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BRIEF REPORT

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Stability and changes in high school students' STEM career expectations: Variability based on STEM support and parent education

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Abstract

Introduction: Why do some students maintain their career expectations in STEM (science, technology, engineering, mathematics), whereas others change their expectations? Using situated expectancy-value and social cognitive career theories, we sought to investigate the extent to which STEM support predicted changes in students' STEM career expectations during high school, and if these processes varied by whether the student had college educated or noncollege educated parents.

Methods: Using the nationally representative data set of the High School Longitudinal Study, we investigated the predictors of changes in US students' STEM career expectations from 9th to 11th grade ($n = 13{,}100$, 54% noncollege educated parents, 51% girls, 55% White, 21% Latinx, 12% Black).

Results and Conclusions: Students with noncollege educated parents were significantly more likely to change from STEM to non-STEM career expectations by 11th grade or to have stable non-STEM career expectations (compared to having stable STEM expectations or changing from non-STEM to STEM expectations). Additionally, students with noncollege educated parents were less likely to receive STEM support from parents and attend extracurricular activities compared to students with college educated parents. However, when examining the predictors among students with noncollege educated parents, students were more likely to maintain their expectations for a STEM career from 9th to 11th grade (compared to switching to a non-STEM career) if they had parental STEM support. Additionally, all students regardless of parents' level of education were more likely to maintain their expectations for a STEM career (vs. switching to a non-STEM career) through high school if they received teacher STEM support. Furthermore, students were more likely to develop STEM career expectations (vs. maintaining non-STEM career expectations) if they had parent STEM support. These findings highlight how parent and teacher STEM support may bolster STEM career expectations, particularly among students with noncollege educated parents.

KEYWORDS

career interest, extracurriculars, math, motivation, parent education, parents, science, teachers

1 | INTRODUCTION

One group that is making headway in terms of representation in college, but remains underrepresented in STEM (science, technology, engineering, mathematics) is first-generation college students—students whose parents do not have a 4-year college degree. First-generation college students are less likely to graduate with a STEM major compared to their continuing-generation counterparts—students whose parents have a 4-year college degree (Bettencourt et al., 2020). Though this STEM disparity exists in college, it likely has roots in high school where students with noncollege educated parents experience more barriers compared to students with college educated parents (Bettencourt et al., 2020). For example, students with noncollege educated parents may be more likely to attend underfunded schools and have parents with less STEM capital (or knowledge about STEM content and careers; Archer et al., 2012). That said, students with noncollege educated parents have many strengths, including strong educational values, resilience, communal values, and close family ties (e.g., Azmitia et al., 2018). Yet, most research on STEM pathways focuses on deficit perspectives concerning students with noncollege educated parents (Bettencourt et al., 2020).

Investigating what predicts the changes in students' STEM career expectations during high school could identify potential STEM supports that may help close the persistent disparities between students with college educated and noncollege educated parents. Thus, our research goals were to (1) describe the patterns of stability and change in high school students' STEM career expectations from 9th to 11th grade, (2) test differences in students' STEM career expectation patterns over time and STEM support between students with college educated and noncollege educated parents, and (3) examine the extent to which STEM support relates to students' STEM career expectation patterns separately for students with college educated and noncollege educated parents to document what best supports students in each group.

1.1 | High school students' STEM career expectations

Students' STEM career expectations are defined as whether a student expects to hold a STEM career as an adult, which includes STEM occupations that require a 4-year degree (e.g., veterinarian) as well as those that do not (e.g., veterinary technician). According to situated expectancy-value theory (Eccles & Wigfield, 2020) and social cognitive career theory (Lent & Brown, 2019), individuals' career expectations are key predictors of their short- and long-term choices, including coursework and college major. Expecting to obtain a STEM career is an example of an achievement-related choice in situated expectancy-value theory (Eccles & Wigfield, 2020) and a choice goal in social cognitive career theory (Lent & Brown, 2019). These expectations shape individuals' outcomes in several ways. In social cognitive career theory, for instance, these choice goals shape students' choice actions (e.g., persistence and course enrollment), which in turn determine their subsequent performance and attainment. Thus, high school students who expect to have a STEM career are likely to take more STEM courses and do better in those courses than students whose career expectations lie outside of STEM – making students' STEM career expectations an important indicator to study.

According to both theories, students' career expectations develop over time based on intrapersonal and contextual processes. Situated expectancy-value theory argues that adolescence is a developmentally rich period with substantial changes in youth's beliefs about STEM as well as other achievement-related domains (Eccles & Wigfield, 2020). Given high school students' increasing preparation for college and the workforce, it is important to understand changes in students' STEM career expectations from when they start in high school and where they stand in 11th grade, just before they apply to college. The stability and changes in students' STEM career expectations include four distinct patterns. Students who expect to have STEM careers at the beginning of high school (9th grade) may either maintain those expectations in 11th grade (maintained STEM expectations) or switch to non-STEM careers by 11th grade (switched from STEM to non-STEM expectations). Similarly, students who expect to have non-STEM careers in 9th grade can either maintain those non-STEM career expectations in 11th grade (maintained non-STEM expectations) or switch to expect a STEM career by 11th grade (switched from non-STEM to STEM expectations). Though the existing literature focuses on declines in individuals' STEM motivation and how many people leave STEM (e.g., Ball et al., 2017; Scherrer & Preckel, 2019), there are actually four unique patterns of stability and change over time, including stable STEM career expectations or switching from non-STEM to STEM expectations. Yet, little research describes how many students develop STEM expectations in high school or what STEM supports help students maintain their STEM expectations, particularly for students with noncollege educated parents (Jiang et al., 2020). Thus, it is important to describe what STEM supports might push individuals with the same initial expectations on two different paths. In other words, our goal was to understand (a) differences between students who maintained their STEM expectations versus those who switched from STEM to non-STEM by 11th grade, and (b) differences between students who never expected to have a STEM career versus those who switched from non-STEM to STEM by 11th grade.

1.2 | Contextual STEM support

According to situated expectancy-value theory (Eccles & Wigfield, 2020) and social cognitive career theory (Lent & Brown, 2019), individuals' beliefs about STEM, including their career expectations, are influenced by the social contexts in which they are embedded and the extent to which they receive support to pursue STEM from those contexts. In fact, Eccles and Wigfield (2020) recently renamed the expectancy-value theory to the situated expectancy-value theory to underscore that individuals' development, including changes in their career expectations, is situated in and influenced by their surrounding contexts. Though social cognitive career theory argues that contextual supports directly impact individuals' career expectancies (and other choice goals) whereas situated expectancy-value theory argues that contextual influences are mediated by individuals' interpretation and motivational beliefs, they both agree that STEM supports matter for individuals' career expectations. Moreover, both theories argue that the most central contextual supports will be in the same domain. In this case, the central contextual supports of students' STEM career expectations are STEM contextual supports. Both theories claim that families and schools are two critical contexts for students' educational and occupational expectations. Parents, for example, are youth's first and primary socializer (Simpkins et al., 2015). Furthermore, both situated expectancy-value theory and social cognitive career theory posit that parents provide a variety of supports around STEM that collectively promote their children's STEM goals, expectations, and motivational beliefs, such as engaging in STEM activities together and talking about STEM courses (Eccles & Wigfield, 2020; Lent & Brown, 2019). Similarly, both theories posit that support from teachers (such as through STEM teaching quality and encouraging students to take more STEM courses) can shape students' STEM motivation and choices. Finally, situated expectancy-value theory highlights that school-based STEM extracurricular activities are a second primary way schools can further enrich and support students' STEM interests. These theories argue that students are more likely to be interested in pursuing STEM as a career if they collectively receive STEM support from these multiple sources.

Based on these theories, we expected that STEM support from parents and teachers, and participation in STEM extracurricular activities would positively relate to students' STEM career expectations (Garriott et al., 2013). Parents provide STEM support to adolescents through various strategies, such as coactivity and advice (Simpkins et al., 2015; Šimunović & Babarović, 2020). Additionally, teachers provide valuable STEM support through their teaching quality (supporting students' learning) and course taking support (e.g., Simpkins et al., 2020). STEM extracurricular activities offer opportunities to engage in STEM experiences that contribute to students' expectations (Chan et al., 2020; NRC, 2015). Studies combining STEM support from multiple sources have sometimes found that all uniquely predict students' STEM beliefs (Rice et al., 2013) whereas only parent support remains significant in other studies (Simpkins et al., 2020).

1.3 | Within and between group differences based on parent higher education

Situated expectancy-value theory (Eccles & Wigfield, 2020) and social cognitive career theory (Lent & Brown, 2019) posit that individuals' development and the contexts they develop within are influenced by their demographic characteristics. Parents' level of education is a powerful determinant of youth's development and the quality of children's family, school, and extracurricular activity contexts (Eccles, 2005). For example, parents with more education talk to their children more and with more varied language (Hoff, 2003), have higher expectations for their children (W. Wang et al., 2020), and expose their children to more educational opportunities such as science and computer programs and summer camps (Shih & Yi, 2014). Furthermore, despite strong family connections and motivation to do well academically (e.g., Covarrubias et al., 2019), students with noncollege educated parents may be less likely to receive STEM support due to systemic barriers. For example, students with noncollege educated parents may experience less STEM support overall due to attending schools with fewer resources (and thus less funding to cultivate teachers and afterschool programs) and having parents with less STEM capital, all of which limits their access to engaging in STEM-related experiences compared to students with college-educated parents (Archer et al., 2012; Aschbacher et al., 2010; Bettencourt et al., 2020). This may be why students with noncollege educated parents, on average, have lower STEM motivation and are less likely to select STEM majors (Jiang et al., 2020). Additionally, they are less likely to persist in their college career expectations, although less is known specifically about STEM careers (Gao & Eccles, 2020). Aligned with theory (Eccles, 2005), whether or not a parent has a 4-year college degree is a powerful and meaningful indicator of youth's educational opportunities and outcomes.

On a positive note, studies have found that students with noncollege educated parents have many strengths, such as resilience and strong connections to family (Covarrubias et al., 2019). Additionally, prior research finds that noncollege educated parents are a central, positive influence on their adolescents' academic outcomes (e.g., Bryan & Simmons, 2009; Ramos Carranza & Simpkins, 2021). In fact, some studies suggest that STEM support may have a larger impact on youth with noncollege educated parents when compared to students with college educated parents (Garriott & Nisle, 2018; Hsieh & Simpkins, 2022). These positive processes in families with noncollege educated parents are often ignored or overshadowed by the comparisons between college and noncollege educated parents. Documenting the processes and what works within each group is vital to help support positive family and developmental processes within that group. (e.g., Causadias et al., 2018; Quintana et al., 2006; Simpkins et al., 2015). That information cannot be gleaned from group comparisons. Examining relations between parent support and outcomes is important to understanding how these processes work within each group allows us to examine specific factors that support youth's success within each group and helps demonstrate the variability within-groups.

In sum, we chose to focus the present paper on the between- and within-group differences based on parent education, because parent education is associated with students' STEM college outcomes (Jiang et al., 2020), but has been understudied in terms of high school students' STEM outcomes. Prior studies find that parent education predicts parent expectations and youth academic outcomes more strongly than parent income (e.g., Davis Kean, 2005). However, we recognize that there are other historically marginalized groups in STEM, most notably those from working-class backgrounds, girls/women, and Black and Latinx individuals. Furthermore, parent education, socioeconomic status, gender, and race/ethnicity often overlap in meaningful ways (e.g., Garriott et al., 2021).

1.4 | Current study

We examined between- and within-group differences based on parent education because we wished to test mean level differences in STEM support and career expectations across groups while also identifying which STEM supports might be helpful for students within each group. Exploring within-group differences can help avoid deficit-based perspectives and foster positive developmental recommendations (e.g., Causadias et al., 2018). First, we considered between-group differences, hypothesizing that students with noncollege educated parents (a) are more likely to switch from STEM to non-STEM career expectations and maintain their non-STEM expectations from 9th to 11th grade and (b) will report fewer STEM supports than students with college educated parents. Second, examining within-group differences, we expected STEM support (from parents, teachers, and extracurriculars) will predict students maintaining their STEM career expectations and switching from non-STEM to STEM expectations from 9th to 11th grade among students with college educated parents and among students with noncollege educated parents. We controlled for math achievement, gender, and race/ethnicity, given these factors are related to both individuals' STEM expectations and parent college education (Garriott et al., 2021; Schoon & Eccles, 2014).

2 | METHOD

2.1 | Participants

The analytic sample included 13,100 adolescents from the High School Longitudinal Study (HSLS), a nationally representative longitudinal study of over 20,000 students from 944 schools in the US (NCES, 2020). Students were excluded if (a) they or their parent were selected but at least one of them did not participate in the first year of the study ($n = 8780$), (b) they did not take any math or science courses in 9th grade ($n = 2100$)[1] (c) they were missing career expectations in 9th or 11th grade ($n = 1200$), or (d) they were missing parent education ($n = 12$). Student participants identified as 51% girls, 55% White, 21% Latinx, 12% Black, and 3% Asian. Parents reported their education level 54% of parents reported that they had not graduated from a four-year college.

2.2 | Procedures and measures

Data were collected by NCES in 2009 when students were in 9th grade with a follow-up in 2011 when students were in 11th grade. Additionally, high school transcript data were collected in 2013. The student survey took students about 90 min to complete, and the majority of students completed it in school. When students were in 9th grade, parents took the survey in their own time. A majority of the surveys were filled out by students' mother or stepmother (76%) or their father or stepfather (21%). More details, including the items, are in the Supporting Information Material and on the NCES website (NCES, 2020; see https://nces.ed.gov/surveys/hsls09/).

2.2.1 | Students' STEM career expectations

Students were asked in 9th and 11th grade: "As things stand now, what is the job or occupation that you expect or plan to have at age 30?" Answers were coded dichotomously for STEM content by NCES based on O*NET occupational categories, including jobs related to the biological, physical, and computer sciences, mathematics, and engineering. Careers included occupations that required a college degree (or above) and those that typically do not require college degrees. A similar measure of career

[1]Students who did not take any math or science courses in 9th grade were excluded because the teacher STEM support questions were specifically asked about students' math and science teachers. If students were enrolled in at least one math or science course, they were included in the analytic sample. Compared to students who were enrolled in at least one math or science course, students not enrolled in any science or math courses in 9th grade were significantly less likely to have college educated parents and less likely to have STEM career expectations ($ps < .03$). However, they did not significantly differ in STEM parent support or STEM extracurricular activities. As a robustness check, all of the analyses were re-estimated on a sample which included students in the main analytic sample and those who did not take a math or science course in 9th grade. As shown in Supporting Information: Tables 1–4 in the Supporting Information Materials, the patterns of findings replicated those in the main analyses.

expectations has been used in prior studies (Edwin et al., 2019; Gao & Eccles, 2020; Gottlieb, 2018; Starr & Simpkins, 2021). Changes from 9th to 11th grade could fall into four groups: students could (a) maintain STEM expectations, (b) switch from STEM to non-STEM expectations, (c) maintain non-STEM expectations, or (d)switch from non-STEM to STEM expectations.

2.2.2 | Parent STEM support

Theories such as situated expectancy-value theory as well as empirical studies (e.g., Simpkins et al., 2015) argue that parents use a variety of strategies to support youth in STEM, including discussions about courses and STEM home activities. Our measure included both of these strategies. Parent STEM support in 9th grade was measured using 12 dichotomous items (1 = *yes*, 0 = *no*; $a = 0.70$). Six of these items were asked of adolescents regarding their STEM discussions with parents (e.g., "I talked to my [mother/father] about courses to take in [math/science])". Parents were asked the remaining six items regarding STEM home activities during the past year, for example, "Built or fixed something such as a vehicle or appliance." These 12 items were averaged to create a scale that ranged from 0 to 1. Similar measures have been used in prior studies using situated expectancy-value theory and social cognitive career theory as frameworks (Lee & Simpkins, 2021; Simpkins et al., 2015; M. T. Wang & Sheikh-Khalil, 2014) including indicators that combine youth- and parent-reported measures (e.g., Hsieh & Simpkins, 2022). Incorporating different forms of measurement, including different reporters, can help strengthen formative measures to offer a more complete picture of support (Bradley, 2004). Prior studies have used this method to measure constructs, including the home environment (Bradley et al., 2019).

2.2.3 | Teacher STEM support

Prior theory and empirical research suggest that teachers' support is important (e.g., Lent & Brown, 2019) and that teachers support their students in STEM through a variety of ways (e.g., Simpkins et al., 2020). Two important ways teachers can support students are through discussions about coursework (e.g., suggesting courses to adolescents) and through quality teaching that keeps students interested and motivated. Teacher STEM support in 9th grade was measured using 22 items ($a = 0.84$). Eight dichotomous items focused on teacher course support, asking adolescents how often they talked about courses with their math/science teachers and school counselor; "I talked to [math teacher/counselor] about courses to take in math" ($M = 0.14$, SD = 0.343). Additionally, 14 questions focused on the quality of the students' 9th grade math or science teacher; "Your [math/science] teacher makes [math/science] interesting" (1 = *strongly disagree*, 4 = *strongly agree*; $M = 1.92$, SD = 1.03). Subscales were averaged and standardized before combining. Prior studies based on situated expectancy-value theory and social cognitive career theory as frameworks have used similar measures to examine teacher support (Lee & Simpkins, 2021; M. T. Wang, 2009).

2.2.4 | STEM extracurricular activities

Extracurricular activities can be a valuable source of support for adolescents, where they may receive mentorship in STEM from adults and fellow students (e.g., Chan et al., 2020). Extracurricular STEM activities in 9th grade were measured using six dichotomous items asking adolescents about their participation during the past year in "[math/science] club," "[math/science] competition," and "[math/science] camp" (1 = *yes*, 0 = *no*). These items were averaged to create a scale that ranged from 0 to 1. Prior studies have used similar items to measure extracurricular activities (Wai & Allen, 2019).

2.2.5 | Background and control variables

Adolescents were asked to report their gender and ethnic/racial background. To measure math achievement in 9th grade, adolescents were given a 118-item item response theory (IRT)-estimated math assessment which was developed by an expert panel to assess students' algebraic reasoning, including content knowledge and ability to solve algebraic problems (IRT-estimated reliability = 0.92; Ingels et al., 2011). Student scores were then standardized by NCES. Parents reported their education level (ranging from 1 = *less than high school* to 7 = *Ph.D/M.D/Law*). Parent education level was used to determine whether a student had noncollege educated or college educated parents.[2] Gender, race/ethnicity, and math achievement were used as control variables. These indicators were chosen as covariates based on their relations to individuals' STEM career

[2]We compared whether there were differences among students with college educated and noncollege educated parents based on race/ethnicity and gender. There were significant racial/ethnic differences, but not gender differences ($p = .508$). When compared to students with college educated parents, students with noncollege educated parents were significantly more likely to be Black or Latinx and significantly less likely to be White or Asian (all $ps < .001$).

expectations in prior research (e.g., Schoon & Eccles, 2014). Additionally, race/ethnicity was controlled for categorically due to their relation to college generation (e.g., Garriott et al., 2021). Students were asked to select from a list "which of the following choices describe your race?" Whether a participant identified as Asian, Black, Latinx, or White was coded dichotomously (yes/no) by NCES. Whether or not a participant identified as Asian, Black, or Latinx was used as a control variable. This method of controlling for race/ethnicity is similar to other studies (e.g., Lee & Simpkins, 2021) and accounts for the categorical nature of race/ethnicity variables. More detail about background and control variables can be found on the NCES website (NCES, 2020).

2.3 | Plan of analysis

Analyses were conducted in STATA version 15.1 and Mplus version 8.4 (Muthén & Muthén, 1998-2017). Students with missing data (missing ranged from 1% for the item "I'm taking my current math course because my parent[s] encouraged it" to 13% for the item "My science teacher thinks all students can be successful") were included by using the maximum likelihood estimation with robust standard errors, estimated with the mlr command in Mplus and by imputing 30 data sets using auxiliary variables for the regression analysis (Enders, 2010). When compared to adolescents in the analytic sample with missing data, adolescents in the analytic sample without missing data reported significantly more extracurricular STEM support and parent STEM support ($ps < .001$), and were significantly more likely to expect to have a STEM career in 9th and 11th grade ($ps < .001$). Additionally, they were significantly more likely to identify as White and less likely to identify as Black ($ps < .001$), and more likely to identify as a girl ($p = .03$).

Measures met statistical assumptions for inferential testing (e.g., both skewness and kurtosis were between 1 and -1, Mauchly's Test of Sphericity was not significant). Given the complex sampling methods, all analyses in this study were adjusted to be representative of the study population by using sampling weights, clusters, and strata. These account for nonresponse rates in the nationally representative sampling process; the weight used (W2W1STU) accounted for both 9th and 11th grade data collection. Correlations were run between all major variables (see Table 1).

The first hypothesis on between-group differences included two parts. Hypothesis 1a investigated differences in STEM career expectations from 9th to 11th grade based on parent education. Latent transition analysis (LTA) in Mplus was used to estimate probabilities of change over time from one class to another (Lanza et al., 2013). LTA allows researchers to examine change over time, including how predictors relate to these transition probabilities. In our case, the transition probabilities are the conditional probability of having STEM or non-STEM career expectations at 11th grade, given their career expectations and other covariates in 9th grade. There were four possible patterns of stability and change in students' career expectations: students could (a) maintain STEM career expectations, (b) switch from STEM to non-STEM career expectations, (c) switch from non-STEM to STEM career expectations, or (d) maintain non-STEM career expectations. For the first hypothesis, we tested whether parent education significantly predicted the stability and change in students' STEM career expectations. We controlled for covariates (i.e., math achievement, gender, and race/ethnicity) in these analyses.

Hypothesis 1b, our next between-groups hypothesis, examined differences in the STEM support adolescents received in 9th grade based on parent college education. Because STEM support was measured at one time point (in 9th grade), we did not employ LTA. We employed linear regression in STATA to test these differences across the two parent college education groups. Regressions were estimated with and without controlling for math achievement, gender, and race/ethnicity.

TABLE 1 Correlations and means of the focal indicators for students with college (above the diagonal) and noncollege educated parents (below the diagonal) ($n = 13{,}100$)

Indicator	1	2	3	4	5	Students with noncollege educated parents %/*M* (SD)	Students with college educated parents %/*M* (SD)
1. STEM expectations 9th	-	.37***	.13**	.13**	.11	30%	33%
2. STEM expectations 11th	.36***	-	.10**	.11**	.08	32%	37%
3. Parent STEM support 9th	.09**	.10***	-	.35***	.16**	0.31 (0.23)	0.48 (0.22)
4. Teacher STEM support 9th	.08**	.08**	.30***	-	.16***	−0.24 (1.36)	0.06 (1.52)
5. STEM extracurriculars 9th	.05	.03	.12**	.12**	-	0.14 (0.55)	0.22 (0.67)

Note: For correlations, students with noncollege educated parents are below the dashes and students with college educated parents are above the dashes. Teacher support is standardized. Parent STEM support and STEM extracurriculars are unstandardized averaged scales, on a scale of 0–1.

Abbreviation: STEM, science, technology, engineering, mathematics.

**$p < .01$; ***$p < .001$

Source: US Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base Year and First Year Follow-up public data set, *n*'s rounded to the nearest tens place.

Hypothesis 2 investigated within-group differences on the extent to which the three different sources of STEM support (from teachers, parents, and extracurricular activities) significantly predicted LTA transition probabilities of the changes in students' STEM career expectations. These analyses were estimated separately for students with noncollege educated parents and students with college educated parents to identify which kinds of STEM support related to the stability and changes in students' STEM career expectations within each group. In each parent education group, an LTA was run. This LTA was similar to the LTA described in hypothesis 1a (i.e., examining transition probabilities in STEM career expectations from 9th to 11th grade, controlling for covariates), but it also included all three forms of STEM support as predictors to examine how they related to the transition probabilities of STEM career expectations.

3 | RESULTS

As shown in Table 1, the correlations show that parent and teacher support in 9th grade were positively related to STEM expectations in 9th and 11th grade across both parent education groups. Participating in STEM extracurricular activities was not associated with students' STEM career expectations. Roughly 30%–33% of students had STEM career expectations in 9th grade; by 11th grade, the number of students who had STEM career expectations increased to 32%–37% (see Table 1).

Table 2 presents the changes in students' STEM career expectations based on parent education. First, we describe the frequencies of stability and change in students' career expectations among students with noncollege educated parents. Specifically, 30% of 9th grade students with noncollege educated parents expected to have a STEM career as an adult ($n = 2100$). Of those students, 57% maintained their STEM career expectations from 9th to 11th grade whereas 43% switched to a non-STEM career expectation by 11th grade. In contrast, 70% of 9th grade students with noncollege educated parents expected to have a non-STEM career as an adult ($n = 4910$). Of those students with 9th grade non-STEM career expectations, 79% maintained their non-STEM expectations from 9th to 11th grade, and 21% switched to a STEM career by 11th grade. The percentage of students displaying these patterns of stability and change was similar among students with college educated parents. Specifically, 33% of 9th grade students with college educated parents expected to have a STEM career as an adult ($n = 1980$). Of those students, 62% maintained their STEM career expectations from 9th to 11th grade whereas 38% switched to a non-STEM career. Approximately 65% of 9th grade students with college educated parents had non-STEM

TABLE 2 STEM career expectations from 9th to 11th grade, by parent education ($N = 13{,}100$)

	9thgrade	Pattern of stability and change	11th grade
Students with noncollege educated parents ($n = 7010$)			
STEM career expectations	2100 (30%)	Maintained STEM 1190 (57%) Switched to non-STEM* 910 (43%)	2210 (32%)
Non-STEM career expectations	4910 (70%)	Switched to STEM 1020 (21%) Maintained non-STEM** 3890 (79%)	4800(68%)
Students with college educated parents ($n = 6090$)			
	9th grade	Pattern of stability and change	11th grade
STEM career expectations	1980 (33%)	Maintained STEM 1230 (62%) Switched to non-STEM* 750 (38%)	2230 (37%)
Non-STEM career expectations	4110 (67%)	Switched to STEM 1000 (24%) Maintained non-STEM** 3110 (76%)	3860 (63%)

Note: *p* values indicate that students with noncollege educated parents were more likely to be represented in that group when compared to stable STEM group in latent transition models. Model fit: Log Likelihood = −95,387.405; AIC = 190846.811; BIC = 19,1116.106; Likelihood ratio $\chi^2 = 148.563$, $df = 96$, $p = .001$.

Abbreviation: STEM, science, technology, engineering, mathematics.

$^{**}p < .01$.

Source: US Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base Year and First Year Follow-up restricted data set.

career expectations ($n = 4110$). Of those students, 76% maintained their non-STEM career expectations whereas 24% switched to a STEM career by 11th grade.

3.1 | Between-group differences in STEM support and career expectations

For hypothesis 1a, we anticipated that compared to students with college educated parents, students with noncollege educated parents would be more likely to switch from STEM to non-STEM career expectations and maintain their non-STEM expectations from 9th to 11th grade. To investigate hypothesis 1a, we employed LTA to examine the odds ratio for changing career expectations based on parent college education, controlling for covariates. Among students who had STEM expectations in 9th grade, those with noncollege educated parents were significantly more likely than students with college educated parents to switch from STEM to non-STEM career expectations (rather than maintain their STEM career expectations) (OR = 17.788, $p < .001$). Additionally, among students who did not have STEM career expectations in 9th grade, students with noncollege educated parents were significantly more likely than students with college educated parents to maintain their non-STEM expectations from 9th to 11th grade (rather than switch from non-STEM to STEM career expectations) (OR = 5.695, $p < .001$). In other words, as expected, when compared to students with college educated parents, students with noncollege educated parents were significantly more likely to switch to non-STEM career expectations or maintain non-STEM career expectations.

For Hypothesis 1b, we expected that students with noncollege educated parents would report significantly less STEM support than students with college educated parents. Because the support data was from only one time point (9th grade) we used regression analysis (instead of LTA). As hypothesized, the regression findings suggest that students with noncollege educated parents reported significantly less STEM support from parents and teachers as well as participated in fewer extracurricular STEM activities than students with college educated parents (see Table 3). Once the control variables were included, the significant differences based on parent education in parent STEM support and extracurriculars remained, but the significant difference in teacher STEM support was not statistically significant (see Table 3). In sum, students with noncollege educated parents received lower STEM parent support and participated in fewer STEM extracurricular activities when compared to students with college educated parents, even after controlling for other factors.

3.2 | Within-Group differences: Predictors of STEM career expectations from 9th to 11th grade

To examine if STEM support predicts the stability and changes in students' STEM career expectations, we added covariates and the three STEM support indicators to the latent transition model run for the prior analysis (see Table 4). Because we sought to identify the predictors for students with noncollege educated parents and separately for students with college educated parents, we estimated separate latent transition models for each of the two parent education groups.

We first describe findings among students with noncollege educated parents. Among those who began 9th grade with STEM career expectations, students with noncollege educated parents were more likely to maintain their STEM career expectations in 11th grade compared to switching to non-STEM career expectations if they received STEM support from their parents ($B = 3.467$, SE = 0.511, $p < .001$) and their teachers ($B = 0.250$, SE = 0.077, $p = .001$). Support from STEM extracurricular activities was not significantly related to students' maintaining their STEM career expectations or not. Among those who began 9th grade with non-STEM career expectations, students with noncollege educated parents were more likely to switch to STEM career expectations in 11th grade compared to maintaining their non-STEM career expectations if they received STEM support from their parents ($B = 1.450$, SE = 0.507, $p = .004$). STEM support from teachers and extracurricular activities was not significantly related to students maintaining their non-STEM career expectations or switching to STEM career expectations among students with noncollege educated parents.

We examined the same STEM social support predictors among students with college educated parents. Among those who began 9th grade with STEM career expectations, students with college educated parents were more likely to maintain their STEM career expectations in 11th grade compared to switching to non-STEM careers if they received support in STEM from their teachers ($B = 0.266$, SE = 0.074, $p < .001$) and participated in STEM extracurricular activities ($B = 1.284$, SE = 0.249, $p < .001$). STEM support from parents was not significantly related to maintaining STEM career expectations or not among students with college educated parents. Among those who began 9th grade with non-STEM career expectations, students with college educated parents were more likely to switch to STEM career expectations in 11th grade compared to maintaining the non-STEM career expectations if they received support in STEM from their parents ($B = 3.873$, SE = 0.630, $p < .001$) and from their teachers ($B = 0.302$, SE = 0.069, $p < .001$). STEM extracurricular activities were not significantly related to switching to STEM career expectations among students with college educated parents.

TABLE 3 Regression analysis testing differences in high school students' STEM support based on parent education

Predictor	Models without controls *B* (SE)	Models with controls *B* (SE)
Parent STEM support		
Constant	0.478 (0.005)***	1.549 (0.432)***
Noncollege educated parents	−0.133 (0.006)***	−1.004 (0.184)***
Math achievement		0.040 (0.008)***
Girl		0.178 (0.135)
Black		−0.222 (0.216)
Latinx		−0.325 (0.196)
Asian		0.664 (0.226)*
F	54.37***	20.00***
Pseudo R^2	0.09	0.32
Teacher STEM support		
Constant	0.089 (0.031)**	−0.036 (0.215)
Noncollege educated parents	−0.256 (0.037)***	−0.085 (0.054)
Math achievement		0.006 (0.003)
Girl		0.166 (0.058)*
Black		0.273 (0.088)*
Latinx		−0.023 (0.076)
Asian		−0.020 (0.123)
F	3.45*	4.15**
Pseudo R^2	0.01	0.42
STEM extracurriculars		
Constant	0.212 (0.011)***	−4.472 (0.044)***
Noncollege educated parents	−0.100 (0.013)***	−0.296 (0.090)***
Math achievement		0.050 (0.005)
Girl		−0.139 (0.083)
Black		0.297 (0.178)
Latinx		0.005 (0.154)
Asian		0.511 (0.142)***
F	40.22***	25.33***
Pseudo R^2	0.02	0.31

Abbreviation: STEM, science, technology, engineering, mathematics.

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

Source: US Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base Year and First Year Follow-up restricted data set.

4 | DISCUSSION

This study addressed two critical gaps in the literature: the diverse changes in students' STEM career expectations from 9th to 11th grade, and the STEM contextual supports associated with those diverse changes. Both were examined for students with college educated parents and those with noncollege educated parents. First, as expected, students with noncollege educated parents were less likely to receive STEM support from parents and to participate in STEM extracurricular activities compared to students with college educated parents. Additionally, students with noncollege educated parents were more likely to switch

TABLE 4 The LTA analysis with students' STEM support predicting the changes in STEM career expectations from 9th to 11th grade

Predictor	Maintaining STEM expectations (vs. switching to non-STEM) B (SE)	Switching to STEM expectations (vs. maintaining non-STEM) B (SE)
Students with noncollege educated parents		
Parent STEM support	3.467 (0.511)**	1.450 (0.507)*
Teacher STEM support	0.250 (0.077)*	0.110 (0.064)
STEM extracurriculars	0.901 (0.527)	−0.115 (0.256)
Students with college educated parents		
Parent STEM support	2.575 (0.909)	3.873 (0.630)**
Teacher STEM support	0.266 (0.074)**	0.302 (0.069)**
STEM extracurriculars	1.284 (0.249)**	0.714 (0.389)

Note: Model fit students with noncollege educated parents: Log Likelihood = −45,372.789; AIC = 90,825.578; BIC = 91,098.853; Likelihood Ratio $\chi^2 = 60.179$, $df = 37$, $p = .009$. Model fit students with college educated parents: Log Likelihood = −38,392.879; AIC = 76,865.757; BIC = 77,133.644; Likelihood Ratio $\chi^2 = 74.334$, $df = 37$, $p < .001$.

Abbreviation: STEM, science, technology, engineering, mathematics.

$^{*}p < .01$.; $^{**}p < .001$.

Source: US Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base Year and First Year Follow-up restricted data set.

from STEM to non-STEM career expectations or maintain their non-STEM career expectations when compared to students with college educated parents. Thus, disparities in STEM that are evident in college were traced back to high school in these data (e.g., Bettencourt et al., 2020). This is congruent with prior research and theory suggesting that parent education is a strong determinant of youth outcomes (Eccles, 2005). Parents' education influences their income, values, skills, and knowledge, which in turn impacts the support youth receive from parents and their access to high-quality contexts, such as enriching schools and extracurricular activities (Eccles, 2005).

Situated expectancy-value theory and social cognitive career theory suggest that support from important people in youth's lives, such as teachers and parents, contribute to developing and maintaining career expectations in specific domains (Eccles & Wigfield, 2020; Lent & Brown, 2019). In line with these theories, we found that STEM support from parents, teachers, and STEM extracurricular activities predicted students maintaining their STEM career expectations or switching from non-STEM to STEM career expectations. Among students who had STEM career expectations in 9th grade, 57% of students with noncollege educated parents and 62% of students with college educated parents maintained those STEM career expectations in 11th grade, which was positively predicted by teacher STEM support for all students. Additionally, parent STEM support positively predicted students maintaining their STEM career expectations for those with noncollege educated parents. Finally, STEM extracurricular activities positively predicted maintaining STEM career expectations for students with college educated parents. These findings align with the tenets of both situated expectancy-value theory and social cognitive career theory in that STEM support provided by individuals' surrounding contexts matters in terms of adolescents maintaining their STEM career expectations versus switching to non-STEM careers.

Furthermore, we found that 21%–24% of high schoolers who did not endorse STEM career expectations in 9th grade switched to having STEM career expectations by 11th grade. Eccles and her colleagues have underscored throughout their work that adolescence is a developmental period characterized by substantial changes in students' motivational beliefs (e.g., Eccles & Wigfield, 2020). These changes are due to a variety of processes, including adolescents' deeper exploration of various domains, their greater understanding of what they are good at and enjoy as well as how they define themselves, and their ability to think in complex ways about how they fit within society. Historically, the empirical work founded on situated expectancy-value theory has focused on average changes across all youth, which are typically the declines in students' STEM beliefs (e.g., Scherrer & Preckel, 2019). Our findings suggest that about one in four or five high school students who originally planned on a non-STEM career changed to a STEM career by 11th grade. Moreover, students were more likely to make the switch from non-STEM to STEM when parents provided STEM support. This finding emerged for all students regardless of parent education level. Future research should not only consider average changes, but also examine the rich variability in how youth's beliefs can change over time, including those who hold more positive beliefs about STEM over time. Relatedly, it is possible that different patterns of change (e.g., switching from non-STEM to STEM vs. maintaining STEM career expectations) may have different precursors. Researchers will need to examine the extent to which the various processes described in situated expectancy-value theory and social cognitive career theory equally apply to different patterns of change. For example, do the same supports help students maintain their STEM expectations as those that push students to switch from non-STEM to STEM expectations? Our findings suggest parent and teacher STEM support were more consistent predictors of both types of patterns than extracurricular activities. More work is needed to understand if similar or unique supports are needed to develop versus maintain STEM career expectations.

The finding that students with noncollege educated parents were less likely to receive parent STEM support and participate in STEM extracurricular activities falls in line with situated expectancy-value theory and social cognitive career theory suggesting that parent education makes a difference in the amount of support youth receive and in their career expectations (e.g., Eccles, 2005). However, the finding that parent STEM support mattered for this group speaks to how noncollege educated parents are still important in supporting their children, even if they experience barriers to the amount of support they may be able to give. Given that theory posits parents might give different kinds of support based on their demographic characteristics, future research might explore additional kinds of support that may be more common among noncollege educated families. For example, a recent qualitative study with majority noncollege educated parents found that Latinx parents were especially likely to support their adolescents in STEM by using consejos (culturally specific words of encouragement) and leveraging their social connections (Soto-Lara & Simpkins, 2020). On a positive note, our finding that about a fifth of students developed STEM career aspirations is noteworthy given that prior literature often focuses on high school as a time when students, especially underrepresented students, leave STEM (Ball et al., 2017). Moreover, the two positive findings regarding parent support demonstrate that parents are a source of strength, particularly among families with noncollege educated parents, which aligns with emerging work (Bryan & Simmons, 2009; Ramos Carranza & Simpkins, 2021; Soto-Lara & Simpkins, 2020).

These findings also have implications for future research and school policy concerning adolescence as a developmental period. Two hallmarks of adolescence are autonomy and identity development. Due to the increasing importance of autonomy, some assume parent and teacher support is not as important for adolescents or that less support is needed—but our findings underscore the point that support from parents and teachers still matters. However, the type of support provided is important to consider. Scholars have argued that autonomy-granting support from adults is particularly effective during adolescence. Autonomy-granting academic support is characterized by high levels of involvement that prioritizes positive feedback that highlights adolescents' strengths while simultaneously supporting them in places where they have room to grow (Pomerantz et al., 2014). Additionally, Pomerantz et al. (2014) argued that autonomy-granting support is less controlling and emphasizes effort rather than ability. To support parents and families in this endeavor, teachers and schools can provide parents with information and resources so that they can effectively support their children in the home (Harackiewicz et al., 2012). For example, one intervention found that providing parents with information about STEM careers and the connections between high school coursework and those careers resulted in more parent-adolescent conversations and adolescents taking, on average, one semester more of high school science and mathematics (Harackiewicz et al., 2012). Thus, relatively simple interventions from schools and teachers may help parents provide autonomy-granting STEM support for their adolescents.

In addition to autonomy, identity development is another important task in adolescence. Intentionally connecting STEM to students' personal interests, lives, and how they define themselves may be a particularly effective way of promoting STEM career expectations during high school. Both social cognitive career theory and situated expectancy-value theory posit that importance and interest beliefs are precursors to career expectations (Eccles & Wigfield, 2020; Lent & Brown, 2019). Thus, making personal connections between the material, adolescents, and their interests may help high school students develop (and maintain) STEM career expectations. For example, parents or teachers could connect STEM learning to local community activism, or get students involved in identity-affirming STEM groups (e.g., Black Girls Code).

Furthermore, adolescence, and high school in particular, is an important time to study and intervene in students' STEM career expectations, given students are preparing for college or the workforce (M. Wang et al., 2017). Adolescence is a developmental period when parents can motivate their children to develop STEM career expectations, through talking about math and science courses and participating in STEM-related conversations and activities together. Parental STEM support at the high school level may be especially valuable for students with noncollege educated parents, for whom parents both helped youth gain as well as maintain career expectations in STEM. Teachers and schools could involve parents through STEM-related activities and conversation starters (e.g., Harackiewicz et al., 2012) and build on families' funds of knowledge. Additionally, STEM support from teachers can help students maintain their STEM career expectations across high school. STEM course advice from teachers (e.g., recommending courses for students to take) and teacher quality (e.g., making lessons interesting) can help students maintain their STEM career expectations. Given that roughly a third of adolescents switched out of their STEM career expectations over high school, teachers may be particularly useful to help students maintain their STEM expectations during this developmental period.

4.1 | Limitations and future directions

We found that STEM extracurricular activities only positively related to maintaining STEM career expectations among students with college educated parents. This may have been because families with noncollege educated parents may have limited opportunities and resources available to participate in high-quality STEM extracurricular activities (e.g., science camp). Additionally, in comparison to the teacher and parent STEM support measures, the extracurricular measure was more limited. The measure indicated whether students participated in six different STEM extracurricular activities but did not indicate the frequency or quality of those activities. Future studies might investigate a wider breadth of STEM extracurriculars in addition to examining support from adults and the quality of those settings.

Furthermore, future research might explore the specific ways parents and teachers can help support students, especially those with noncollege educated parents, maintain their STEM career expectations or switch to STEM career expectations. Teachers should learn about how parents are supporting their adolescents and help build on what families already do. For example, teachers might include parents in activities (e.g., family math nights; Jacobbe et al., 2012) and celebrate the strengths noncollege educated families possess (e.g., Covarrubias et al., 2019).

5 | CONCLUSION

In conclusion, our study investigated the extent to which STEM support predicted changes in students' STEM career expectations and if those patterns varied by whether the student had college educated or noncollege educated parents. In line with situated expectancy value and social cognitive career theories (Eccles & Wigfield, 2020; Lent & Brown, 2019), we found that across high school, students were more likely to maintain career expectations if they received STEM support from teachers and were more likely to develop STEM career expectations if they had STEM support from parents. Additionally, STEM support from their parents also increased the odds that students with noncollege educated parents maintained their STEM career expectations versus switching to non-STEM. Thus, support from parents and teachers may be a promising way to maintain or develop STEM career aspirations across high school, particularly among students with noncollege educated parents.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data is available via the National Center for Educational Statistics: https://nces.ed.gov/surveys/hsls09/

ETHICS STATEMENT

Approval for this study was granted by the Institutional Review Board at the University of California, Irvine.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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