Gender Differences in the Paths Leading to a STEM Baccalaureate*

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Objectives. Many have wondered why U.S. women continue to shun certain STEM fields, including science, technology, engineering, and mathematics. This study investigates this question and examines the pathways that women and men follow in attaining their STEM bachelor's degrees. *Methods.* Using NELS 88-00 and the postsecondary transcript data, the descriptive analysis examines gender differences in the three stages of the STEM pipeline: expected college major, first major, and bachelor degree major. The multivariate analysis examines the outcomes of STEM degree attainment, the subfields attainment and the pathways in a series of logical steps. *Results.* Drawing from the pipeline model and its associated cumulative disadvantage theory, and the alternative framework of revolving door theory, analyses from this study indicate that men are more likely than women to follow the complete persistence pathway to attain STEM degrees, but women are as persistent as men once they expect a major in STEM as high school seniors. High school achievement, attitudes, and course taking are related to the subfields attainment, as well as the pathways of the STEM degree attainment. *Conclusions.* Taken together, the results are more aligned with revolving door theory and support the contextual variability in the salience of gender to understand gender differences in attaining STEM fields.

Women have achieved substantial success in postsecondary education for the past few decades (Buchmann, DiPrete, and McDaniel, 2008). However, women do not enjoy the parallel success in STEM fields, including science, technology, engineering, and mathematics. While women have surpassed men in college attendance and completion rates, women received only 19 percent of bachelor's degrees in engineering, and 19 percent in computer science and 21 percent in physics in 2007 (NSB, 2010). Jerry Jacobs (1995) has termed the persistent underrepresentation of women in certain STEM fields as "the most stubborn basis for gender segregation." In this increasingly technologically advanced world, women's underrepresentation in STEM is widely considered as one of the bottleneck issues facing women's advancement into leadership

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positions in the United States (Charles and Bradley, 2002; England, 2010; NAS, 2005).

Many have wondered why U.S. women continue to shun certain STEM fields. To start this effort, it is essential to understand what characterizes the process of the attainment of a STEM baccalaureate, which is a strategic focus, given that "the undergraduate STEM education is viewed as the latest point for a standard entry into STEM (as a profession)" (Xie and Shauman, 2003:96). The previous studies on this topic were dominated by the traditional pipeline model, which focuses on the higher attrition rate of women than men (Berryman, 1983; Chang, 2002; Hilton and Lee, 1988; Hanson, Schaub, and Baker, 1996), until the recent path-breaking study by Xie and Shauman (2003), who found much more nuanced pathways of degree attainment. One of the most striking findings of Xie and Shauman's book (2003), *Women in Science: Career Processes and Outcomes*, is that most female STEM baccalaureates entered the STEM education during college, after indicating interest in non-STEM fields in high school, whereas most male STEM baccalaureates followed the early entry and persistence (herein the complete persistence) pathway. Their study highlights the dynamic process of STEM degree attainment, yet they have not gone further to explore what might account for this gender difference.

Moreover, women are not uniformly and universally underrepresented across STEM subfields. Women's increasing representation in life science and persisting token status in engineering and physical science have been well documented (England and Su, 2006; Frehill, 1997; Ma, 2009). Studies on women's underrepresentation, including Xie and Shauman's (2003), rarely examine the STEM subfields separately, with the implicit assumption that they are more similar than different. However, without considering these subfields, we would never start to understand what drives women toward some STEM fields and keeps them away from others.

As such, this study intends to advance previous studies in three aspects. First, this study makes the first attempt to explore the factors that affect the different pathways men and women follow in attaining their STEM degree. Specifically, the complete persistence pathway[1] is differentiated from the pathway of switching from non-STEM to STEM fields. Second, this study pays particular attention to the STEM subfields and examines the question of what factors drive the differential representation of females across STEM subfields. Third, this study uses the National Education Longitudinal Studies: 1988–2000 and its Postsecondary Transcript Study, which are the *most recent* national longitudinal data that allow for the examination of bachelor's degree attainment. It examines gender differences in the trajectory of STEM degree attainment by focusing on the three stages: expected college major, first college major, and bachelor degree major.

[1]My pathway analysis centers on the influx into STEM fields, differentiating the complete persistence from the switching pathways. The pathways leading away from STEM are not the focus of the current inquiry, though my descriptive analysis (Figures 1 and 2) provides the overall picture of the gender differences leaking out of the STEM pipeline.

Among the NELS respondents, 4,036 students attained a bachelor's degree by 2000, among whom 1,017 respondents, or about 25 percent, were granted a bachelor's degree in STEM fields. Although females earned the majority of the bachelor's degrees (2,249 females vs. 1,787 males), only about 41 percent of the STEM degrees were conferred on females, resulting in the three to two gender gap in favor of men. Disaggregating STEM subfields reveals a more complicated pattern of gender differences: while 56 percent of the life science bachelor's degrees were obtained by women, only less than 20 percent of the engineering degrees went to women, which is consistent with the national statistics (NSB, 2010).

The explanatory framework focuses on precollege influences. Oakes (1990) highlighted the three key aspects in her comprehensive review of the factors leading to the underrepresentation of women in science: achievement, course taking, and attitudes. Previous studies often considered these factors as precursors to choices and attainment in STEM (Astin and Astin, 1992; Ethington and Wolfe, 1988; Hilton and Lee, 1988; Seymour and Hewitt, 1997; Xie and Shauman, 2003; Ma, 2009). My multivariate analysis focuses on these three aspects of precollege experiences on the outcome of bachelor's degree attainment in STEM fields.

Pipeline Model, Cumulative Disadvantage, and Revolving Door

Since Berryman (1983) first introduced the "pipeline model" to analyze empirically the educational and occupational process of becoming a scientist, the "pipeline model" has been useful to understand the underrepresentation of women and racial minorities in STEM. Following the pipeline model, previous research has consistently focused on the higher attrition rate of women than men from every stage of the pipeline. The *Report of the Committee on Maximizing the Potential of Women in Academic Science and Engineering* from the National Academy of Science (2007) states: "More women than men leave at nearly every stage of the career trajectory. Fewer high school senior girls than boys state a desire to major in science or engineering in college. Girls who state such an intention are likelier than comparable boys to change their plans . . . ." As strong as the pattern of attrition seems to be, it is viewed from one direction only—starting from the interest and preparation in high school to a college major in STEM and, ultimately, to degree attainment. In short, the pipeline model highlights complete persistence as the key route, if not the only one, to the attainment of STEM degrees. Other educational trajectories, for example, planning on a non-STEM path, is viewed as "leaking from the pipeline."

If the pipeline model provides an imagery to understand the process of representation and attainment in STEM fields, cumulative disadvantage theory (Merton, 1968; DiPrete and Gregory, 2006) offers some theoretical grounding. Cumulative disadvantage theory posits that early gender socialization leads women to be ambivalent toward math and science, manifested in a low expectation for STEM careers, which makes them further disadvantaged in choosing a college major in STEM and even less likely to obtain related degrees. In other words, cumulative disadvantage theory emphasizes the higher attrition among women than men. The cumulative disadvantage theory has a couple implications. One is that women are more likely to drop out of the pipeline than are men, and the possibility of influx of women later into the pipeline is small. Thus, the gender gap should be increased within the same cohort. The second implication is that complete persistence should be the dominant path for women to pursue in male-dominated fields. The chance of switching into the field later should be low.

On the other hand, Jerry Jacobs (1989) proposes the theory of revolving doors to understand gender-role socialization in leading to occupational sex segregation. Jacobs found substantial flows of women into and out of male-dominated occupations. Contrary to cumulative disadvantage theory and the pipeline model, revolving door imagery could well capture the delayed entry and the fluidity in aspirations and choices. The rationale behind the revolving door imagery is that it recognizes a variety of stages in the career-development process that provide differential pressures women face in pursuing male-dominated fields. What Jacobs argues for is the varying effect of gender socialization, which he termed as social control, across different stages of the lifecourse and contexts of development.

In this study, the relevant contexts are high school and college. Due to data constraint, my explanatory framework focuses on the influence of students' precollege experiences on STEM degree attainment. In what follows, three main areas—achievement, course taking, and attitudes/aspirations in high school—are discussed.

Achievement, Attitude, and Course Taking

Achievement

Understanding gender differences in achievement test scores in math has been the focus of research for decades (Benbow and Stanley, 1980; Fennema and Sherman, 1977; Leahey and Guo, 2001). Recent research has consistently shown that gender differences in math achievement have been substantially reduced (Adelman, 2006; Catsambis, 1994; Nowell and Hedges, 1998). Xie and Shauman (2003) have found that men are still more represented at the higher end of the achievement distribution than are women, but that does not account for the gender gap in the degree attainment in STEM. Their study has not disaggregated the STEM fields. This study posits that the gender gap in math achievement, though small and decreasing, may have significant influence on the attainment of STEM subfields. Though STEM in general are more math intensive than humanities and arts, the subfields of STEM differ in the extent of being math intensive. Although an engineering curriculum usually requires a rigorous hierarchical structure of math courses (Adelman, 1998), life science is considered the least quantitative field among natural science disciplines (Storer, 1972). Therefore, this study hypothesizes that:

H_{1a}: *A higher math test score in high school is associated with a lower chance of attaining degrees in life science as compared to engineering.*

On science achievement, studies find a gender gap in favor of boys starting from young ages and across grade levels (Lee and Burkam, 1996; Becker, 1989). High school science courses lay important foundations for college STEM fields of study. In addition, a high science achievement in high school may send a strong message to students that they could consider STEM fields as their future education and career choices. As such, this study expects that:

H_{1b}: *Science achievement test score in high school is positively associated with STEM degree attainment, after controlling for math test scores.*

If one's science achievement test score is high, it may further influence the pathway a student travels, in that one is more likely to have an expectation to major in STEM and claim an initial major in STEM. In other words, this study expects that:

H_{1c}: *Science achievement in high school is positively related to the pathway of complete persistence in attaining STEM fields, controlling for math achievement.*

Attitude

Attitudes toward math matter in the choice and attainment of STEM. Previous studies have shown that students perceive math to be a male domain (Astin and Astin, 1992; Catsambis, 1994; Eccles, 1994; Frome and Eccles, 1998; Hyde et al., 1990). Overall, the belief of male mathematical superiority is pervasive in U.S. culture. This gender belief about math manifests in students' self-assessments of abilities. Shelley Correll (2001, 2004) shows that women at the same achievement level tend to give a lower self-assessment on their math ability than do men, and this negatively impacts women's choice in math-intensive fields. Further, a positive self-assessment in math often bodes well for early interest in STEM. Studies have consistently shown that one of the key reasons for students to choose STEM is that they think they are good at math[2] (Seymour and Hewitt, 1997). As such, this study expects that:

H_{2a}: *Math self-assessment in high school is positively associated with STEM degree attainment in college, controlling for achievement test scores.*

[2]Science self-assessment should also be relevant, but NELS has not contained information on science self-assessment, so this study is not able to examine it.

H_{2b}: *Math self-assessment in high school is positively associated with the complete persistence pathway of attaining a STEM degree.*

In addition to math attitude, gender differences in career values are salient. Historically, women are found to be more likely than men to express concern and responsibility for the well-being of others and less likely to value material benefits (Beutel and Marini, 1995; Eccles, 1994; Eccles, Adler, and Meece, 1986), although recent research has found that women place emphasis on extrinsic values such as income and prestige (Marini et al., 1996; Sax and Harper, 2007) as well. To the extent that different fields are associated with different financial remuneration, the gendered values would influence education and career choices men and women make. Given STEM are among the more financially rewarding fields (Hecker, 1995; Frehill, 1997); therefore:

H_{2c}: *The value placed on money is expected to be positively associated with STEM degree attainment.*

On the other hand, if women value caring and helping other people more than men, the STEM fields in general may not be the appealing options for them. Pervasive stereotypes exist among young people in the United States that scientists and engineers are socially inept "geeks" and "nerds" (May and Chubin, 2003). Studies show a common perception among young people that work in STEM is sedentary and involves little contact with other people (COSEPUP, 2005). However, among STEM subfields, life science may be perceived as more amenable to helping and caring for people, as many students major in life science as a preparation for seeking a medical-related profession. Therefore:

H_{2d}: *The value placed on helping people is positively associated with attaining life science degrees as compared to engineering.*

Course Taking

Recent studies show that high school coursework matters more than high school test scores and GPA in students' postsecondary attainment (Adelman, 2006). In the 1970s, there was a considerable gender gap in high school math course taking in favor of boys, but the gap has narrowed substantially since then (Bae et al., 2000). Studies do show, however, a gender gap in science course taking. Hanson and others, in their cross-national studies of seven countries, found that the United States and most of the other countries have fewer females in chemistry courses than in biology and still fewer in physics courses (Hanson, Schaub, and Baker, 1996). Xie and Shauman (2003) also identified physics as the only science subject in high school witnessing stubborn gender segregation. Therefore, this study expect that:

H_3: *Math and science courses in general and physics in particular are expected to be positively associated with the attainment of STEM degrees.*

However, we are not sure how specific science course taking is translated into attaining degrees in STEM subfields. For example, is taking more biology courses in high school associated with a higher chance of graduating with a life science degree? What high school courses, if any, are associated with a higher chance of attaining an engineering degree in college? This study will take a close look at these questions.

In sum, this article focuses on specific aspects of high school achievement, attitudes, and course-taking behaviors to understand gender differences in attaining STEM degrees, as well as the pathways of STEM degree attainment.

Data and Analytical Strategy

This article uses data from the National Education Longitudinal Study (NELS: 88-2000) and its postsecondary transcript data, collected by the National Center for Education Statistics (NCES). NELS is a nationally representative longitudinal study that spans from students' eighth grade to eight years after high school, when students are about 26 to 27 years old.[3] The NELS are the most recent national longitudinal data available to examine the issue of bachelor's degree attainment.

Following Xie and Shauman (2003), this study selects three key locations of the STEM pipeline: the expected college major at 12th grade, the claimed college major from the first postsecondary institution[4] two years after high school by 1994,[5] and the bachelor's degree attainment eight years after high school by 2000. This information is from the final three waves of the NELS, capturing key aspects of students' plans, actual choices, and final degree attainment in STEM fields. The descriptive analysis describes gender differences in the trajectory of STEM degree attainment based on the three locations of the pipeline.[6]

The multivariate analysis[7] examines the process of STEM degree attainment in a series of logical steps. The first step concerns whether the bachelor's

[3]This study used the survey commands in STATA to address the NELS complex survey design, so as to yield the correct variance and significance tests.

[4]Postsecondary institutions include both two-year and four-year institutions.

[5]NELS did not provide information regarding the specific time students declare their college major. This study used the college major information at the first postsecondary institution students attended by 1994 to capture initial college major information.

[6]The main analysis in this article focuses only on gender differences. The supplemental analysis examines the intersection between gender and race, and finds that similar gender gaps favor men for each of the four racial/ethnic groups, despite the fact that significant differences exist within each gender group. For example, Asian women are most represented in each location of the pipeline, but they are still significantly less represented than their male counterparts. Therefore, the main analysis in this article presents gender differences only.

[7]This study used the weight variable F2F2P1WT for the analysis. This postsecondary education weight applies to the 12th-grade freshened panel who responded in 1992, 1994, and 2000 (F2, F3, and F4) and who had credible claims of participation in postsecondary education by the return of a postsecondary transcript, transfer credit noted on another institution's transcript, or support for postsecondary attendance provided by other sources (e.g., the National

degree is in STEM fields. The sample consists of all the bachelor's degree earners ($N = 4{,}036$). This is to gain an overall picture of what leads to women's underrepresentation in STEM fields. The second step focuses on the STEM subfields in order to further understand what factors drive women to go into certain fields, and avoid others. The sample for STEM subfields consists of those who have attained a STEM bachelor's degree by 2000 ($N = 1{,}017$). The final step focuses on the pathways of STEM degree attainment: the complete persistence pathway versus the pathway of switching from non-STEM to STEM fields. The sample includes those who have attained a STEM bachelor's degree by 2000 ($N = 1{,}017$). For the pathway of switching, I further differentiate between early switching and late switching, with the former defined as having a college major in STEM by 1994, after expecting to major in an non-STEM field in 1992, and late switching defined as having no college major in STEM by 1994, but still obtaining a STEM degree by 2000. The multinomial logistic model[8] examines what factors affect the three pathways of STEM degree attainment: early switching, late switching, and complete persistence.

Measures

Dependent Variables

There are three dependent variables in this study, based on the three steps of the multivariate analysis. The first dependent variable is the dummy variable indicating whether the bachelor's degrees are in STEM fields, including life science, math, physical science, computer science,[9] and engineering (of all sorts). The bachelor's degree major is obtained from the NELS: 88/2000 Postsecondary Transcript files. The second dependent variable is the three-category STEM subfield, consisting of life science, physical science,[10] and engineering. Among 1,017 students who attained a STEM bachelor's degree, 516 students were in life science, 286 students were in engineering, and 215 students were in physical science. The final dependent variable is the three-category variable indicating the pathways students travel to obtain their STEM

Student Loan Data System or accounts of the respondent's occupation, income, and high school background).

[8]The multinomial model requires testing of the IIA (independence of irrelevant alternatives). That is, testing whether the categories are truly distinct from one another. This study used the Hausman test for IIA in STATA and did not find any evidence that the IIA assumption was violated.

[9]We want to differentiate computer science from computer engineering here. The former is less applied than the latter but, sometimes, computer science is housed in the engineering school. Those structural differences may impact the gender differences in STEM subfields based on this typology.

[10]Physical science includes math, physics, and computer science; life science includes biology and agricultural science.

degrees. Among the 1,017 students who attained the STEM degrees, 424 students followed the complete persistence pathway, 258 students traveled the early switching pathway, and 335 students traveled the late switching pathway.

Independent Variables

The key independent variables in this study include precollege achievement, attitudes, and course-taking variables. High school achievement variables include three standardized tests[11] NELS administered to all the respondents at 12th grade in 1992: reading, math, and science. Achievement variables are continuous, ranging from 0 to 100. NELS has administered the standardized tests to all respondents. Attitude variables include self-assessment of one's abilities, which indicates whether respondents think math or English is one of their best subjects. It would be good to include science self-assessment but, unfortunately, NELS has not included the comparable survey question for science. In addition, attitude also includes two variables that reflect one's beliefs. One variable indicates whether having lots of money is very important, which was measured during the students' 12th-grade year; the other variable indicates whether helping others in the community is very important. Attitude variables are all dichotomous, with 1 indicating agreement with the statement. Course-taking variables include both math and science course-taking information, which is from high school transcript data. This study focuses on specific courses, including whether students have taken calculus in high school, and four science course credits, including physics, chemistry, life science, and computer science. Course-taking variables are information on course credits and therefore are continuous as well.

Control Variables

Control variables include four categories of race/ethnicity, family SES, college selectivity, and the first-year college GPA. Previous studies report that some students switch out of STEM due to their weak academic performance, often reflected in GPA in their first year, which has a chilling effect and drives students away from STEM (Seymour and Hewitt, 1997). The four categories of race/ethnicity include non-Hispanic whites, non-Hispanic blacks, Hispanics, and Asians. Family SES is measured by a composite provided by NELS to include parents' education, occupation, and family income. The college selectivity[12] variable is about the first institution the student has attended, which is

[11] Standardized achievement test scores have nontrivial amounts of missing data. This study uses multiple imputations to treat missing data on those variables (Acock, 2005).

[12] Previous studies suggest that highly selective schools are more likely to have large engineering programs (Gerber and Cheung, 2008), so the choice in STEM fields needs to control for college selectivity.

from the postsecondary transcript files. There are five broad selectivity bands: highly selective, selective, nonselective, open door, and nonratable. The assignment of institutions to the bands is based on the Cooperative Institutional Research Project (CIRP) for 1992. The NELS "open-door" category includes community colleges and area vocational technical institutes. An example of nonratable is a foreign institution.

Descriptive Results

Gender Differences in High School Achievement, Attitude, and Course Taking

Table 1 presents gender differences in high school achievement, attitude, and course taking. For standardized achievement test scores, women lead men in reading, while men lead women in math and science. The gender achievement gap in science is most salient. Table 1 also shows quite salient gender differences in attitudes: in terms of academic self-assessment, women are less positive about math than are men, but more positive about English

TABLE 1

Gender Differences in High School Achievement Test Scores, Attitudes, and Course Taking

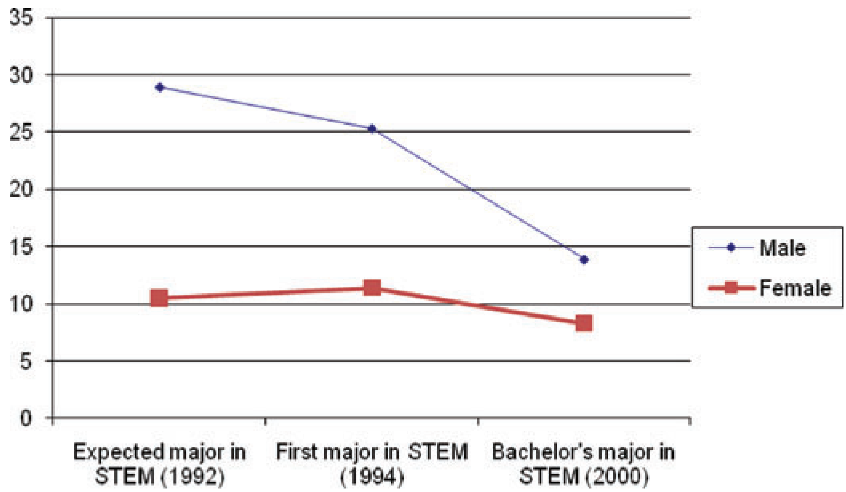
Variable	Women's Mean	Men's Mean	*t* Test
Achievement			
Reading test score	53.46	52.24	7.18**
Math test score	52.79	54.12	−7.74***
Science test score	51.35	54.21	−16.35***
Attitude			
Think math is one's strength	0.52	0.62	−10.58***
Think English is one's strength	0.65	0.55	9.60***
Think money is very important	0.26	0.43	−18.07***
Think helping community is very important	0.38	0.28	10.36***
Course Taking			
Physics	0.27	0.39	−11.59***
Computer science	0.55	0.56	0.55
Life science	1.23	1.18	4.37***
Chemistry	0.68	0.70	1.422
Calculus	0.11	0.13	−3.44***
N	5,055	4,315	

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (two-tailed test), for the hypothesis that there is no mean difference between males and females.

SOURCE: NELS 88-00.

FIGURE 1

Gender Differences in the Key Locations of the STEM Pipeline (Percentages) ($N = 9{,}370$)



SOURCE: NELS 88-00.

abilities; in terms of values, women are less likely than men to think money is very important in their life, but more likely to think helping others in the community is very important.

With regard to coursework, women reached parity with and even surpassed men (e.g., in biology courses) in all the science courses except physics. A slightly higher proportion of men (13 percent) have taken calculus in high school than women (11 percent). These gender differences are statistically significant.

Gender Differences in the Key Locations of the STEM Pipeline

Figure 1[13] delineates the trajectories formed out of the three locations of the STEM pipeline, and shows that the largest gender gap in favor of men is at the first location—when students indicated their expectation for college majors as high school seniors. Note that the sample consists of all postsecondary participants for whom data are available at the three locations. Almost 30 percent of male students intended to major in STEM fields during high

[13]Both Figures 1 and 2 examine the STEM fields as an aggregate. Due to space concerns, parallel analysis has been conducted for STEM subfields, but not presented. The pattern is similar, in that gender gaps are most salient during high school, and women are as persistent as men in attaining degrees, once they expect to choose a STEM major. In particular, women who expected to major in engineering actually are more persistent than their male counterparts.

school but only 10 percent of female students had similar plans. However, males experienced a significant loss at the second location of the pipeline when they claimed their initial college majors, and this loss continued toward degree attainment. Females, on the other hand, did not experience any loss from the first location to the second location; instead, a slightly higher proportion of females claimed their initial majors in STEM than did so in high school. Females experienced some loss from the second location to the third, but their loss was much less salient than that of males.

The finding that women are less likely to expect a STEM major is not striking. The question is what happened to those who did have such a plan. Figure 2a presents the probability for those who expected to major in STEM and ultimately obtained their STEM degree. Figure 2b presents the probabilities for those who claimed their initial major in STEM and ultimately obtained their STEM degree. Overall, women are no more likely than men to leak out of the pipeline. Actually, women and men have almost equal transitional probability (close to 0.3) from expecting to major in STEM fields to ultimately attaining their STEM degree. This is a different finding from Xie and Shauman's work (2003) using HSB data from the 1980s, which found that the corresponding transitional probability is 0.285 for men and only 0.160 for women. This suggests that women have improved their persistence in STEM during the 1990s. The persistence among women is further confirmed from Figure 2b, which shows that 43 percent of women who initially claimed a major in STEM ultimately attained their degree, compared with 38 percent of men who did so. The above result has brought the attrition issue for *men* to the forefront. Both Figures 2a and 2b show that men left not just the STEM field, but college altogether. That male students have a higher drop-out rate than females from college has been reported (Buchmann and DiPrete, 2006), and this study shows that female persistence manifests in STEM fields as well.

Multivariate Analysis

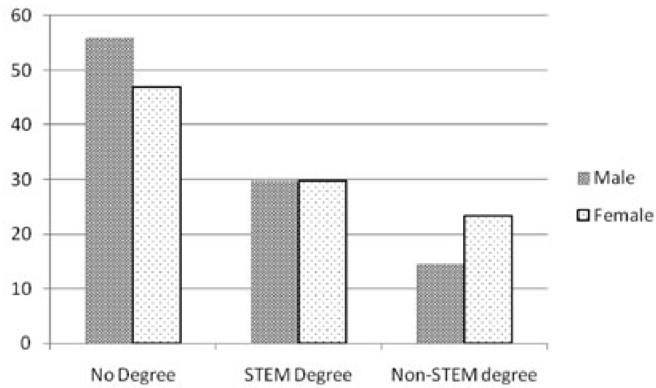
The multivariate analysis starts from examining the STEM degree attainment. Table 2 presents the logit models on STEM degree attainment in order to assess the effects of the key predictor variables in achievement, attitudes, and course taking during high school. Females are less likely than males to attain a STEM bachelor's degree. Although the gender gap is reduced a bit, female underrepresentation in STEM fields remains after taking into account high school achievement, attitude, and course-taking variables. In addition, this study has attempted to add interaction terms between female and the key independent variables in order to identify the differential effects, if any, of the key independent variables on males and females, but none of the interaction terms are significant, so they are not presented in the tables.[14]

[14]I also tried to test for the interaction terms between female and key independent variables for Tables 3 and 4, but none is significant either.

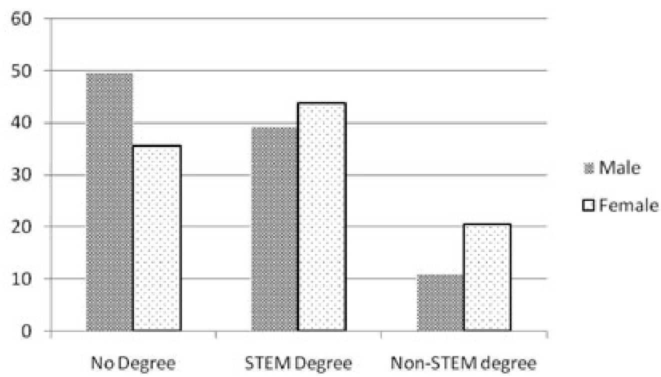
FIGURE 2

Gender Differences in Leaking Out of the Pipeline (Percentages)

a. Among Those Who Expected a STEM College Major as a High School Senior (*N* = 1,777)



b. Among Those Who Claimed Their Initial STEM College Major (*N* = 1,670)



Source: NELS 88-00.

Table 2 presents several key findings. First, science achievement test scores are positively related to STEM degree attainment. A one-point increase in science standardized test score in 12th grade is associated with a 5 percent (exp^0.05 = 1.05) increase in terms of odds in graduating with a STEM degree. This supports Hypothesis 1b. Math achievement is also important, but is not significant any more after taking into account high school coursework variables. Second, a positive self-assessment of math ability is associated with STEM degree attainment. Specifically, a positive assessment of math ability increases the odds of STEM degree attainment by 67 percent (exp^0.51 = 1.67). This supports Hypothesis 2a. In addition, Table 2 also shows that those who value the importance of money tend not to attain STEM degrees. In

TABLE 2

Logistic Model Coefficients for the STEM Degree Attainment ($N = 4{,}037$)

	Model I	Model II	Model III
Female	−0.528***	−0.507***	−0.478***
	(0.081)	(0.084)	(0.086)
Achievement			
Reading test score	−0.032***	−0.024***	−0.021***
	(0.007)	(0.008)	(0.008)
Math test score	0.055***	0.042***	0.008
	(0.009)	(0.009)	(0.010)
Science test score	0.052***	0.051***	0.046***
	(0.008)	(0.008)	(0.008)
Attitude			
Think math is one's strength		0.506***	0.403***
		(0.093)	(0.096)
Think English is one's strength		−0.281***	−0.304***
		(0.085)	(0.087)
Think money is very important		−0.147*	−0.224**
		(0.085)	(0.088)
Think helping community is very important		0.003	−0.027
		(0.080)	(0.082)
Coursework			
Physics			0.418***
			(0.077)
Computer science			0.239***
			(0.061)
Life science			0.258***
			(0.069)
Chemistry			0.508***
			(0.088)
Calculus			0.639***
			(0.097)
−2 Log Likelihood	333.60	373.10	558.01

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
The control variables include four categories of race/ethnicity, family SES, GPA, and college selectivity.

SOURCE: NELS 88-00.

other words, although STEM fields are generally more lucrative than non-STEM fields, the financial appeal in STEM is not strong enough. Therefore, Hypothesis 2c is not supported. Third, math and science coursework are all positively related to STEM degree attainment. Physics is the only science subject that females are still substantially underrepresented during high school, and the importance of physics to college STEM degree attainment points to one of the key factors for women's underrepresentation in STEM fields. This supports Hypothesis 3.

TABLE 3

Multinomial Logit Model Coefficients of STEM Subfields Attainment (Engineering as the Reference Field: $N = 1{,}017$)

	Model I		Model II		Model III	
	Life Science	Physical Science	Life Science	Physical Science	Life Science	Physical Science
Female	1.550***	0.685***	1.396***	0.581***	1.333***	0.584***
	(0.182)	(0.216)	(0.187)	(0.222)	(0.195)	(0.223)
Achievement						
Reading test score	0.032**	0.016	0.025	0.011	0.027	0.011
	(0.016)	(0.018)	(0.016)	(0.018)	(0.017)	(0.018)
Math test score	−0.064***	−0.013	−0.055***	−0.006	−0.027	0.001
	(0.019)	(0.022)	(0.019)	(0.022)	(0.021)	(0.023)
Science test score	0.009	−0.001	0.012	−0.001	−0.008	−0.006
	(0.018)	(0.021)	(0.018)	(0.021)	(0.019)	(0.021)
Attitude						
Math is one's strength			−0.730***	−0.533**	−0.605**	−0.570**
			(0.224)	(0.259)	(0.237)	(0.264)
English is one's strength			0.501***	0.216	0.415**	0.208
			(0.172)	(0.196)	(0.181)	(0.198)
Money is very important			−0.201	−0.357	−0.223	−0.390
			(0.172)	(0.202)	(0.181)	(0.205)
Helping community is very important			0.330*	0.079	0.213	0.060
			(0.172)	(0.202)	(0.181)	(0.203)
Coursework						
Physics					−0.364**	−0.191
					(0.161)	(0.175)
Computer science					−0.307**	0.205*
					(0.128)	(0.122)
Life science					1.077***	0.352*
					(0.162)	(0.180)
Chemistry					0.326**	0.231
					(0.163)	(0.179)
Calculus					−0.775***	−0.179
					(0.195)	(0.215)
−2 Log Likelihood	127.69		153.48		258.77	

$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.
NOTE: The same set of control variables as in the previous tables.
SOURCE: NELS 88-00.

To examine what factors drive the differential representation of females across STEM subfields, Table 3 presents multinomial logit models[15] in

[15]This study also tested for the IIA assumption, that is, whether the categories are truly distinct from one another. This study used the Hausman test to confirm that the three NS&E subfields are valid.

examining the process of attaining life science and physical science degrees, with the reference category engineering, which is the least represented field for women. The overall message that Table 3 conveys is that among those who attained a STEM bachelor's degree, females are much more likely to attain a life science degree than an engineering degree. This pattern remains after taking into account high school achievement, attitude, and course-taking variables. Further, Table 3 shows that math achievement test scores and a positive self-assessment of math abilities in high school are negatively associated with graduating in life science versus engineering. This supports Hypothesis 1a. This may imply that life science does not demand as high a math achievement or require as strong a confidence in math as does engineering. In addition, those who think helping others is very important are more likely to attain a life science degree than an engineering degree. This supports Hypothesis 2d, which indicates that life science degrees are perceived to be relatively amenable to helping and caring work among the STEM subfields. High school coursework emerges as the most important predictor among the three aspects of precollege experience. Specifically, high school physics, computer science, and calculus credits are negatively associated with obtaining life science degrees versus engineering degrees. In other words, the attainment of a life science bachelor's degree may not require training from courses such as calculus and physics to the extent engineering degrees do. Taken together, this speaks clearly about the role of high school course taking in understanding gender concentration in STEM subfields.

Table 4 presents multinomial logit models on the three pathways of STEM degree attainment: early switching, late switching from non-STEM fields, and complete persistence as the reference category. Several key findings emerge. First, science achievement test score during high school is negatively associated with late switching as compared to complete persistence. That is, the higher the science achievement, the higher the chance of following the complete persistence path compared to late switching. This supports Hypothesis 1c. Second, a positive assessment of math ability during high school is negatively associated with late switching, as compared to the complete persistence pathway. This supports Hypothesis 2b. In addition, the value placed on helping the community is positively associated with the switching pathway versus the complete persistence pathway. In other words, students seemed not to associate STEM fields as helpful for their community until college where they may become more familiar with STEM fields. They did not realize the utility and significance of STEM fields during high school, and this contributes to the lower likelihood of early entry and persistence in STEM fields. Third, course taking in high school continues to exert strong effects. Physics and computer science courses in high school are negatively associated with the switching pathway. After taking into account the three aspects of high school achievement, attitude, and course taking, males are still more likely than females to follow the complete persistence path to attain a STEM degree, but the gender gap is reduced.

TABLE 4

Multinomial Logit Model Coefficients on the Pathways of STEM Degree Attainment (Complete Persistence as Reference Category: $N = 1{,}017$)

	Model I		Model II		Model III	
	Early Switch	Late Switch	Early Switch	Late Switch	Early Switch	Late Switch
Female	0.760***	0.749***	0.658***	0.611***	0.568***	0.566***
	(0.173)	(0.162)	(0.182)	(0.169)	(0.186)	(0.173)
Achievement						
Reading test score	0.017	0.005	0.011	−0.002	0.013	−0.002
	(0.016)	(0.015)	(0.017)	(0.015)	(0.017)	(0.016)
Math test score	−0.032*	−0.018	−0.031	−0.011	−0.010	0.012
	(0.019)	(0.018)	(0.020)	(0.018)	(0.021)	(0.019)
Science test score	−0.024	−0.044**	−0.019	−0.043**	−0.027	−0.040**
	(0.019)	(0.017)	(0.019)	(0.017)	(0.020)	(0.018)
Attitude						
Math is one's strength			−0.263	−0.488**	−0.125	−0.394*
			(0.218)	(0.197)	(0.225)	(0.203)
English is one's strength			0.581***	0.511***	0.537***	0.506***
			(0.185)	(0.169)	(0.190)	(0.173)
Money is very important			0.338*	−0.010	0.404**	0.081
			(0.180)	(0.173)	(0.186)	(0.177)
Helping community is very important			0.599***	0.380**	0.552***	0.412**
			(0.172)	(0.163)	(0.177)	(0.168)
Course Taking						
Physics					−0.465***	−0.715***
					(0.163)	(0.154)
Computer science					−0.565***	−0.186
					(0.142)	(0.114)
Life science					0.347**	−0.048
					(0.139)	(0.136)
Chemistry					−0.077	−0.064
					(0.166)	(0.153)
Calculus					−0.230	−0.147
					(0.196)	(0.182)
−2 Log Likelihood	75.35		112.47		171.96	

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
NOTE: Complete persistence refers to those who expected a STEM major in 1992, claimed a STEM major by 1994, and obtained a STEM degree by 2000. The early switch is defined as having a college major in STEM by 1994, after expected to major in a non-STEM field in 1992; the late switch is defined as having no college major in STEM by 1994, but still having obtained a STEM degree by 2000. The same set of control variables as in previous tables.
SOURCE: NELS 88-00.

Discussion

The explanation for women's underrepresentation in STEM fields has often centered on two issues: one is that women are less likely to choose STEM majors and the other is that women are more likely to leave STEM after their initial choice (McIlwee and Robinson, 1992; Seymour and Hewitt, 1997). However, this article found that, in fact, women were as persistent as men in attaining a STEM degree once they expected to major in STEM fields while in high school, and even more persistent than men once they claimed their initial major in a STEM field.

We may cheer for the improved persistence among women who have an initial inclination toward STEM fields. However, not many women are inclined toward STEM fields in the first place. This study found that the gender gap in favor of men is most salient when high school seniors indicate their expectation for their college major. Men are close to three times as likely as women to expect a college major in STEM during high school. In other words, recruitment of women planning to major in STEM fields is the key to increasing women's STEM degree attainment. However, the implication that recruitment is more important than retention needs to be considered in the context of undergraduate years. It is possible that further along the pipeline, that is, in graduate school and academic careers, retention may emerge as a more salient issue. Women may drop out partially due to the so-called chilly environment in some graduate programs, and due to lifestyles that are not very amenable to family in certain STEM careers (Ginorio, 1995; Sax, 1994; Xie and Shauman, 2003). Future research should further identify at which point of the pipeline women may start to leak more often than men.

Perhaps because of women's lack of early interest and aspirations in STEM fields, fewer women than men follow the early entry and persistence pathways to attain a STEM degree; instead, among women who received a bachelor's degree in STEM, most switched into the fields during college, after indicating interest or claiming majors in non-STEM fields. This is consistent with one of the key findings of Xie and Shauman's study (2003), with data a decade more recent than theirs. This article makes the first attempt to identify factors that may influence men and women to follow these different pathways. The empirical analysis reveals two factors are relevant: one is that women value helping the community more than men do in high school; the other is that women have a lower self-assessment of their math abilities than do men. Both factors are negatively associated with the complete persistence pathway in attaining STEM degrees.

What is the implication of this? It may be that women in high school tend not to view STEM fields as amenable to realizing their values of helping the community. Therefore, the message that STEM fields are of tremendous significance to our community and the world at large needs to be clearly conveyed to women during relatively early stages of their schooling. Various venues can help achieve this, among which is early exposure to science research, which could provide opportunities to understand what science is about and help dispel the myths and stereotypes, so that more girls would be able to link STEM fields with their future career interests. With respect to women's lower assessment of their math abilities, this needs to be considered in the broad context of our gendered society where such gender belief as "math is masculine" is deeply ingrained. Charles and Bradley (2009) argue that this cultural ideology is more salient in affluent societies, such as the United States, where the focus on freedom of choice seems to ironically give agency to stereotypically gendered "selves." In their study (2009) of cross-national data for 44 countries, they reveal that the gender gap in eighth graders' math attitudes is significantly smaller in less affluent countries than in rich ones. As such, the cross-national variability belies the often-held presumption that certain fields such as math are inherently masculine.

Women's lower self-assessment in math is also relevant in understanding women's differential representation in STEM subfields. In particular, it is associated with their lower representation in engineering fields. In addition, coursework information turns out to be the most significant factor in understanding differential concentrations in STEM subfields. Taking calculus and physics courses in high school is instrumental in attaining engineering and physical science degrees, but not so much for life science degrees. Although there are deep cultural reasons for women to consider engineering as an unattractive career option (Faulkner, 2000), this article finds that encouraging women to take calculus and physics courses in high school would help boost their degree attainment in engineering in college. In the end, more women engineering graduates turn into more women engineers. This process is not just a one-way street—more women engineers will inspire more girls to consider engineering as their career choice. Ma (2011) has argued that demographic similarity is an underlying force for influencing educational and occupational decisions, and this is even more so for technical fields. Her study (2011) has found that technical fields including engineering have much stronger role-modeling effects than other fields such as humanities or business.

This article provides hope that women seem to pick up interest in STEM during college. This fluidity in aspirations and choices echoes with Jacobs's (1989) revolving door theory, which is also consistent with Ridgeway's (2009) arguments of contextual variability in the salience of gender. Precollege and college are different stages of schooling that could provide different gender-socialization environments. The fact that women pick up their interest in STEM fields during college might allude to the relatively more encouraging and supportive environment that college provides for women to pursue nontraditional fields, STEM included (Fox, Sonnet, and Nikiforova, 2009). In other words, it is possible that the social control that prevents women from entering STEM fields is weakened during college. Since this study lacks data on college environment, future studies could include a measure of college environment to assess specifically what led to a more supportive environment for women to study math and science. This will help us better understand the socialization contexts that are relevant to the gendered process in STEM degree attainment.

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