescents. We conducted a 4-group multi-group analysis on the model depicted in Figure 6 to test whether the paths were significantly different across the four groups. When we constrained all focal paths shown in Figure 6 to be equal across four groups, we found that the model was significantly different across the four groups, $\Delta \chi^2 (24) = 55.309$, $p < .001$. We estimated a series of follow-up tests to identify which paths were significantly different across the four groups. The only significantly different path across the four groups was the path from parents' educational expectations to parents' school-based involvement. Among the four groups, potential female potential first-generation college students were significantly different from female potential continuing generation students and male potential continuing generation students, $\Delta \chi^2 (1) = 11.405$, and $\Delta \chi^2 (1) = 26.431$, $p < .001$. And the path from parents' educational expectations to parents' school-based involvement was not significant for female potential first-generation college students (β = -.03, $p = .398$), but it was significant for female potential continuing generation students ($\beta = .09$, $p < .001$) and male potential continuing generation students ($\beta = .15$, $p < .001$). Also, for the same path from parents' educational expectations to parents' school-based involvement, the standardized coefficient was significantly different between male potential first-generation (β = .06, $p = .017$) and male potential continuing-generation students ($\beta = .15$, $p < .001$), $\Delta \chi^2 (1) =$ 11.739, $p < .001$. Overall, there is no strong evidence that the associations among the indicators varied across groups of potential first- and continuing-generation female and male adolescents.

Robustness check

Robustness check analysis was conducted using the full sample to test whether the results hold for all participants. We re-estimated the model presented in Figure 6 with a more inclusive sample that included students whose parents did not complete the parent survey. The analysis results were very similar to the main analysis (see Appendix A).

Discussion

The current study examined parent and child factors related to parents' school-based involvement and STEM-specific support. Based on Eccles' situated expectancy-value theory and Hoover-Dempsey and Sandler's parental involvement framework (Eccles & Wigfield, 2020; Hoover-Dempsey & Sandler, 1997), we examined parent-level factors of parents' educational expectations for children and parents' STEM efficacy beliefs and child-level factors of adolescents' math achievement and STEM interest. This paper extended the literature by examining both parent and child factors that theories suggest parents take into account when providing academic support during high school. In addition, this paper tackles the issue of diversity in STEM by examining the differences in these indicators at the intersection of gender and potential college generation status.

The current paper examined how parents' efficacy beliefs related to parents' both school-based involvement and STEM-specific support. Prior literature has found that parents' efficacy beliefs are positively related to parents' involvement in general education (Shumow et al., 2011; Simpkins et al., 2012). However, little work examined how parents' STEM-specific efficacy beliefs related to parents' school-based involvement and STEM-specific support. This paper found that parents' STEM-specific efficacy related to both types of parent academic support. This finding aligned with Hoover-Dempsey and Sandler's parental involvement framework (1997) that parents consider their own efficacy beliefs to decide whether to get involved in children's education. This finding has implications for intervention targeting parents' academic support to not only provide strategies to support their children but also bolster their efficacy beliefs.

Second, this paper also examined how parents' educational expectations related to parents' supportive behaviors for their children. Prior literature often examined parents' educational expectations by directly relating parents' educational expectations to children's outcomes such as achievement and future plans (Briley et al., 2014; Froiland & Davison, 2016). However, the relations between parents' educational expectations and children's outcomes could be possibly mediated by parents' supportive behaviors due to theory and literature (Davis-Kean, 2005; Eccles & Wigfield, 2020). This paper found that parents' educational expectations positively predicted parents' school-based involvement and STEM-specific support. Our finding suggests that future studies on parents' educational expectations and children's outcomes could consider parental support as a mediator. Although parents' educational expectations were not specifically related to STEM, it still predicted parents' STEM-specific support. This could be because parents understand the importance of STEM in college entrance. When parents expect their children to go further in education, they would be more likely to provide more STEM support. However, more work is needed to understand whether parents who have higher educational expectations would provide equal amounts or more support to adolescents in other subjects such as literature.

Previous literature often examined how parental level indicators predict parental support (Green et al., 2007; Hoover-Dempsey et al., 2001; Shumow & Lomax, 2002); however, growing literature argues that researchers should also consider how children shape parenting (Briley et al., 2014; Simpkins, Fredricks, et al., 2015). For example, it is not always parental behaviors that predict children's outcomes; it could also be that parents' behaviors are responses to children's characteristics. We found that parents were more likely to provide more support both in general and in STEM when adolescents had higher levels of math achievement. Adolescence might need more autonomy during adolescents, and prior literature found that parents are less likely to provide parental support to high achievers since they are "doing well" in school (Eccles & Midgley, 1989; Sy et al., 2013). However, in our case, while adolescents had higher levels of math achievement, parents would provide more academic support, including involvement in children's education in school and provide more STEM-specific support. This might be because the literature that found parents were less involved are examining home-based support, such as homework help (Sy et al., 2013), which would be less helpful when adolescents are in high school. However, we measured parents' school-based support and STEM-specific support, both kinds of support would still be necessary for adolescents to gain better academic outcomes in high school. Our results also suggested that parents would provide more STEM-specific support to children who are more interested in STEM, which could lead to children's higher motivation in STEM later on. This could become a positive reciprocal relationship between parents and children on their way to better STEM outcomes, which aligned with what was posited in the situated Expectancy-value theory, however, it was less studied in the literature. These findings confirmed our hypothesis and suggested that parents are responsive to children's characteristics. Future studies should consider the reciprocal relations between parents and children.

This paper examined the mean-level differences in parents' and children's beliefs, parental support, and process-level differences at the intersection of gender and potential college generation status in focal constructs' relations. Prior literature has suggested that examining the group differences across a single category is not enough and neglects rich within-group differences (Hyde, 2014). Therefore, in this study, we examined group differences at the intersection of gender and potential college generation status. For mean-level differences, aligned with our hypothesis, we found that parents of male and female potential continuing-generation students would have higher beliefs and provided more support compared to male and female potential first-generation college students. Parents provided the highest level of STEM-specific support to male potential continuing-generation college students and the lowest level of STEM-specific support to female potential first-generation college students, while the other two groups were in the middle. Our finding aligns with prior literature that parents hold higher educational expectations for daughters than sons (Froiland & Davison, 2016). And parents provide more STEM-specific support to sons than daughters (Simpkins, Fredricks, et al., 2015). Our research provided insights for future research to examine whether gender differences are the same for different social groups. For example, gender differences did not hold within groups of potential first- and continuing-generation students on their STEM-interest, math achievement, and their parent's school-based involvement. This could be because parents' educational level matters more than gender stereotypes for adolescents on these indicators. Future studies would focus on where and why these gender differences hold or not hold.

Limitations and Future Directions

This paper provided important information on how parents' supportive behaviors are related to parent- and child-level factors; however, it is not without limitations. This study is a concurrent study in which the predictors and outcomes were measured in 9th grade. Future longitudinal studies are needed to further examine the reciprocal relations between parent support and child outcomes. For example, at what age do the reciprocal relations start? Who took the initiative? And how can interventions support the reciprocal relations between parent and children to become a more positive loop that leads to better child outcomes?

This paper took a quantitative approach to examine which factors were related to parents' support in general education and STEM. Our findings are valuable since we provided numerical comparisons of which factors drive more parental support. However, we cannot consider every possible reason for parental support in a quantitative paper. Qualitative papers are needed to understand fully why and what drives parents' involvement and support in children's education in general and STEM. Especially for female and male potential first-generation and continuing-generation students, the background story of how their parents decided to get involved or not involved in their education, and in what ways would be beneficial to understand the group differences among these groups.

Conclusions

Parents play an essential role in supporting children's educational outcomes, including motivation, achievement, and choices in both general education and STEM (Eccles & Wigfield, 2020; Hill & Tyson, 2009). To understand what drives parents' supportive behaviors, this paper examined factors for both parent- and child-level. We found that parents' beliefs and adolescents' achievement predicted parents' supportive behaviors in both general education and STEM. Parents would also provide more STEM support to adolescents who are more interested in STEM. Our findings provided important evidence for future research to consider both parent and child-driven parental support, especially for adolescents who belong to underrepresented groups in STEM, such as females and first-generation college students.

Table 4

Comparisons between Analysis and Excluded Samples

Measurements	Analysis sample N	Mean	SD	Min	Max	Excluded sample N	Mean	SD	Min	Max	*t*-test or Chi-square test	Effect size
9th grade parent indicators												
School-based involvement	11960	3.38	1.73	0.00	6.00	3540	3.04	1.73	0.00	6.00	10.21***	.19
STEM-specific support	12050	3.12	1.45	0.00	6.00	3570	2.93	1.47	0.00	6.00	6.75***	.12
STEM-specific efficacy belief	12240	2.16	0.64	1.00	3.00	3620	2.12	0.64	1.00	3.00	2.79**	.05
Educational expectation	11070	7.06	2.36	1.00	10.00	3150	6.38	2.67	1.00	10.00	13.94***	.28
9th grade child STEM-specific indicators												
STEM interest	16730	2.86	0.70	1.00	4.00	2380	2.81	0.71	1.00	4.00	3.42***	.07
Covariates												
Female	16760	0.50	0.50	0.00	1.00	8390	0.46	0.50	0.00	1.00	29.17***	.03[a]
Caucasian	16760	0.57	0.50	0.00	1.00	6480	0.42	0.49	0.00	1.00	383.98***	.13[a]
Hispanic	16760	0.16	0.36	0.00	1.00	6480	0.21	0.41	0.00	1.00	-107.77***	-.07[a]
African American	16760	0.09	0.29	0.00	1.00	6480	0.17	0.37	0.00	1.00	-250.53***	-.10[a]
Asian	16760	0.08	0.27	0.00	1.00	6480	0.12	0.32	0.00	1.00	73.32***	.06[a]
Other ethnicities	16760	0.10	0.30	0.00	1.00	6480	0.08	0.27	0.00	1.00	30.23***	.04[a]
First-generation college students	12970	0.38	0.49	0.00	1.00	3950	0.53	0.50	0.00	1.00	-288.17***	-.13[a]
Parent highest education	13030	3.40	1.53	1.00	7.00	3960	2.91	1.44	1.00	7.00	17.83***	.32
Family income	13030	4.85	3.09	1.00	13.00	3920	3.91	2.75	1.00	13.00	16.95***	.31
High school English GPA	15590	2.64	0.92	0.00	4.00	6170	2.40	0.97	0.00	4.00	17.07***	.26
Math achievement	16760	52.04	9.86	24.10	82.19	4690	47.80	10.15	24.02	79.53	25.85***	.43

Note. Independent sample *t*-tests were used for continuous variables, and Chi-square tests were used for dichotomous variables. Effect sizes are Cohen's *d* for continuous variables: small effect .10, moderate effect .30, large effect .80. [a]indicates effect sizes that are phi coefficients: small effect .10, moderate effect .30, large effect .50. ***$p < .001$. The Ns were rounded to the nearest tens place according to the IES restricted-use data guidelines.

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Table 5

Descriptive Statistics and Correlations of Focal Variables

	1	2	3	4	5	6
1. Parents' STEM-specific efficacy beliefs	-					
2. Parents' child-specific educational expectations	.08***	-				
3. 9th Grade math achievement	.08***	.28***	-			
4. 9th Grade STEM interest	.08***	.14***	.17***	-		
5. Parent school-based involvement	.13***	.13***	.15***	.06***	-	
6. Parent STEM-specific support	.19***	.10***	.07***	.06***	.29***	-
M	2.15	7.33	51.11	2.88	3.30	3.07
SD	.64	2.63	10.08	.58	1.73	1.45
Skewness	-.15	-.40	-.06	-.40	-.15	-.04
Kurtosis	1.95	2.31	2.87	3.27	2.11	2.47

Note.

**p* < .05. ***p* < .01. ****p* < .001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Table 6

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

Indicator	Female potential first-generation college students (F-FG) (n = 1,590) *M(SD)*	Male potential first-generation college students (M-FG) (n = 1,220) *M(SD)*	Female potential continuing-generation college students (F-CG) (n = 3,580) *M(SD)*	Male potential continuing-generation college students (M-CG) (n = 3,450) *M(SD)*	Statistical significance (ANOVA F-test or Chi-square results)	Significant comparisons
Parents' STEM-specific efficacy	1.93(.63)[a]	1.96(.64)[a]	2.26(.62)[b]	2.29(.62)[b]	343.69***	F-FG, M-FG < F-CG, M-CG
Parents' educational expectations	7.16(3.04)[b]	6.55(3.29)[a]	7.79(2.09)[d]	7.40(2.31)[c]	144.73***	M-FG < F-FG < M-CG < F-CG
Math achievement	48.39(8.72)[a]	48.03(9.69)[a]	54.35(9.36)[b]	54.65(10.04)[b]	563.03***	F-FG, M-FG < F-CG, M-CG
STEM interest	2.87 (.66)[ab]	2.82 (.68)[a]	2.90 (.66)[b]	2.90 (.67)[b]	13.18***	M-FG < F-CG, M-CG
School-based Involvement	2.91 (1.71)[a]	2.91 (1.70)[a]	3.76 (1.60)[b]	3.79 (1.62)[b]	172.72***	F-FG, M-FG < F-CG, M-CG
STEM-specific support	2.78 (1.50)[a]	2.97 (1.51)[b]	3.13 (1.40)[c]	3.44 (1.40)[d]	83.97***	F-FG < M-FG < F-CG < M-CG

Note. Within rows, means with dissimilar superscripts are significantly different at $p < .05$.
*$p < .05$. **$p < .01$. ***$p < .001$.

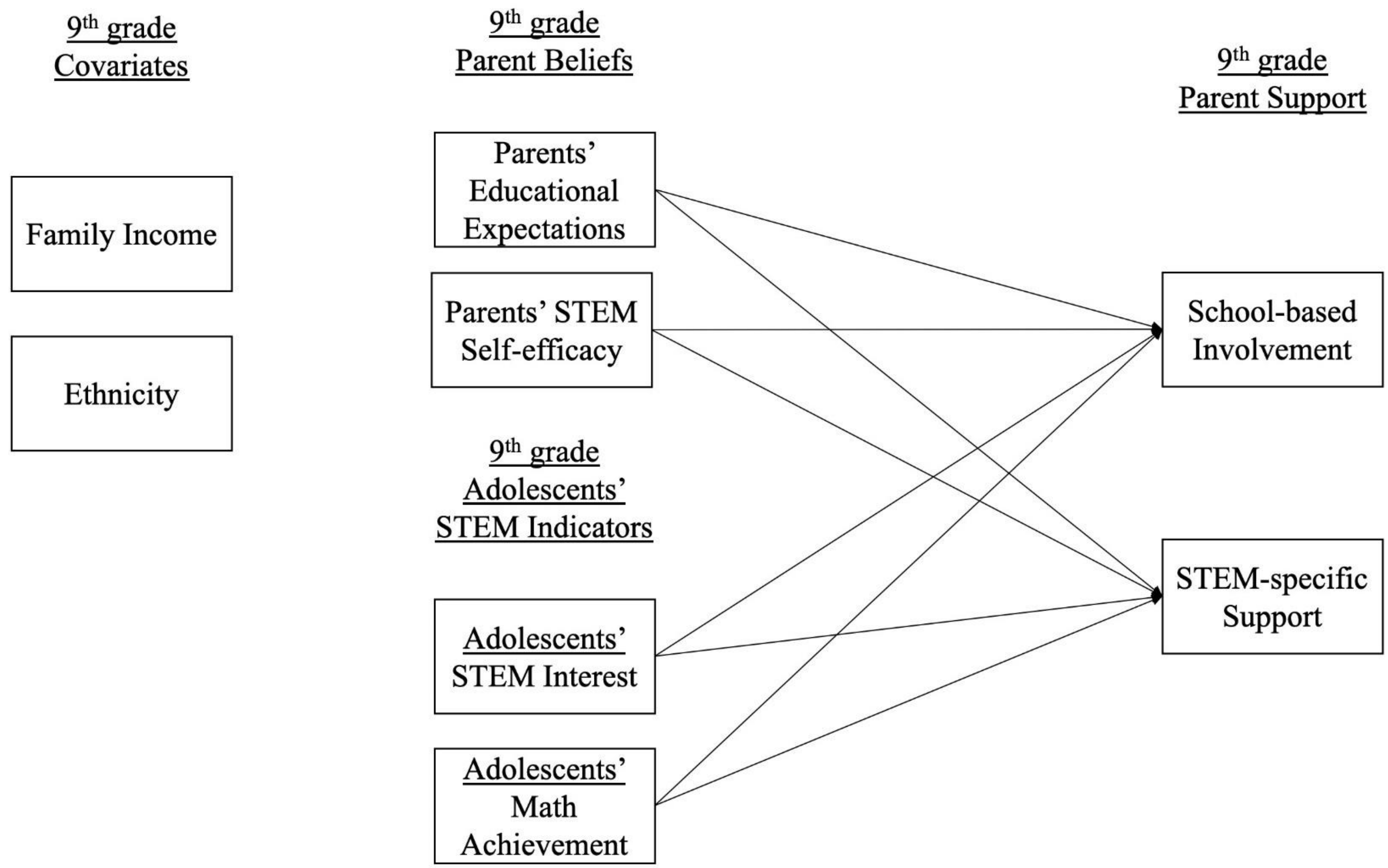

Figure 6. The concept map of the model between parent and child STEM indicators and parental support. The model controlled for family income and students' ethnicity.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

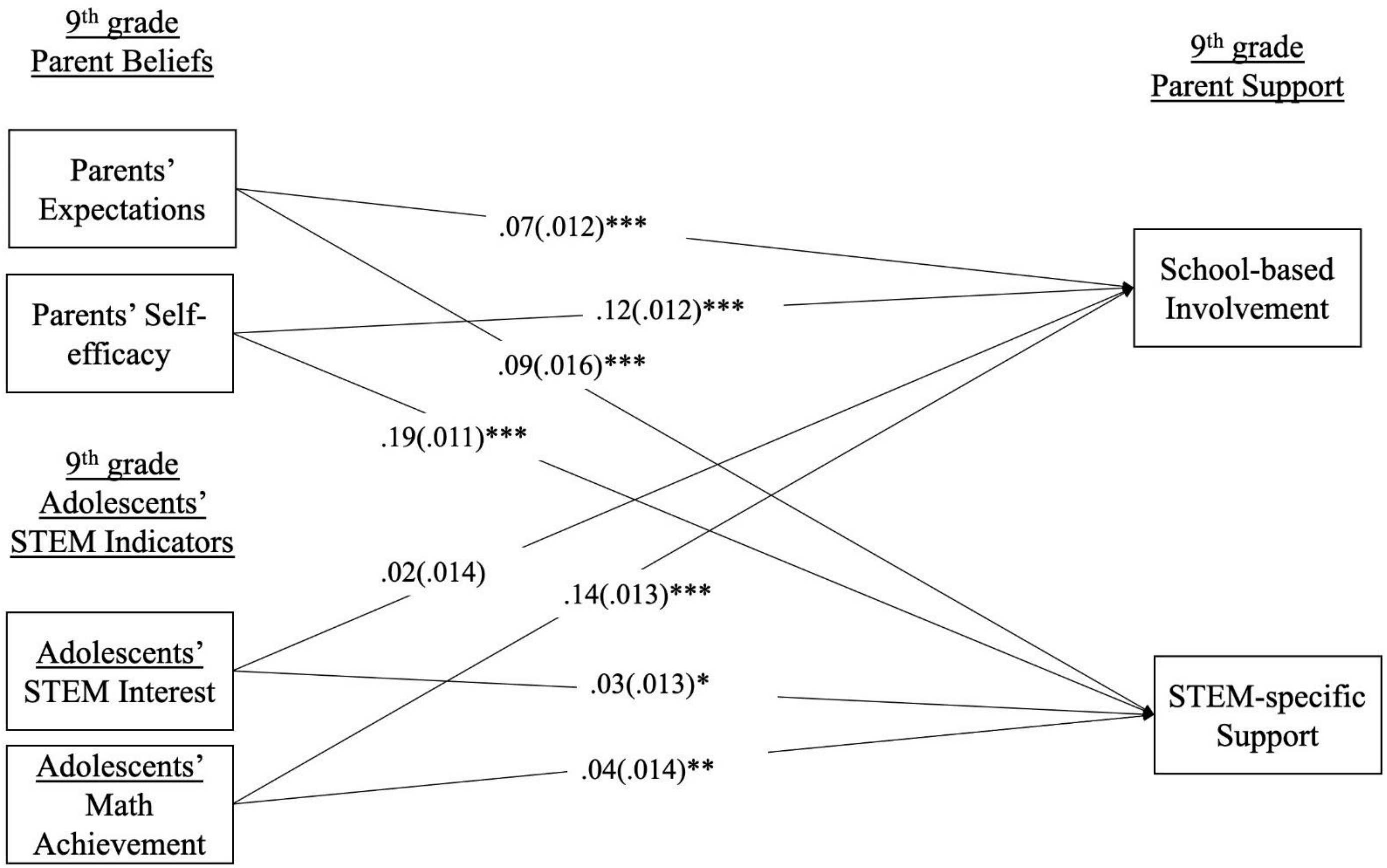

Figure 7. Standardized coefficients of the predictive paths from parent and child STEM indicators to parental support in 9th grade. The model controlled for family income and students' ethnicity.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

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Appendix A

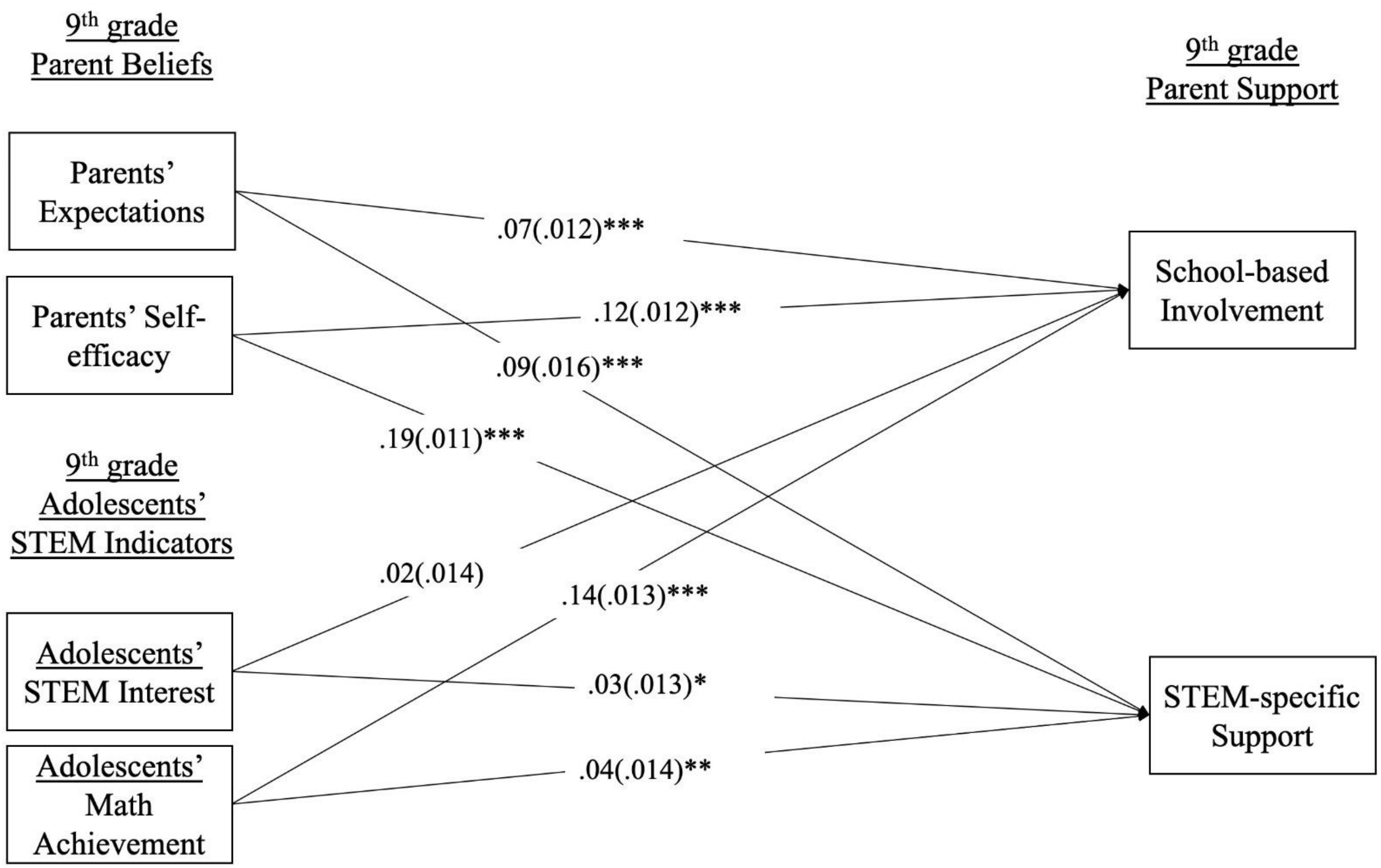
Items of the Focal Measures

Constructs	Items
Math and science interest	How much do you agree or disagree with the following statements about your [fall 2009/spring 2012] [math/science course]? (Strongly agree, Agree, Disagree, or Strongly disagree) 1. You are enjoying this class very much 2. You think this class is a waste of your time 3. You think this class is boring
Parent school-based involvement	Since the beginning of this school year (2009-2010), have you or other adults in your household...(Yes, No) attended a general school meeting such as an open house or a back-to-school night? attended a meeting of the parent-teacher organization or association? gone to a regularly scheduled parent-teacher conference with [your 9th grader] 's teacher? attended a school or class event such as a play, dance, sports event or science fair because of [your 9th grader]? served as a volunteer in [your 9th grader] 's classroom or elsewhere in the school? participated in fundraising for the school?
Parent STEM-specific support	During the last 12 months, which of the following activities have you or another family member done with [your 9th grader]? (Check all that apply.) Visited a zoo, planetarium, natural history museum, transportation museum, or a similar museum Worked or played on a computer together Built or fixed something such as a vehicle or appliance Attended a school science fair Helped [your 9th grader] with a school science fair project Discussed a program or article about math, science, or technology
Parents' STEM-specific efficacy belief	How confident do you feel about your ability to help [your 9th grader] with the homework [he/she] has this year in each of the following subjects? (Very confident, Somewhat confident, Not at all confident) Math

	Science
Parents' child-specific educational expectations	As things stand now, how far in school do you think [he/she] will actually get? Less than high school High school diploma or GED Start but not complete an Associate's degree Complete an Associate's degree Start but not complete a Bachelor's degree Complete a Bachelor's degree Start but not complete a Master's degree Complete a Master's degree Start but not complete a Ph.D., M.D., law degree, or other high level professional degree Complete a Ph.D., M.D., law degree, or other high level professional degree
Gender	What is your sex? Male Female
Ethnicity	Are you Hispanic or [Latino/Latina]? Yes No [In addition to learning about your Hispanic background, we would also like to know about your racial background.] Which of the following choices describe your race? You may choose more than one. (Check all that apply.) White Black or African American Asian Native Hawaiian or other Pacific Islander American Indian or Alaska Native
Parents' highest education	What is the highest level of education [you have/parent #1 has] completed? Less than high school High school diploma or GED

	Associate's degree Bachelor's degree Master's degree Educational Specialist diploma Ph.D., M.D., law degree, or other high level professional degree
	What is the highest level of education [parent #2] has completed? Less than high school High school diploma or GED Associate's degree Bachelor's degree Master's degree Educational Specialist diploma Ph.D., M.D., law degree, or other high level professional degree
Family income	Income is a key family characteristic that factors into many research questions including how family finances affect students' ability to go to college. This information is critically important to the success of this study and will be kept completely confidential. What was your total household income from all sources prior to taxes and deductions in calendar year 2008? Please include all income such as income from work, investments and alimony. * We understand that you may not be able to provide an exact number for your family's income. However, it would be extremely helpful if you would indicate which of the following ranges best estimates your total household income from all sources prior to taxes and deductions in calendar year 2008. Please include all income such as income from work, investments and alimony. $15,000 or less $15,001 - $35,000 $35,001 - $55,000 $55,001 - $75,000 $75,001 - $95,000 $95,001 - $115,000 $115,001 - $135,000 $135,001 - $155,000 $155,001 - $175,000 $175,001 - $195,000 $195,001 - $215,000

	$215,001 - $235,000
	More than $235,000



Appendix A. Robustness check analysis using a full sample. The model controlled for family income and students' ethnicity. SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

**p* < .05. ***p* < .01. ****p* < .001.

CHAPTER 4

Overarching Discussion

This dissertation examined the development and parent socialization processes of adolescents' math and science motivational beliefs. Previous studies have found that adolescents' motivational beliefs in academic domains typically decline during high school (e.g., Dotterer et al., 2009). Though these motivational processes are often analyzed separately by domain, such as examining motivational processes in math separately from science, situated expectancy-value theory and dimensional comparison theory argue that students' beliefs in different domains are interconnected and codetermine their performance and choices (Eccles & Wigfield, 2020; Möller & Marsh, 2013). Little is known about the interrelatedness of the change in math and science motivational beliefs. Guided by Eccles' situated expectancy-value theory (Eccles & Wigfield, 2020), this dissertation found that adolescents' math and science motivational beliefs did not always decline during high school and they are interrelated as they develop together. According to Hoover-Dempsey and Sandlers' (1997) model and the parent socialization model of situated expectancy-value theory (Eccles & Wigfield, 2020), parents' supportive behaviors are related to both parents' beliefs about themselves and children's need for support. Parents' self-efficacy beliefs have been found to be positively related to the amount of parental involvement in their children's general education (Green et al., 2007). However, little do we know whether parents' STEM-specific efficacy beliefs would positively relate to the amount of STEM-specific support they provide for their adolescents (Šimunović & Babarović, 2020). Theory and a growing literature suggest that parents' decisions to get involved in children's education depend not only on their own beliefs but also on the demands and opportunities their children provide for help (Hoover-Dempsey & Sandler, 1997). Questions regarding how parents respond to children remain understudied. In this dissertation, we found that both parent and child-level predictors were positively related to parents' academic support. Although the two studies in this dissertation were written to publish independently, they are closely related to answering our questions about how adolescents decide about STEM major choice and how parents function in the process.

Importance of Adolescence and Emerging Adulthood

Life course theory underscores the importance of trajectories and transitions in individuals' pathways to understanding human development and choices (Elder Jr. & Rockwell, 1979). According to Erikson's theory (1993), adolescence is the primary time when individuals explore their identities in society. Arnett (2007) extended Erikson's work and suggested that individuals continue to explore their identity and associated educational and occupational choices into emerging adulthood, which spans 18-25 years of age. All of these theories highlighted two developmental periods that have a prolonged influence on individuals' life paths: adolescence and emerging adulthood. In this dissertation, we found that different types of adolescents' math and science motivational beliefs develop in different directions, which supported both Erikson's (1993) and Arnett's (2007) theory that adolescents were exploring their identities and possibilities and a sense of self, especially in STEM. This dissertation found that the development of adolescents' math and science motivational beliefs during adolescence matters for later STEM choices in emerging adulthood. These findings supported the theories that adolescents' competence-related beliefs and values developed during adolescence turn into life choices and outcomes during early adulthood (Eccles, 2009). However, since the effect sizes of the coefficients from the development of math and science motivation to STEM major choice were small, adolescents could also be exploring their identity during emerging adulthood, although these developmental processes and decisions during emerging adulthood were driven by prior experiences in adolescence (Arnett, 2000). The findings of this dissertation supported the importance of the transition from adolescence to emerging adulthood in theory and highlighted the value of understanding adolescents' choices more longitudinally.

Historically, adolescence has often been depicted from a deficit perspective that adolescence is seen as a phase of upheaval associated with problem behaviors and a lack of motivation (National Academies of Sciences, Engineering, and Medicine, 2019). This dissertation took a positive perspective to examine the "*Promise of Adolescence*" and how we support adolescence during this important developmental period that adolescents learn and explore their cognitive, social, and emotional skills necessary for productivity in adulthood (National Academies of Sciences, Engineering, and Medicine, 2019). For example, while previous literature found adolescents' math and science motivational beliefs decline during high school (e.g., Hsieh et al., 2019; Jacobs et al., 2002; Petersen & Hyde, 2017; Wang & Degol, 2017), this dissertation found that not all types of adolescents' math and science motivational beliefs declined during high school (utility value increased). While adolescents were seen as losing motivation in almost all academic subjects in the literature (e.g., Dotterer et al., 2009; Wigfield et al., 2015), this dissertation found that adolescents learned and gained knowledge about the importance and usefulness of math and science for their future. These findings highlight the need to examine specific motivational beliefs when studying the development of math and science motivational beliefs since they are theoretically distinct and serve different functions (Eccles & Wigfield, 2020). Understanding where adolescents' might increase in their motivation provided intervention opportunities to support adolescents in high school. Literature has posited and shown that individuals' utility value is a strong direct predictor of their subsequent choices (Jiang et al., 2020; Meece et al., 1990). Previous interventions also showed that utility-value interventions, such as asking adolescents to write about why STEM is relevant and useful, supported adolescents in their STEM course performance and STEM choices (Harackiewicz et al., 2016; Rozek et al., 2017).

The Parental Support: How did It Help and Where did It Come From

This dissertation examined parental support from two central indicators: one with parents' school-based involvement and one with parents' STEM-specific support. Hill and Tyson's (2009) model and meta-analyses have shown that parents' involvement in school settings is associated with children's grades and test scores overall (Castro et al., 2015). According to the parent socialization model of situated expectancy-value theory, parents' math- and science-specific supportive behaviors, including modeling, co-participation, and encouragement in math and science, are positively related to students' math and science motivational beliefs (Eccles & Wigfield, 2020; Simpkins et al., 2018). The two distinct pieces of literature on parent support in general and in STEM both suggest these types of parent support are effective. However, few studies have examined both to test which one might matter more and if these supports help buffer against the typical declines in adolescents' math and science motivational beliefs in high school. This dissertation examined how the two kinds of parental support relate to adolescents' STEM motivation and choices and what parent and child level factors play into these supportive behaviors.

Historically, literature on parent-adolescent relationships emphasized strife and conflict. This dissertation moved away from a deficit-perspective and emphasized parents as a source of strength. Paper 1 found that parents' STEM-specific support was positively related to adolescents' math and science motivational beliefs in 9th grade, meaning that parents were sources of strength to adolescents in supporting adolescents' math and science motivational beliefs at the beginning of high school. Findings of Paper 1 aligned with the parent socialization model of situated expectancy-value theory (Eccles & Wigfield, 2020) and suggested that parents' particular support in STEM, such as doing a STEM project together, would be more supportive of adolescents' STEM motivation than parents' school-based involvement. These supportive behaviors in STEM provided an environment where parents could offer encouragement, discussion opportunities, scaffolding in learning, and role modeling in STEM so that adolescents would develop their interest and competence (Gottfried et al., 2016; Häfner et al., 2018). Parents' STEM-specific support, including helping with adolescents' science fairs, aligned with Hill and Tyson's (2009) framework as a way of academic socialization. Parental support that was provided as academic socialization, such as taking adolescents to museums and working on a science project together, would more likely trigger adolescent's intrinsic motivation in math and science than school-based involvement (Crowley et al., 2001; Ing, 2014; Jacobs & Bleeker, 2004; Mujtaba et al., 2018; Simpkins, Price, et al., 2015; Vedder-Weiss & Fortus, 2013).

Study 2 of this dissertation examined the parent and child level predictors of parental support. Previous literature often examined how parental level indicators predict parental support (Green et al., 2007; Hoover-Dempsey & Sandler, 1997; Shumow & Lomax, 2002); however, growing literature argues that researchers should also consider how children shape parenting (Bell, 1968; Briley et al., 2014; Simpkins, Fredricks, et al., 2015). Study 2 filled the gap in the literature by examining both parent- and child-level factors that predicted parents' supportive behaviors, including involvement in school and STEM-specific support. Our finding aligned with Eccles' situated expectancy-value theory and Hoover-Dempsey and Sandler's parental involvement framework (Hoover-Dempsey & Sandler, 1997; Wigfield et al., 2015), that parent beliefs of efficacy and educational expectation were significant predictors of parents' academic support. These results have implications for intervention targeting parents' academic support to provide strategies to support their children, bolster their efficacy beliefs, and highlight the value of education to parents. Our results confirmed that parents are responsive to children's characteristics, which aligned with theory and literature (Eccles, 2009; Simpkins et al., 2015). This dissertation shed light on future research to examine the reciprocal relations between adolescents and parents to understand parental supportive behaviors.

Differences at the Intersection of Gender and College Generation Status

This dissertation examined differences in the indicators and their relations at the intersection of gender and college generation status. We found mean-level differences among the four groups, although the process-level differences were subtle. In general, we found that male continuing-generation college students were most likely to have higher levels of math and science motivational beliefs, parental beliefs and support, and STEM major choice, whereas female first-generation college students often had the lowest, and the other two groups were in the middle. However, unique patterns emerged in the results.

In this study, female first-generation college students often had the lowest levels of math and science motivational beliefs, parental beliefs and support, and STEM major choice among the four groups. Female first-generation college students are marginalized in STEM because they suffer from both gender stereotypes and a lack of family resources (Gibbons & Borders, 2010; Harackiewicz et al., 2016; Jiang et al., 2020). Both social disadvantages put this group of adolescents at the lowest level regarding STEM outcomes, including motivation, parental support, and STEM major choice. Future interventions targeting this particular group could focus on both their gender beliefs in STEM and support the families with more STEM-related resources since only one aspect might not be adequate to support this group in STEM (Dika & D'Amico, 2016; Stephens et al., 2012; Wilson & Kittleson, 2013).

Female continuing-generation college students had fairly higher parental beliefs, support, and math achievement than first-generation male and female students. However, they tend to have the lowest level of math and science motivational beliefs similar to female first-generation college students. It might be that gender stereotype plays an important role for both parents and daughters of female continuing-generation college students. Both would not consider STEM as a future major for adolescents. Our results suggested that parental support and family resources might not be the solution for supporting female continuing-generation college students' math and science motivational beliefs. Future research could focus on what other factors would be promotive for female continuing-generation college students' math and science motivation.

Male continuing-generation college students had the highest level of almost all STEM indicators, including motivation and parental support, while male first-generation college students were slightly lower on STEM motivation and choices. However, male first-generation college students' STEM motivation and choices were significantly higher than female first-generation college students, even though they had similar levels of parental beliefs and support compared to female first-generation college students. This finding could be because parental support might not be an as critical indicator for male first-generation college students. Being male in STEM and having a higher level of STEM motivation could serve as a buffer for male first-generation students in STEM. They could find more same-gender role models in STEM and studying STEM fits their expectations for them from parents, teachers, peers, etc. However, future studies could examine how male first-generation students cope with their struggles in high school and college when choosing a STEM major to understand how we better support first-generation college students in STEM.

Limitations and Future Directions

The two papers of this dissertation both used the High School Longitudinal Dataset. With the benefit of using a nationally representative dataset of a large number of participants, this dissertation also has its limitations. Study 1 found that 9th grade could be a pivotal time for adolescents to develop their math and science motivational beliefs, and these motivational beliefs were correlated to their later STEM choice. However, we know little about earlier math and science motivational beliefs developmental process from this dataset. Parental support might be more important for adolescents at an earlier age, such as during childhood. Parents could build a foundation for children on their competence, interest, and values in STEM during childhood, and these beliefs would persist in high school. Future study could examine parental support for STEM during childhood to see how parental support change longitudinally and how parental support differently predicts youth' math and science motivation at different age periods.

Second, this dissertation examined one of the socializers, the parents, who play a primary role in supporting adolescents' math and science motivational beliefs. According to Bronfenbrenner's (2006) ecological system theory, child development is the result of the child's interaction with the multiple contexts that the child is living in. More than just parents interact with adolescents in their immediate environment. For example, adolescents also interact with teachers, peers, their community, and siblings. Adolescents might not depend fully on parents when developing their motivation in STEM. Especially during adolescence, when adolescents need more autonomy from parents and teachers, they might interact or rely more on peers or siblings when shaping their motivational beliefs in math and science. More empirical studies are needed to understand which socializer is more important in adolescents' math and science motivation development and what support from multiple socializers would be most helpful.

Quantitative data, such as those utilized in this dissertation, have advantages in testing longitudinal relations and group differences and provide less insight into the actual developmental processes. In order to get a comprehensive picture of how students make their STEM major choices and how parents support adolescents' math and science motivation, qualitative research is needed concerning the complex social context adolescents and parents are living. It would be beneficial to understand the social contextual factors that play into adolescents' STEM major choices. For example, when parent support might help adolescents be resilient about the difficulty they face when pursuing STEM and what types of parental supports were helpful. From the parents' side, qualitative studies could have a more in-depth picture of how parents decide to be involved or not in adolescents' education, what kinds of support they provide for their adolescents and how they implement it. Moreover, future qualitative studies could focus on the groups such as female first-generation college students in the decision-making process of STEM majors, for example, at the intersection of gender and first-generation college students, what social group would adolescents most identify with, and which aspects of their social identity are invoked in certain settings.

Conclusion

This dissertation examined the development of adolescents' math and science motivational beliefs and the parental socialization process of adolescents' math and science motivational beliefs. This dissertation found that not all types of math and science motivational beliefs declined during high school (utility value increased). Also, math and science motivational beliefs were interrelated as they develop in high school that higher scores in one domain supported the increase in the other domain. Parents are important socializers for adolescents' motivational beliefs, especially their STEM-specific support was related to their math and science motivational beliefs in 9th grade. Parents' academic support was predicted by both parent- and child-level indicators that parents are also responsive to children's beliefs or achievements when they provide academic support. We found mean-level differences among these students that can be traced back to the beginning of high school, including parental beliefs and support, math and science motivational beliefs, that are carried forward to whether they declare a STEM major seven years later in college. However, the process-level differences in the relations between focal variables were rarer, suggesting that interventions on parenting or motivation might have similar effects. Our findings provided important evidence for future research to support adolescents in STEM, especially for adolescents who belong to underrepresented groups in STEM, such as females and first-generation college students.

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