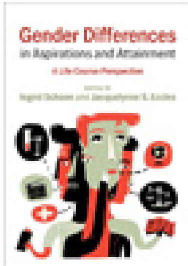

Gender Differences in Aspirations and Attainment

A Life Course Perspective

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13 What happens to high-achieving females after high school? Gender and persistence on the postsecondary STEM pipeline

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Abstract

Although progress has been made in reducing gender inequality in postsecondary education, in the US and in other countries, gender gaps remain in the science, technology, engineering, and mathematics (STEM) fields judged so critical to economic competitiveness. Using the Education Longitudinal Study of 2002, we examine the influence of young women and men's secondary school experiences of on their subsequent courses of study in college. In particular, we use this large-scale study to examine the effect of the psychological indicators (such as deep interest or absorption in the subject matter) suggested to be important predictors of persistence in small-scale studies of women specializing in STEM fields at the postsecondary level. Focusing the analysis on high-achieving youth who have completed the secondary school STEM pipeline course sequences, we find that academic preparation in secondary school is the critically important consideration in keeping US boys on the STEM pipeline midway through their undergraduate postsecondary educational experience. African American boys who have completed these sequences are the most likely to declare STEM majors and Latino males are least likely, net of nativity status. For high-achieving girls on the whole, however, course taking is insufficient to keep them on the STEM pipeline. Their orientation toward mathematics and external supports from engaged family, school staff, and friends are powerful predictors of their persistence in STEM at the postsecondary level.

Introduction

Many explanations have been articulated for why female students are less likely to pursue science, technology, engineering, and mathematics (STEM)

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majors in college. Particularly powerful has been the recognition that failure to complete specific mathematics and science course sequences in secondary school is predictive of postsecondary transitions and outcomes. Also influential are differences in actual and perceived abilities that lead many to conclude they are less well-suited to succeed in certain STEM fields (see also Chow & Salmela-Aro; Parker, Nagy, Trautwein, & Lüdtke; M. Wang & Kenny, this volume). Together this evidence suggests that young women who perceive themselves as less able to perform well in math and science, and complete fewer advanced mathematics and science courses in high school, would be less likely than those women who perceive themselves as more able, and who are better prepared to remain in the STEM pipeline. Similarly girls and boys who complete advanced courses in science and mathematics by the time they graduate from secondary school would seem especially well prepared to declare a STEM major in postsecondary school.

This chapter assesses the links between high school experiences and tendencies to remain on the STEM pipeline in postsecondary programs of study. In particular, we explore whether the academic and subjective experiences of students on the STEM pipeline in secondary school differ from those of students off the pipeline, and assess to what extent these experiences vary by gender.

Gender differences in science participation

Countries across the globe have made considerable progress toward the goal of decreasing disparities between women's and men's average education levels. In the early 1990s, males in Organization of Economic Co-operation and Development (OECD) countries were more likely than females to obtain postsecondary degrees (Vincent-Lancrin, 2008). By the mid-1990s, the trend began to change. In the US, females were as likely as males to graduate with a postsecondary degree (US Department of Education, 1995, p. 1). Gender parity was achieved among OECD countries in 2008 when the average proportion of females aged 25 to 64 with university-level education was the same as that found in the population overall (21%) (OECD, 2010, tables A1.3a–c).

Progress has also been made in the STEM fields judged so critical to economic competitiveness. In the US, for example, important gains were made at the undergraduate level in the four decades from 1966 to 2006. The percentage of bachelor's degrees earned by women more than doubled in the biological and agricultural sciences (increasing from 25 to nearly 60%), nearly tripled in chemistry (increasing from 18 to 52%), and approximately quadrupled in the earth, atmospheric, and ocean sciences (moving from 9 to 41%) and physics (from 5 to 21%) (Hill, Corbett, & St. Rose, 2010, p. 9).

With these gains, women were receiving nearly one half of the undergraduate degrees in mathematics and chemistry, and the majority of the bachelor's degrees in biology. However, much remains to be done to close persistent – in some cases, widening – gender gaps in other STEM fields in the US and other countries. US women were still gaining less than a third of the bachelor's degrees in

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physics in 2007, and only a small fraction of the degrees awarded in engineering. In computer science there was actually a decreasing proportion of undergraduate degrees awarded to women (Hill et al., 2010, pp. 9–10).

This troubling pace toward gender equity across the STEM fields is not unique to the US. Less than one quarter of the entering postsecondary student population in OECD countries are women in mathematics and computer science (24%) and engineering, manufacturing, and construction (23%).[1] These patterns of enrollment are often foreshadowed by students' expectations while still in secondary school. In US high schools, more adolescent boys than adolescent girls expect they will pursue STEM majors in higher education, especially in the more quantitative sciences, despite the fact that female high school students have been more likely than males to report that they expect to attend and graduate from college since the 1990s (Burke, 2007; Goldin, Katz, & Kuziemko, 2006). Consistent with these educational expectations and female underrepresentation in STEM fields in postsecondary institutions, women constitute a substantially smaller proportion than men of the US labor force in key STEM fields, including computer and information sciences (where only 26% of those employed are women), chemistry (23%), physics/astronomy (14%), electrical engineering (9%), aerospace engineering (8%), and mechanical engineering (7%).[2] Women, however, averaged a little over half (51%) of those entering postsecondary majors in the life sciences and agriculture.

This chapter examines the reasons for this persistent underrepresentation of women in specific STEM fields, starting with experiences in secondary education, which are then linked to participation in science fields during postsecondary education. Using data from the Education Longitudinal Study of 2002 (ELS), the most recent US representative sample of adolescents designed to capture high school to postsecondary transitions, we explore the secondary school experiences of young women and men, and the impact of these experiences on their subsequent courses of study in college.[3] Specifically, we consider whether efforts to further increase young women's preparation in mathematics and science in secondary school are likely on their own to keep more women on the STEM pipeline midway through the typical 4-year US undergraduate postsecondary school experience. Our study takes into account that preparation for science courses during secondary school is often conflated with ability, as students with a particular aptitude for a subject are often those who choose to pursue advanced studies in this area. We thus take into account variations in academic ability as well as a number of other possible confounding factors associated with the school experience.

[1] Countries differ with respect to their gender gaps in STEM fields. In mathematics and computer science, women ranged from 9% (in Belgium) to 44% (in Greece); see OECD (2010, table A2.6). (Web only, percentage of new entrants into tertiary education and proportion of females, by field of education, 2008.)

[2] Authors' calculations, based on data on employment in science and engineering careers provided in NSF (2009, table H-5): "Employed scientists and engineers, by occupation, highest degree level, and sex: 2006."

[3] ELS presently includes a base-year student survey in 2002 and two follow-ups in 2004 and 2006. In 2002, 15,400 students were included in the sample. This dataset also includes information from parents, students' teachers, and their schools. In 2002, 750 schools completed the base-year questionnaire.

Key dimensions of the US secondary school experience: school academic supports and opportunities

Students' experiences in secondary school are conditioned by a variety of factors, some unique to the school, some to the student, some to broader familial, neighborhood, and other cultural and social forces. In attempting to parse the relative impacts on students' postsecondary educational choices, it is helpful to distinguish school-level academic supports and opportunities from a wide range of individual-level factors that prior research has shown to have powerful influences on students' interest in STEM, in high school and beyond.

Considerable research supports the association between finishing advanced-level math and science classes and enrolling in and completing college (Adelman, 1999, 2006; Trusty & Niles, 2003). Completing mathematics and science pipeline courses impacts students' grades, test scores, college selectivity, and entrance into a STEM field in postsecondary education. Calculus and physics are both considered particularly important preparation for postsecondary STEM coursework. Although girls are less likely to complete physics than are boys, they complete calculus – perhaps strategically, to help them excel on college entrance examinations and increase their chances of admission to selective postsecondary institutions (Riegle-Crumb, 2010).

Selecting courses can be complicated, especially for students planning STEM careers. The most appropriate sequence of secondary school courses can be unclear to students (Schneider & Stevenson, 1999). Recognizing this, many schools and districts have made concerted efforts to increase students' understandings of the most appropriate courses to take in secondary school, if not earlier.[4] Still, rates and patterns of advanced course taking vary widely at both the individual and school levels. Affluent students tend to take more advanced mathematics and science coursework than their less socioeconomically advantaged peers; similarly, white and Asian students take more advanced courses compared to underrepresented minority students (Dalton, Ingels, Downing, & Bozick, 2007; Riegle-Crumb, 2006). High schools that serve high percentages of minority and low-income youth less commonly offer advanced math and science courses to their students (Adelman, 2006).

Another critical source of support for students as they navigate the demands of their secondary school courses and plan for their futures is provided by adult members of the school community. Teachers in particular can bolster students' educational attainment and persistence. Particularly important to students are their interpretations of their teachers' expectations for and behaviors toward them, especially teachers' positive or negative reinforcement of students' academic behaviors and ambitions. Students may withdraw academically when

[4] Research suggests that middle school should be the primary site for developing STEM ambitions; to be prepared to enter the mathematics pipeline, students should be encouraged to take the more advanced mathematics courses available to them (e.g., Algebra 1) (McDonough, 2004).

they encounter teacher and school attitudes that they perceive as being uncaring or holding low expectations for their academic performance and careers (Valenzuela, 1999). Students' perceptions of the degree to which teachers and peers regard their academic potential can explain differences in their postsecondary enrollment (Perez-Felkner, in press).

Girls are typically perceived as "better" students, harder working and easier to discipline (Jones & Myhill, 2004; Mickelson, 1989). While boys may receive less praise than girls for their overall academic performance, they appear to receive more support from parents and teachers for their interests and ambitions in STEM (Gunderson, Ramirez, Levine, & Beilock, 2012). In short, gendered differences in support may be less evident overall but still persist in some scientific fields. Thus it is critical to gauge the academic support students receive on the basis of self-reports of teachers' expectations, interest, praise, and whether or not they feel put down in class.

Individual-level factors influencing STEM interests and postsecondary choices

It has been suggested that young women's achievement on mathematics and science tests may help to explain why a smaller proportion of women than men pursue certain STEM majors in college. Females are less likely to score in the highest tail of the distribution of both mathematics and science standardized test scores and college entrance examinations. While the gender gap in test scores on the mathematics section of the SAT college entrance examination has narrowed over the years, the percentage of high-scoring boys (i.e., those achieving a score of 700 or better) continues to exceed the percentage of high-scoring girls (Wai, Cacchio, Putallaz, & Makel, 2010).

Influencing female students' assessments of their academic abilities may be the input they receive or perceive from others. High-performing students may attract more interest from college recruiters able to provide STEM fellowship and scholarship aid. As the number of high-performing women is more limited, it can reinforce negative perceptions of female ability to successfully pursue STEM careers in college. For example, teachers and counselors may base the messages they give on teachers' test results and overlook other factors relevant to the appropriateness of pursuing a STEM career (NSF, 2000).

Unpacking and redressing factors that contribute to students' under-assessments of their academic capabilities may be important in tackling the gendered differences that remain in STEM fields. Females' career pursuits have been found to be strongly associated with self-assessments of ability, in particular for STEM careers (Correll, 2001; see also Chow & Salmela-Aro; Parker et al.; Wang & Kenny, this volume). Self-assessments are shaped by local and societal beliefs about women's abilities and career opportunities, especially in the quantitative sciences (Correll, 2004; Ridgeway & Correll, 2004; Eccles (Parsons) et al., 1983).

When teachers emphasize process, memorization, and facts in isolation from the social context and real-world application of scientific or mathematical concepts, girls may still work hard in order to do well, but fail to develop a true passion that can be carried forward to a future university major. Students who express deep interest in particular subject domains (i.e., computer science) prior to postsecondary education have been found to persist in those fields (Margolis & Fisher, 2002; Singh, Allen, Scheckler, & Darlington, 2007). In a qualitative study of women who initially selected computer science majors in university, the authors found that these women reported enjoying working with computers, but came to doubt their identity as computer scientists; compared to their male classmates, they felt that they did not belong, were "guests in a male-hosted world," and did not feel the same "total absorption" (an all-consuming passion for working with computers and robotics in both work time and free time) that their male counterparts reported (Margolis & Fisher, 2002, p. 72).

Interlinked lives

The ongoing relationships among adolescents' psychological and social dispositions and their environments – including their interactions with family, peers, and school staff – can profoundly shape their interests and actions regarding college plans, particularly toward STEM fields. Students' expectations of themselves are shaped in important ways by the expectations others have for and communicate to them, the encouragement they receive from others, their adult and peer role models, and their experiences of broader social environments. Girls have been found to be more academically engaged overall; however, their engagement in mathematics and science in particular is less well understood. Past research has suggested that females underestimate their abilities in content areas in which their gender is not well represented (Correll, 2004).

Adults in the school community (including teachers, counselors, and coaches) are powerful influencers of student expectations. Thus the amount of time students spend interacting with such adults and the nature of these interactions are important in aligning adolescents' ambitions toward college and pursuit of postsecondary plans. It is important then to consider how these interactions vary within and across schools. Particularly relevant are the college advising resources available to students in school. Limited resources exist in many urban disadvantaged schools to help students learn about careers and postsecondary choices; this problem is partially attributable to their low numbers of STEM-trained teachers. Girls may, however, be more likely in disadvantaged secondary schools to achieve in math and science. Recent research suggests that girls in these schools may be receiving more attention and support from their teachers for pursuing STEM careers; African American and Latina girls in these schools complete more advanced mathematics course sequences in comparison to their African American or Latino male peers (Riegle-Crumb, 2006).

Important as their interactions with adults in the high school are, students may enter secondary school with deeply ingrained expectations and beliefs resulting from their internalization of broader social and cultural factors. When these include negative perceptions of STEM – e.g., science and mathematics are for males (Farland-Smith, 2009; Hill et al., 2010) – even the most dedicated adult proponents of STEM in high school (e.g., teachers and counselors) may find them hard to shift. Children as young as 5 have been found to evaluate their behavior according to these gender stereotypes (Eccles & Hoffman, 1984; Huston, 1985). Significantly, parents' socialization messages have been found to have long-term effects on young adults' occupational outcomes, in particular for girls (Chhin, Bleeker, & Jacobs, 2008).

Such socialization may help to explain why young women may still shy away from a career in math or science, even when they choose to pursue STEM majors in college. Women may choose other occupations because they perceive traditionally male-dominated fields to be oriented around competition (Hill et al., 2010). Women are more likely than men to report being motivated to pursue careers in which they help others or can use their skills to generate social benefits (Margolis & Fisher, 2002). In a recent study of Australian adolescents, girls' estimation of the "usefulness" of math was found to be highly predictive of their aspirations to mathematics careers; boys' view of the utility of math bore no effect on their pursuit of math careers (Watt, 2008). Some adolescent girls report viewing careers in computer science as "materialistic" male pursuits in which boys "fool around" with often-violent games (AAUW, 2000, p. 8). Females have generally been found to focus on the quality of their and others' lives in evaluating their educational and career options, as opposed to males who focus more on status rewards (Mickelson, 2003).

School peers also serve a critical role in forming adolescents' ambitions toward postsecondary schools and careers. College-oriented peer cultures can form in schools with high concentrations of students planning to enroll in postsecondary institutions; these cultures can serve to disseminate information and skills to facilitate the alignment of these college ambitions with the behaviors that assist in their realization (Schneider, 2007). The opportunity to develop a science identity may be stalled, perhaps permanently, by peers' and adults' explicit and implicit messages to young girls that science is for boys. Carlone (2004) suggests supportive communities help students embrace a "science identity," for example, that one is a "science person." Farland-Smith (2009) demonstrated that when middle school girls were exposed to female scientists as role models, they developed positive attitudes toward scientific careers and orientations toward pursuing a career in the sciences.[5]

Parents' expectations for their children's education influence students' academic and career aspirations, which in turn have been shown to influence

[5] The lack of female role models in university STEM departments has also been used to explain gender disparities in STEM majors. Only 20% of faculty in science and engineering departments are female (Dworkin, Kwolek-Folland, Maurer, & Schipani, 2008). These ratios are similar across

their career development (Schoon & Parsons, 2002). In the past, parents had lower expectations for their daughters. Today that is no longer the case (Schoon, 2010). In fact, as we will show, parents have higher expectations for females. In considering the impacts of students' educational expectations, identities, and role models on their STEM interests and postsecondary choices, we are particularly interested in how high school students are influenced by their understandings of their parents' expectations for them, the advice and guidance they receive from school staff, and the role models their peers present.

Factors influencing pursuit of a STEM major

Studies of female underrepresentation in STEM subjects in higher education tend to employ small samples of youth at select colleges and universities who are already enrolled in STEM coursework or even STEM majors. Less common are large-scale, prospective studies of youth that capture the periods prior to and through their commitment to a STEM concentration at the tertiary level. Large-scale, nationally representative, longitudinal studies such as the Education Longitudinal Study of 2002 (ELS) provide important opportunities to explore patterns of STEM persistence and attrition at the tertiary level.

ELS follows a cohort of students from secondary school through their transitions to work or postsecondary education, providing information about young people's aspirations, course taking, high school experiences, future plans, and academic achievement. This enables analyses of the influence of family background and school contexts' influence on students' college matriculation and pursuit of STEM majors. Importantly the study allows us to evaluate the degree to which students report engaging in conversations with adults about their courses and about college.

An open question is whether the psychological indicators (such as deep interest or absorption in the subject matter) suggested to be important predictors of persistence in small-scale studies of women specializing in STEM fields at the tertiary level (e.g., Margolis & Fisher, 2002) would be present in large-scale studies. This is particularly relevant with respect to the question of whether females are responding to education policies emphasizing science and mathematics at the secondary level. With its data on the academic experiences of male and female students from their sophomore year in high school into postsecondary education and the labor market, ELS allows us to explore two questions: (1) To what extent are the academic and subjective experiences of students on the STEM pipeline in secondary school different from those of

most STEM fields. Studies have further suggested that STEM professors may contribute to an environment perceived to be hostile or unsupportive for women (Baron-Cohen, 2009; Goodman et al., 2002).

students off the pipeline? and (2) Do these experiences vary by gender, and are these differences sustaining, as evidenced by the college major declared 2 years after high school?

Relating high school experiences to females' and males' tendencies to remain on the STEM pipeline in postsecondary programs of study is complicated, especially when considering not only individual cognitive and social factors but the family and high school contextual factors that are likely to influence choices. We suspect that differences in both individual and contextual factors interact with gender and are likely to influence not only choices but also sustaining interest in postsecondary school. The following analyses take both the individual and contextual factors into account to examine postsecondary matriculation and pursuit of a STEM major, with a special emphasis on females and males. The primary dependent measure indicates whether or not female or male students declare a STEM major 2 years out of secondary school.[6] Analyses also consider whether females and males with high levels of high school STEM preparation are enrolled in a 2- or 4-year college or university.

Assessing gendered differences

To begin, a series of descriptive analyses are conducted to examine if there are differences in the performance and academic experiences of students on and off the STEM pipeline in high school. Generally, it is assumed students *in* the STEM pipeline are those who, by the end of secondary school, have completed coursework in science and mathematics that would prepare them to be eligible for STEM major coursework in postsecondary education. We define *being on the STEM pipeline in secondary school* as successful completion of (1) at least 1 year of physics and chemistry and (2) at least 3 years of high-school-level math coursework, such as completing Algebra 2. Conversely, students described here as *not* in the STEM pipeline are those who have not met one or both of these criteria.

In considering the potential impacts of academic abilities and achievement on students' STEM interests and postsecondary choices, two indicators of students' academic ability are included in the model. The first is overall academic ability over time, administered by examinations given by the US National Center for Educational Statistics (NCES). The second is high school grade point aver-

[6] This variable was measured by the US National Center for Educational Statistics (NCES) for only those respondents who enrolled in postsecondary institutions, as reported in the chapter's descriptive results. For the multinomial analysis, however, all respondents are incorporated into the model to prevent sample bias from missing data. Respondents not enrolled in postsecondary education are coded as "0" for not declaring a STEM major. To include a fuller analytic sample of male and lower socioeconomic status respondents, we recoded those missing on the basis of a "legitimate skip" as "not declaring STEM major" because they are not on track to complete a STEM major 2 years after high school. These models were additionally estimated with the original coding scheme and similar results were obtained.

age (GPA) from their 12th-grade academic transcripts (excluding non-academic courses).

Other student factors include expectations held by 10th-grade students and their parents for their education (how far they will go in school), how frequently students talk with their parents about college and courses, and how frequently they speak with school staff (counselors, teachers, and coaches) about college. In addition to how often they seek out advice from adults, we measure their beliefs about the ability to learn to be good in math, to understand the degree to which they might view academic challenges in mathematics. Further, we examine students' perceptions of the efficacy of their secondary school math and science training for postsecondary education.

School contextual measures include: (1) student responses regarding their plans to take the ACT or SAT college entrance examinations, aggregated to the school level; (2) the proportion of 2003 graduates enrolling in a 2-year college or university; and (3) the proportion of 2003 graduates enrolling in a 4-year college or university.[7] A composite measure of school quality is created, coded into four quartiles based on the proportion of students planning to take the SAT/ACT and percentage of 2003 graduates enrolling in 4-year colleges.

Analyses are conducted on the full sample of ELS students and a subsample of those who were on the STEM pipeline in secondary school as defined above. The experiences and outcomes of these two groups are compared with a special focus on gender differences both during and after high school. Additionally, a series of logistic multilevel models are estimated to examine the relationships among their individual and school-level characteristics and the odds of declaring a STEM major 2 years after secondary school. These analyses employ a hierarchical linear modeling (HLM) approach to consider students' nested positions within schools, by estimating individual-level attributes as predictors at level 1 and school-level attributes as predictors at level 2.[8]

Odds ratio comparisons demonstrate the degree to which each predictor affects the probability of declaring a STEM major 2 years after high school, for males

[7] These school-level variables were generated from the 10th- and 12th-grade school administrator files.

[8] The following logistic hierarchical linear models are used to calculate the odds of declaring a STEM major 2 years after high school:

Level-1 (student-level):

Odds of STEM major (2006) = $\beta_0 + \beta_1$ *Student background characteristics* $_{ij} + \beta_2$ *Student abilities, academic experiences, and achievement in high school* $_{ij} + \beta_3$ *Student educational expectations, identities, and role models in high school* $_{ij} + \beta_4$ *Student engagement in high school* $_{ij} + \beta_5$ *Academic supports in high school* $_{ij} + \beta_6\, q_{ij}$

Level-2 (school-level):

$\beta_{1\,ij} = \gamma_{(0\,-\,\text{fixed})} + \gamma_1$ *High School Characteristics* $_{ij} + \gamma_3\, s_{ij}$

$\beta_{2\,ij} = \gamma_{(0\,-\,\text{fixed})} + \gamma_1$ *High School Characteristics* $_{ij} + \gamma_3\, s_{ij}$

$\beta_{3\,ij} = \gamma_{(0\,-\,\text{fixed})} + \gamma_1$ *High School Characteristics* $_{ij} + \gamma_3\, s_{ij}$

$\beta_{4\,ij} = \gamma_{(0\,-\,\text{fixed})} + \gamma_1$ *High School Characteristics* $_{ij} + \gamma_3\, s_{ij}$

$\beta_{5\,ij} = \gamma_{(0\,-\,\text{fixed})} + \gamma_1$ *High School Characteristics* $_{ij} + \gamma_3\, s_{ij}$

Table 13.1. *Descriptive characteristics of sample population by STEM pipeline course taking*

	Full analytic sample		
	STEM N = 4,632 $\bar{X}$ (SD)	Non-STEM N = 9,508 $\bar{X}$ (SD)	
Student background characteristics[a]			
Race and ethnicity			
White and/or Asian	0.773 (0.419)	0.650 (0.477)	***
Black/African American	0.106 (0.307)	0.159 (0.366)	***
Latino/Hispanic	0.114 (0.318)	0.178 (0.383)	***
Foreign-born	0.087 (0.281)	0.073 (0.260)	**
Family composition	0.748 (0.434)	0.657 (0.475)	***
Number of siblings	2.052 (1.399)	2.433 (1.567)	***
Socioeconomic status	0.300 (0.718)	−0.119 (0.685)	***
Student abilities, academic experiences, and achievement in high school			
Overall academic ability	0.558 (0.959)	−0.277 (0.921)	***
Math ability	0.563 (0.946)	−0.289 (0.916)	***
Hours spent per week on extracurricular activities	2.577 (1.263)	2.147 (1.246)	***
Hours spent per week on math homework	3.404 (2.143)	3.031 (2.350)	***
Math pipeline completion[b]	7.167 (0.781)	4.774 (1.409)	***
Science pipeline completion[b]	6.503 (0.500)	4.364 (1.163)	***
GPA (all academic courses only)[b]	6.326 (1.245)	4.255 (1.642)	***
Total AP/IB Science courses[b]	0.385 (0.604)	0.021 (0.151)	***
Student educational expectations, identities, and role models in high school[c]			
College educational expectations	5.658 (1.203)	4.890 (1.484)	***

Table 13.1. (*cont.*)

	Full analytic sample		
Parent expectations (10th)	5.564 (1.179)	4.955 (1.467)	***
Parent volunteering in school (10th)	0.359 (0.480)	0.251 (0.434)	***
Talk with parents about courses (12th)	2.216 (0.655)	2.059 (0.683)	***
Talk with parents about college (12th)	2.419 (0.636)	2.273 (0.686)	***
Talk to school staff about college			
Counselor	0.599 (0.490)	0.473 (0.499)	***
Teacher	0.317 (0.465)	0.270 (0.444)	***
Coach	0.099 (0.298)	0.076 (0.265)	***
Most people can learn to be good in math	2.952 (0.663)	2.955 (0.696)	
Friends' plans to attend 4-year college	3.647 (0.999)	3.084 (1.100)	***
Student engagement in high school			
Engagement (keeps studying even if difficult)	2.913 (0.866)	2.556 (0.865)	***
Gets absorbed in math	2.617 (0.799)	2.439 (0.810)	***
Student experience of school academic climate 9th through 12th			
Academic support from teachers	2.922 (0.492)	2.819 (0.526)	***
High school characteristics[d]			
Urban	0.328 (0.470)	0.273 (0.446)	***
Suburban	0.499 (0.500)	0.513 (0.500)	*
Rural	0.172 (0.378)	0.213 (0.410)	***
% enrolled in dropout prevention program	2.735 (1.340)	2.701 (1.274)	
% minority	31.099 (30.416)	34.752 (30.439)	***
Plans to take SAT or ACT	2.589 (0.294)	2.427 (0.315)	***
% enroll in 2-year college or university	3.314 (0.961)	3.523 (0.869)	***

	Full analytic sample		
% enroll in 4-year college or university	4.714	4.262	***
	(1.068)	(1.066)	
Transition outcomes			
Does not complete high school	0.034	0.075	***
	(0.181)	(0.263)	
High school graduate or equivalent (GED)	0.141	0.358	***
	(0.348)	(0.479)	
Attend 2-year college or university	0.142	0.297	***
	(0.349)	(0.457)	
Attend 4-year college or university	0.718	0.335	***
	(0.450)	(0.472)	
Postsecondary experience[e]			
For those enrolled in postsecondary			
College selectivity rank	2.858	1.892	***
	(1.133)	(1.057)	
Social or behavioral sciences major, 2 years after high school	0.135	0.100	***
	(0.342)	(0.301)	
STEM major 2 years after high school	0.406	0.290	***
	(0.491)	(0.454)	
Biological or bio-medical sciences	0.091	0.036	***
	(0.287)	(0.186)	
Clinical or health sciences	0.110	0.159	***
	(0.313)	(0.366)	
Physical sciences (chemistry, physics, or related sciences)	0.028	0.005	***
	(0.164)	(0.074)	
Engineering	0.103	0.031	***
	(0.305)	(0.173)	
Computer science	0.027	0.030	
	(0.162)	(0.171)	
Mathematics (including statistics)	0.018	0.004	***
	(0.132)	(0.063)	
Other sciences (agricultural, architectural, and technology)	0.030	0.024	
	(0.170)	(0.154)	

Table 13.1. (*cont.*)

	Full analytic sample		
Perceives that high school math prepared for postsecondary	2.465 (0.614)	2.257 (0.677)	***
Perceives that high school science prepared for postsecondary	2.274 (0.679)	2.085 (0.721)	***

Source: US Department of Education, National Center for Education Statistics, Educational Longitudinal Study of 2002 (ELS: 2002).

Notes: Data are weighted to population means. Significant differences were calculated using t-tests. ^ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
a. Family composition was coded 1 for married or marriage-like relationships and 0 for all other nonmissing categories. SES and academic ability are constructed by NCES. SES is a standardized z-score ranging from −2.11 to 1.82.
b. These measures were generated by NCES from the Transcript File. Math and science pipeline measures were also generated by NCES and range from 1 (no course in the subject) to 8 (most advanced courses) and 1 (no course in the subject) to 7 (most advanced courses), respectively. The STEM pipeline subsample consists of respondents who were coded 6 or higher on both the math and science pipelines. GPA is coded 0 (0.00 to 0.50) to 8 (more than 4.00), includes only academic courses, honors weighted. Total AP/IB science courses is coded 0 (no courses) to 2 (two or more courses).
c. Students' and parents' educational expectations in the 10th grade are coded 1 (less than high school diploma) to 7 (doctorate). Parent expectations and volunteering were obtained from the 10th-grade parent survey. Talking with parent variables correspond to students' 12th-grade responses, ranging from 1 (never) to 3 (often).
d. The first four outcomes in this category are mutually exclusive. The variable "Does not complete high school" is a dummy: 0 (high school graduates) and 1 (those who did not receive a high school diploma, including GED recipients). SAT/ACT plans are derived by averaging 12th-grade responses, aggregated to the school level and averaged within each school cluster, ranging continuously from 0 (not planning to take) to 2 (have taken). Percentage enrolled corresponds to administrator-reported proportions of high school graduates' postsecondary enrollments.
e. College selectivity rank, ranging from 1 (least selective) to 4 (most) is based on Carnegie Institution rankings.

and females. While ELS asks only those respondents enrolled in postsecondary education about their declared major, we include those not attending postsecondary school in our logistic HLM analyses to better understand the national sample's postsecondary transitions into STEM.

On and off the STEM pipeline in secondary school

Table 13.1 presents a set of descriptive analyses that compare the experiences of girls and boys on the STEM pipeline in high school with those who were not, and their subsequent pathways into postsecondary school majors. Comparisons were determined using ANOVA and Bonferroni tests for statistical significance.

Looking at Table 13.1, those on the STEM pipeline have notably higher socio-economic backgrounds than those who are not. Racial and ethnic differences emerged as well. Of those on the STEM pipeline, only 11% are black or Latino, compared to those not on the STEM pipeline, of whom 16% are black and 18% are Latino. Students still on the pipeline in 12th grade scored higher than their non-STEM pipeline peers on 10th-grade examinations of their math and overall academic ability.

The STEM pipeline group also spent on average 26 more minutes per week on extracurricular activities and an extra 22 more minutes per week on math homework. Those off the pipeline on average completed only the lower-level "middle academic" math sequence, equivalent with Algebra 2, whereas their peers on the STEM pipeline completed pre-calculus. In science, STEM pipeline students on average completed Chemistry 1 and Physics 1, compared to their non-STEM peers who on average completed only general biology.

Clear differences were apparent between students on and off the STEM pipeline in secondary school with respect to their educational expectations, identities, and role models, with one exception: differences in beliefs that most people can learn to be good in math existed *within* rather than between groups, by gender. Those on the STEM pipeline reported considerably higher expectations for their education (between bachelor's and master's completion) than did their non-STEM peers (slightly less than a bachelor's degree). Interestingly, parents of students off the STEM pipeline had slightly higher expectations for their children than did the students themselves; while for students on the STEM pipeline, their parents' expectations were slightly lower than their own. Those on the pipeline were also more likely to talk with their parents about high school courses and college than were their non-STEM peers.

The same pattern holds for students' discussions with school staff about college. Perhaps because of the social composition of their academic courses, students on the STEM pipeline in high school were more likely to have friends planning to attend a 4-year college than their non-STEM peers. Rounding out the profile of STEM students, those on the STEM pipeline were significantly more engaged in their academic studies – including total absorption in math – more often than those not on the STEM pipeline. They also experienced higher levels of academic support from their teachers.

Students on the STEM pipeline were more likely to be enrolled in urban and rural schools than their non-STEM peers. Their schools were also more oriented toward college. Their 12th-grade classmates had taken or planned to take the College Board exams at higher rates than the 12th-grade non-STEM peers. Moreover, of the schools attended by STEM pipeline students, the previous year's graduates enrolled in 4-year colleges or universities at significantly higher proportions (just under 50%) than those from schools where the majority were non-STEM pipeline students. As expected, students who completed the more rigorous coursework that placed them on the STEM pipeline had a greater tendency to attend 4-year colleges and enroll in STEM majors. Some 72% of those on the STEM pipeline enrolled in a 4-year college. They tended to enroll in more selective postsecondary institutions compared to those off the pipeline, of whom only 34% enrolled in 4-year colleges. Students on the STEM pipeline in secondary school were significantly more likely than all other students to enroll in STEM majors at the tertiary level, with the exception of two majors: computer science and other sciences (agricultural, architectural, and technology), whose applied appeal might make them more accessible to those with less rigorous course backgrounds. Both of these categories had strong gender differences, favoring males. As expected, STEM course pipeline completers had a higher tendency to report that they perceived their secondary school math and science coursework as good preparation for their postsecondary studies.

Gendered differences in secondary school

Using similar analytic procedures, we next examine the differences between female and male students on the STEM pipeline in secondary school (see Table 13.2). One of the more unusual findings is that in the subsample of students who are not on a STEM pipeline, females complete more rigorous course sequences than their male peers. With respect to those who are on the STEM pipeline, the gendered differences are more pronounced, in the opposite direction. Males completed slightly more rigorous math sequences than girls and had significantly higher scores on 10th-grade tests of math ability. Within this group, girls spent more hours per week on both math homework and extracurricular activities and had significantly higher grade point averages in their academic classes overall. Interestingly, STEM girls are from less socioeconomically advantaged families. Similar trends are evidenced in the non-STEM subsample, with the exception of coursework.

Educational expectations, identities, and role models

Earlier we noted that those on the STEM pipeline reported considerably higher expectations for their education than did their non-STEM peers. Looking more closely at those on the STEM pipeline, we find that girls have significantly higher expectations for their education, as do their parents for them (echoing previously discussed research findings, e.g., Smith, 2002).[9] Boys, meanwhile, have a significantly greater tendency to believe that most people can learn to be good in math, a worldview that could bolster their self-confidence and resilience in challenging courses. Girls' self-confidence and resilience, in turn,

[9] Recall that these results represent *general* educational expectations, that is, how far in school parents expect their children to go. We do not have a similar measure for how long parents expect their children to persist in STEM.

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Table 13.2. *Descriptive characteristics of sample population by STEM pipeline course taking and gender*

	STEM pipeline			Non-STEM		
	Females	Males		Females	Males	
	N = 2,515 $\overline{X}$ (SD)	N = 2,445 $\overline{X}$ (SD)		N = 5,202 $\overline{X}$ (SD)	N = 5,208 $\overline{X}$ (SD)	
Student background characteristics[a]						
Race and ethnicity						
White and/or Asian	0.775 (0.418)	0.771 (0.420)		0.650 (0.477)	0.650 (0.478)	
Black/African American	0.101 (0.301)	0.111 (0.314)		0.156 (0.363)	0.162 (0.369)	
Latino/Hispanic	0.118 (0.323)	0.110 (0.313)		0.183 (0.183)	0.174 (0.379)	
Foreign-born	0.081 (0.273)	0.093 (0.290)		0.080 (0.272)	0.065 (0.247)	**
Family composition	0.746 (0.435)	0.751 (0.433)		0.660 (0.474)	0.654 (0.476)	
Number of siblings	2.070 (1.420)	2.034 (1.379)		2.490 (1.579)	2.377 (1.553)	**
Socioeconomic status	0.266 (0.724)	0.335 (0.709)	***	−0.132 (0.698)	−0.107 (0.672)	^
Student abilities, academic experiences, and achievement in high school						
Overall academic ability	0.537 (0.917)	0.578 (1.000)		−0.253 (0.893)	−0.301 (0.948)	**

Table 13.2. (*cont.*)

	STEM pipeline			Non-STEM		
Math ability	0.487	0.639	***	−0.331	−0.248	***
	(0.914)	(0.973)		(0.894)	(0.936)	
Hours spent per week on extracurricular activities	2.600	2.553		2.141	2.154	
	(1.226)	(1.300)		(1.208)	(1.283)	
Hours spent per week on math homework	3.648	3.158	***	3.258	2.810	***
	(2.184)	(2.073)		(2.393)	(2.285)	
Math pipeline completion[b]	7.132	7.204	**	4.925	4.626	***
	(0.781)	(0.781)		(1.377)	(1.425)	
Science pipeline completion[b]	6.517	6.488	^	4.481	4.250	***
	(0.500)	(0.500)		(1.100)	(1.211)	
GPA (all academic courses only)[b]	6.572	6.057	***	4.649	3.865	***
	(1.111)	(1.325)		(1.608)	(1.581)	
Total AP/IB Science courses[b]	0.375	0.395		0.024	0.018	
	(0.603)	(0.605)		(0.165)	(0.136)	
Student educational expectations, identities, and role models in high school[c]						
College educational expectations	5.805	5.505	***	5.172	4.608	***
	(1.107)	(1.278)		(1.402)	(1.510)	
Parent expectations (10th)	5.627	5.496	***	5.093	4.809	***
	(1.154)	(1.203)		(1.441)	(1.479)	
Parent volunteering in school (10th)	0.371	0.347	^	0.268	0.234	***
	(0.483)	(0.476)		(0.443)	(0.424)	
Talk with parents about courses (12th)	2.289	2.139	***	2.125	1.987	***
	(0.647)	(0.655)		(0.673)	(0.686)	
Talk with parents about college (12th)	2.501	2.333	***	2.357	2.180	***
	(0.602)	(0.658)		(0.660)	(0.703)	

Talk to school staff about college						
Counselor	0.624	0.574	***	0.525	0.422	***
	(0.484)	(0.495)		(0.499)	(0.494)	
Teacher	0.322	0.312		0.287	0.254	***
	(0.467)	(0.463)		(0.452)	(0.435)	
Coach	0.085	0.113	***	0.056	0.096	***
	(0.279)	(0.317)		(0.229)	(0.294)	
Most people can learn to be good in math	2.891	3.018	***	2.903	3.013	***
	(0.648)	(0.673)		(0.697)	(0.691)	
Friends' plans to attend 4-year college	3.765	3.527	***	3.204	2.966	***
	(0.949)	(1.033)		(1.086)	(1.102)	
Student engagement in high school						
Engagement (keeps studying even if difficult)	2.945	2.878	*	2.583	2.527	**
	(0.844)	(0.888)		(0.878)	(0.848)	
Gets absorbed in math	2.582	2.654	**	2.399	2.484	***
	(0.781)	(0.817)		(0.806)	(0.813)	
Student experience of school academic climate 9th through 12th						
Academic support from teachers	2.958	2.884	***	2.847	2.791	***
	(0.463)	(0.518)		(0.507)	(0.541)	
High school characteristics[d]						
Urban	0.326	0.331		0.278	0.269	
	(0.469)	(0.471)		(0.448)	(0.443)	
Suburban	0.508	0.490		0.508	0.518	
	(0.500)	(0.500)		(0.500)	(0.500)	
Rural	0.165	0.179		0.214	0.213	
	(0.372)	(0.384)		(0.410)	(0.409)	

Table 13.2. (*cont.*)

	STEM pipeline			Non-STEM		
% enrolled in dropout prevention program	2.701	2.769		2.712	2.690	
	(1.335)	(1.345)		(1.300)	(1.248)	
% minority	31.278	30.920		34.431	35.065	
	(30.498)	(30.340)		(30.589)	(30.292)	
Plans to take SAT or ACT	2.592	2.586		2.445	2.409	***
	(0.294)	(0.294)		(0.315)	(0.314)	
% enroll in 2-year college or university	3.341	3.287		3.524	3.522	
	(0.966)	(0.955)		(0.877)	(0.861)	
% enroll in 4-year college or university	4.691	4.739		4.266	4.257	
	(1.0899)	(1.044)		(1.065)	(1.067)	
Transition outcomes						
Does not complete high school	0.027	0.041	**	0.062	0.088	***
	(0.162)	(0.198)		(0.240)	(0.283)	
High school graduate or equivalent (GED)	0.117	0.165	***	0.306	0.409	***
	(0.322)	(0.372)		(0.461)	(0.492)	
Attend 2-year college or university	0.140	0.143		0.307	0.287	*
	(0.347)	(0.350)		(0.461)	(0.452)	
Attend 4-year college or university	0.745	0.690	***	0.374	0.293	***
	(0.436)	(0.463)		(0.484)	(0.455)	
Postsecondary experience[e]						
For those enrolled in postsecondary						
College selectivity rank	2.882	2.832		1.942	1.829	***
	(1.117)	(1.151)		(1.079)	(1.027)	

Social or behavioral sciences major, 2 years after high school	0.139	0.131	***	0.116	0.077	***
	(0.346)	(0.337)		(0.320)	(0.266)	
STEM major 2 years after high school	0.367	0.451	***	0.304	0.267	*
	(0.482)	(0.498)		(0.460)	(0.443)	
Biological or biomedical sciences	0.098	0.082		0.039	0.031	
	(0.297)	(0.275)		(0.194)	(0.173)	
Clinical or health sciences	0.172	0.038	***	0.224	0.061	***
	(0.377)	(0.191)		(0.417)	(0.240)	
Physical sciences (chemistry, physics, or related sciences)	0.027	0.029		0.004	0.007	
	(0.161)	(0.168)		(0.064)	(0.086)	
Engineering	0.027	0.193	***	0.006	0.068	***
	(0.162)	(0.395)		(0.079)	(0.252)	
Computer science	0.010	0.046	***	0.011	0.059	***
	(0.101)	(0.210)		(0.102)	(0.236)	
Mathematics (including statistics)	0.010	0.027	***	0.004	0.004	
	(0.098)	(0.162)		(0.060)	(0.067)	
Other sciences (agricultural, architectural, and technology)	0.024	0.036	^	0.017	0.036	***
	(0.153)	(0.187)		(0.129)	(0.185)	

Table 13.2. (*cont.*)

	STEM pipeline		Non-STEM		
Perceives that high school math prepared for postsecondary	2.460	2.471	2.239	2.280	*
	(0.622)	(0.606)	(0.690)	(0.660)	
Perceives that high school science prepared for postsecondary	2.260	2.288	2.101	2.065	^
	(0.685)	(0.673)	(0.721)	(0.721)	

Source: US Department of Education, National Center for Education Statistics, Educational Longitudinal Study of 2002 (ELS: 2002).

Notes: Data are weighted to population means. Significant differences were calculated using t-tests. ^ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p \leq 0.001$.

a. Family composition was coded 1 for married or marriage-like relationships and 0 for all other nonmissing categories. SES and academic ability are constructed by NCES. SES is a standardized z-score ranging from −2.11 to 1.82.

b. These measures were generated by NCES from the Transcript File. Math and science pipeline measures were also generated by NCES and range from 1 (no course in the subject) to 8 (most advanced courses) and 1 (no course in the subject) to 7 (most advanced courses), respectively. The STEM pipeline subsample consists of respondents who were coded 6 or higher on both the math and science pipelines. GPA is coded 0 (0.00 to 0.50) to 8 (more than 4.00), includes only academic courses, honors weighted. Total AP/IB science courses is coded 0 (no courses) to 2 (two or more courses).

c. Students' and parents' educational expectations in the 10th grade are coded 1 (less than high school diploma) to 7 (doctorate). Parent expectations and volunteering were obtained from the 10th-grade parent survey. Talking with parent variables correspond to students' 12th-grade responses, ranging from 1 (never) to 3 (often).

d. The first four outcomes in this category are mutually exclusive. The variable "Does not complete high school" is a dummy: 0 (high school graduates) and 1 (those who did not receive a high school diploma, including GED recipients). SAT/ACT plans are derived by averaging 12th-grade responses, aggregated to the school level and averaged within each school cluster, ranging continuously from 0 (not planning to take) to 2 (have taken). Percentage enrolled corresponds to administrator-reported proportions of high school graduates' postsecondary enrollments.

e. College selectivity rank, ranging from 1 (least selective) to 4 (most) is based on Carnegie Institution rankings.

may be increased through the support they receive from their parents; girls' parents are more actively engaged in their education than are boys' parents, and girls are more likely than boys to report that their parents volunteer in the school. Girls report talking to their parents about both classes and college significantly more frequently than boys do, consistent with research indicating girls have stronger and more frequent communication with their families (Kao, 2004; Stattin & Kerr, 2000). Girls are also more likely to talk with school guidance counselors about college compared to boys, whereas boys are more likely to talk with their coaches about college than are their female peers. Girls' friends were also more likely to be attending 4-year colleges than were boys' friends, echoing female students' greater engagement of adult role models in their college and course planning. These boy–girl differences are again consistent with those in the non-STEM pipeline group.

Girls have a greater tendency to keep studying when the material is difficult than boys, especially in the non-STEM group. Despite their diligence, this significantly lower tendency to become “totally absorbed” in math, even in the STEM pipeline group, foreshadows why girls in the STEM pipeline group do not enter STEM majors as much as do their male peers. One might expect females to enroll in STEM majors more readily than males, given their qualifications and ambitions, but this is not the case.

At the postsecondary level, STEM pipeline females are more likely to enroll in social or behavioral sciences after high school than males and are highly significantly less likely to enroll in STEM majors. Only 37% of these females declare STEM majors, compared to 45% of their male counterparts. Within the STEM fields, females tend to enroll in the clinical or health sciences (17% of females compared to 4% of males) rather than engineering (3% of females compared to 19% of males) and computer science (1% of females compared to 5% of males). Gender differences do not, however, exist in declaring a biological science or a physical science major. Using this data on secondary school experiences, we conduct a series of analyses to determine the characteristics of females who stay on the STEM pipeline in postsecondary school and what factors are most predictive of their persistence.

On and off the STEM pipeline in postsecondary education

Recognizing these gendered differences, we conducted a logistic HLM analysis to investigate the degree to which these differences helped explain persistence in a STEM major 2 years after high school graduation. Table 13.3 reports on the two-level logistic HLM regression models. We conducted separate logistic HLM models for each subgroup, estimating the proportion of variance in choosing a STEM major that can be attributed to student- and high-school-level

Table 13.3. *Likelihood of declaring a STEM major 2 years after high school, by STEM pipeline and gender*

	Declaring a STEM major							
	STEM pipeline				Non-STEM[f]			
	Females OR (SE)		Males OR (SE)		Females OR (SE)		Males OR (SE)	
Student background characteristics[a]								
Race (reference: White/Asian)								
Black/African American	1.011 (0.006)	*	2.181 (0.013)	***	1.317 (0.005)	***	1.277 (0.007)	***
Latino/Hispanic	0.741 (0.004)	***	0.374 (0.002)	***	0.922 (0.003)	***	1.148 (0.006)	***
Foreign-born	0.727 (0.003)	***	1.548 (0.006)	***	1.118 (0.004)	***	0.177 (0.002)	***
Family composition	1.092 (0.004)	***	0.965 (0.004)	***	1.302 (0.003)	***	1.269 (0.005)	***
Socioeconomic status	0.795 (0.001)	***	0.859 (0.002)	***	0.917 (0.001)	***	0.814 (0.002)	***
Student abilities, academic experiences, and achievement in high school								
Overall academic ability	0.628 (0.001)	***	0.869 (0.002)	***	0.794 (0.001)	***	0.702 (0.002)	***
Hours spent per week on extra-curricular activities	0.941 (0.001)	***	0.952 (0.001)	***	1.005 (1.005)	***	1.114 (0.001)	***
Hours spent per week on math homework	1.003 (0.001)	***	0.875 (0.001)	***	0.969 (0.969)	***	0.993 (0.001)	***
Math pipeline completion[b]	1.302 (0.002)	***	1.292 (0.003)	***	1.193 (0.001)	***	1.287 (0.002)	***

Science pipeline completion[b]	1.402	***	1.569	***	1.102	***	1.266	***
	(0.003)		(0.004)		(0.001)		(0.002)	
GPA (all academic courses only)[b]	1.211	***	1.400	***	1.118	***	1.520	***
	(0.002)		(0.002)		(0.001)		(0.002)	
Student educational expectations, identities, and role models in high school[c]								
College educational expectations	1.355	***	1.073	***	1.283	***	1.093	***
	(0.002)		(0.002)		(0.001)		(0.002)	
Parent expectations (10th)	1.101	***	0.902	***	0.965	***	1.121	***
	(0.002)		(0.001)		(0.001)		(0.001)	
Parent volunteering in school (10th)	0.990	***	0.746	***	0.663	***	1.527	***
	(0.002)		(0.002)		(0.002)		(0.005)	
Talk with parents about courses (12th)	1.379	***	1.056	***	0.999		0.922	***
	(0.003)		(0.002)		(0.002)		(0.002)	
Talk with parents about college (12th)	0.853	***	0.894	***	0.956	***	1.102	***
	(0.002)		(0.002)		(0.002)		(0.003)	
Talk to school staff about college								
Counselor (12th)	0.853	***	0.872	***	1.065	***	1.259	***
	(0.002)		(0.003)		(0.003)		(0.005)	
Teacher (12th)	0.774	***	1.055	***	0.991	***	1.270	***
	(0.002)		(0.003)		(0.002)		(0.004)	
Coach (12th)	0.829	***	0.618	***	0.738	***	0.875	***
	(0.003)		(0.003)		(0.003)		(0.004)	
Most people can learn to be good in math	1.064	***	1.338	***	1.057	***	1.125	***
	(0.002)		(0.003)		(0.002)		(0.003)	
Friends plan to attend 4-year college (12th)	1.128	***	0.918	***	0.960	***	0.915	***
	(0.002)		(0.002)		(0.001)		(0.002)	

Table 13.3. (*cont.*)

	Declaring a STEM major							
Student engagement in high school								
Engagement (keeps studying even if difficult)	1.233	***	1.087	**	1.042	***	0.967	***
	(0.002)		(0.002)		(0.001)		(0.002)	
Gets absorbed in math	1.216	***	1.242	***	0.982	***	1.389	***
	(0.002)		(0.002)		(0.001)		(0.003)	
Student experience of school academic climate 9th through 12th								
Academic support from teachers (10th)	0.981	***	0.727	***	1.153	***	0.627	***
	(0.003)		(0.002)		(0.002)		(0.002)	
High school characteristics[d]								
Urbanicity (reference: Suburban)								
Urban	1.025	***	0.908	***	0.956	***	0.722	***
	(0.003)		(0.003)		(0.002)		(0.003)	
Rural	1.262	***	2.050	***	1.282	***	0.771	***
	(0.004)		.0076656		(0.003)		(0.003)	
School quality level (reference: Highest)								
Lowest	0.714	***	0.826	***	1.019	***	0.852	***
	(0.003)		(0.004)		(0.003)		(0.004)	
Low–middle	1.041	***	0.844	***	1.001		0.981	***
	(0.003)		(0.003)		(0.003)		(0.004)	
Middle–high	0.845	***	0.651	***	1.238	***	1.340	***
	(0.002)		(0.002)		(0.004)		(0.006)	
% minority	1.001	***	1.005	***	1.001	***	1.000	
	(0.000)		(0.000)		(0.000)		(0.000)	

Hierarchical linear model statistics[e]								
Level 1 variance component	0.002		0.002		0.251		0.600	
Level 2 variance component	−12.257		−12.458		−2.764		−1.020	
Intraclass correlation	0.000		0.000		0.019		0.099	
Log likelihood	−2,409,920	***	−2,025,653	***	−3,634,946	***	−1,843,654	***
N observations	2,359		800		1,696		1,292	
N clusters	381		357		550		502	

Source: US Department of Education, National Center for Education Statistics, Educational Longitudinal Study of 2002 (ELS: 2002).

Notes: Data are weighted to population means. Significant differences were calculated using t-tests. ^ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p \leq 0.001$.

a. Family composition was coded 1 for married or marriage-like relationships and 0 for all other nonmissing categories. SES and academic ability are constructed by NCES. SES is a standardized z-score ranging from −2.11 to 1.82. Number of siblings was also included in the analysis but the comparisons were not significant. Results are available by request.

b. These measures were generated by NCES from the Transcript File. Math and science pipeline measures were also generated by NCES and range from 1 (no course in the subject) to 8 (most advanced courses) and 1 (no course in the subject) to 7 (most advanced courses), respectively. The STEM pipeline subsample consists of respondents who were coded 6 or higher on both the math and science pipelines. GPA is coded 0 (0.00 to 0.50) to 8 (more than 4.00), includes only academic courses, honors weighted.

c. Students' and parents' educational expectations in the 10th grade are coded 1 (less than high school diploma) to 7 (doctorate). Parent expectations and volunteering were obtained from the 10th-grade parent survey. Talking with parent variables correspond to students' 12th-grade responses, ranging from 1 (never) to 3 (often).

d. SAT/ACT plans are derived by averaging 12th-grade responses, aggregated to the school level and averaged within each school cluster, ranging continuously from 0 (not planning to take) to 2 (have taken). Percentage enrolled corresponds to administrator-reported proportions of high school graduates' postsecondary enrollments.

e. College selectivity rank, ranging from 1 (least selective) to 4 (most) is based on Carnegie Institution rankings.

f. The null hypothesis is rejected for both models: the likelihood-ratio test of rho = 0 is significant, $p < 0.001$ for each model.

differences.[10] The odds ratios (OR) for predictors represent how these independent variables relate to the likelihood of females' and males' pursuit of a STEM major 2 years after high school.

It has been argued that increasing college preparatory mathematics coursework requirements has detrimental effects on the academic performance of underrepresented minority students and bears no positive effect on their college matriculation (Allensworth, Nomi, Montgomery, & Lee, 2009). We find, however, that, holding all other variables in the model constant, African American youth who have completed the secondary school pipeline courses are more likely to persist to a STEM major in college than are their white and Asian peers. African American males were more than twice as likely as white and/or Asian males to continue on a STEM pipeline. Foreign-born males were 55% more likely than otherwise similar white and/or Asian males to major in a STEM field. The odds of persistence in STEM were lower for Latino males and females. This disadvantage was strongest for males, however, who were 63% less likely to declare a STEM major than their white and Asian peers.

Looking more closely at the effects of course taking within the STEM pipeline sample, we find that for every additional high-school-level mathematics course completed in secondary school, the odds of remaining in STEM increased about 30% for females and males. Completing science pipeline courses in high school similarly increased the odds of remaining on the STEM pipeline in college, especially for males, whose odds increased about 57%. For females, every additional science pipeline course completed was associated with a 40% increase in odds of remaining on the STEM pipeline.

Students' academic abilities and overall academic performance also influenced males' and females' pursuit of a STEM major. Students demonstrating greater academic ability in the 10th grade were less likely to remain on the STEM pipeline in college; this tendency was particularly strong for females. It is important to remember, however, that the academic ability variable is an overall measure, which does not give particular weight to the math and science domains. Unlike this 10th-grade measure of academic potential, however, increases in students' academic performance (their GPA) increase their odds of majoring in a STEM field. This is especially the case for males, whose odds increase 40% for every one-unit increase in GPA. Here again, males who succeed academically are more likely than otherwise similar females to major in STEM, even within this subsample of those who completed STEM college preparatory coursework.

Particularly salient for female and less so for male college students who are STEM majors were the educational expectations, identities, and role models reported while they were in high school. For every one-unit increase in educational expectations, the odds of declaring a STEM major increased 36% for

[10] This model can be referred to as a two-level hierarchical *generalized* linear model (HGLM) with a binary outcome. See Bryk and Raudenbush (2002) and Rabe-Hesketh and Skrondal (2008) for further discussion of HGLM.

girls and 7% for boys. Controlling for all other variables in the model, talking to parents about courses also increased the odds of remaining in STEM in college; again, more positively impacting females than males. A one-unit increase in talking with parents about high school courses was associated with a 38% increase in odds for remaining in STEM for girls, and a 6% increase in odds for boys. However, talking about college (as opposed to high school) with parents had a negative impact on both females and males. These results suggest that for this highly prepared subsample, conversations with parents about specific subjects are more important than more general discussions of academic futures.

How do females on and off the secondary STEM pipeline differ with respect to declaring a STEM major?

Girls on the pipeline see almost four times the return from each additional advanced science course than non-pipeline girls do. Their odds of persisting in STEM increase 40% for each additional science course completed. Girls who were not on the secondary school STEM pipeline still see a benefit, however, with their odds of moving onto the STEM pipeline at the post-secondary level increasing 10% for each additional science course. The gap between these females decreases with respect to the push they each receive for each additional mathematics course completed. STEM females' odds of persisting in STEM increase by 30%, while those of non-STEM females increase by 19%.

Differences emerge between these groups with respect to talking with family and in-school adults about their coursework and their futures. Informational exchanges between females on the STEM pipeline and their parents and adults in school serve as strong predictors of females' persistence in STEM. Specifically, talking with parents about courses positively predicts declaring a STEM major for STEM females with no strong effect for females off the pipeline. For girls on the pipeline, every one-unit increase in talking with parents about courses (e.g., from "sometimes" to "often") increases their odds of declaring a STEM major by 38%, compared to girls not on the pipeline, whose odds remain the same. When it comes to speaking with adults about college generally, however, girls on the STEM pipeline decrease their odds at greater levels than their non-pipeline counterparts with every one-unit increase in talking with counselors and teachers about college.

If teachers and counselors are discouraging girls from pursuing STEM careers, the effect is greatest for those girls on the STEM pipeline. Interestingly, although less than 10% of girls talk to their coaches about college (see Table 13.2), for those that do, the negative effect is stronger for girls not on the STEM pipeline. In a related finding, STEM pipeline girls who report academic support from teachers are less likely to major in STEM, as compared to all other girls, who are more likely to major in a STEM field. On the other hand, having friends planning to attend a 4-year college is a more powerful, and positive, predictor for STEM pipeline females (odds increase 13%) than for non-pipeline model females (odds decrease 4%).

Next, we turn to girls' engagement in school and their experience of the academic climate. For every one-unit increase in their academic engagement and deep interest in math, STEM pipeline girls are considerably more likely to declare STEM majors than are their non-pipeline counterparts. For example, STEM pipeline girls who "often" keep studying when the material is difficult are 23% more likely to persist to declare a STEM major than those who keep studying only "sometimes." For a girl who is not on the pipeline, the same increase would make her only 4% more likely to move onto the pipeline by declaring a STEM major. Similarly, absorption in math increases the odds of a STEM major much more so than it does for non-STEM girls. STEM pipeline girls who "strongly agree" that they get totally absorbed in math are 22% more likely to declare a STEM major than those who only "agree." The same one-unit change in absorption decreases the odds by 2% for girls who are not on the STEM pipeline.

Overall, school-level predictors are more significant for STEM pipeline girls than for non-STEM pipeline girls. The level 2 variance component is significantly lower for girls who are not on the STEM pipeline and the level 1 variance component is significantly higher. Therefore, for girls on the STEM pipeline, there is less variation between girls in the same school and more variation across schools. The effect of the school is weaker for girls who were not on the STEM pipeline.

How do boys on and off the secondary STEM pipeline differ with respect to declaring a STEM major?

The greatest differences between predictors of boys' declaration of a STEM major pertain to their individual background and school characteristics. Race affects boys similarly but the magnitude is significantly higher for boys who completed the advanced STEM pipeline courses in secondary school. Their odds of majoring in STEM in college more than double if they are African American, as compared to non-STEM pipeline boys whose odds increase by only 28%. For boys on the STEM pipeline in high school, being Latino dramatically reduces odds by 63%, as compared to an increase of 15% for all other boys. Being foreign-born also dramatically affects the odds of declaring a STEM major, although differently for those on and off the STEM pipeline in high school. Specifically, foreign-born males on the STEM pipeline are 55% more likely than those who are native-born to declare a STEM major in college. However, for males already off the STEM pipeline in high school, being foreign-born decreases the odds of declaring a STEM major by 82%.

With respect to their school characteristics, being from a rural school more than doubles the odds of declaring a STEM major for STEM pipeline boys, as compared to a decrease of 22% for all other boys. With the exception of non-STEM pipeline boys, enrollment in a rural secondary school improves the odds of declaring a STEM major, for all subsamples studied. This finding is consistent with research that suggests students in urban schools receive qualitatively different, and often less effective, mathematics and science instruction than their suburban and rural peers (Schmidt, Cogan, Houang, & McKnight, 2009, p. 72). Students' classroom experiences in science have also been found to impact their postsecondary aspirations (J. Wang, 1999; J. Wang & Staver, 2001).

Conclusions

Our findings suggest that academic preparation in secondary school is the critically important consideration in keeping US males on the STEM pipeline midway through their undergraduate postsecondary educational experience, with race and ethnicity providing an additional impetus for African American males and posing an additional obstacle for Latino males. Based on our analyses, however, US women need something more. Rigorous math and especially science course taking in secondary school are important predictors of female university students' persistence in STEM, but on its own such course taking is insufficient to keep young women on the STEM pipeline.

Our analyses underscore the critical role of external supports (e.g., received from parents, or through positive role models that their peers provide) to young women's persistence in STEM studies. While not altogether surprising in light of the relatively recent inroads that have been made in equalizing gendered differences in higher educational attainment more generally, this is a sobering finding that reminds us that absent seismic external forces, social and cultural climates tend to change slowly and incrementally. Until this evolutionary change process is complete, additional external supports are likely to be necessary to sustain females across the life course in imagining and achieving significant roles for themselves in previously male-dominated fields of study and work domains.

Others have demonstrated the importance of personal supports and a wide range of factors affecting subjective perceptions in sustaining females' interest, persistence, and success in STEM fields and careers, including: perceived similarity to others in a field; stereotypes embodied in physical environments (e.g., the physical characteristics of classrooms); encouragement from peers, mentors, and role models; and positive relationships with advisors (Anderson-Rowland, Bernstein, & Russo, 2007; Cheryan & Plaut, 2010; Cheryan, Plaut, Davies, & Steele, 2009; Rohlfing et al., 2009). In addition to these proximal influences, recent research suggests that more fundamental differences in the status and welfare of women have a powerful role to play in explaining the cross-national variability in gender gaps that persist (Else-Quest, Hyde, & Linn, 2010).

Against this background, we should perhaps not be surprised that the supports teenage girls perceive and receive midway through their time in secondary school would have such a crucial influence on their educational choices midway through their postsecondary educational experience. Important progress has been made toward the goals of decreasing disparities between women's and men's average education levels, and diminishing the gendered differences in the STEM fields so critical to economic competitiveness. Sustaining this progress and closing the gaps that remain seem likely to require continued dedicated efforts to provide the social and emotional supports instrumental in keeping well-qualified women on a STEM trajectory.

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