Math and Science Identity Change and Paths into and out of STEM: Gender and Racial Disparities

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Abstract
Researchers emphasize the role of math and science identities in science, technology, engineering, and mathematics (STEM) education. However, little is known about whether these identities might evolve during college; likewise it is not known how changes in math and science identities are associated with switching majors between STEM and non-STEM fields. This study addresses these questions. With data from the Pathways through College Study, this study revealed that science identity changes matter more than math identity changes in their association with the decision to switch majors. Most notably, underrepresented racial minority women are the most vulnerable in terms of decreasing science identity and the associated probabilities of leaking out of STEM. The authors also find evidence that Asian students are the least sensitive to their science identity drop. These findings have significant policy implications with regard to STEM choice and attainment.

Keywords
STEM, math and science identity, college major switching, gender and race

The significance of producing a sufficient number of graduates in science, technology, engineering, and mathematics (STEM) is self-evident, as the leadership of America in the world depends on its strength in science and technology (NAS et al. 2007; Xie and Killewald 2012). However, the urgency to produce enough STEM talent is blunted by the persistent underrepresentation of women and underrepresented minorities (URMs)—blacks, Hispanics, and Native Americans—in STEM fields, despite the considerable inroads they have made in postsecondary education generally (Chen and Soldner 2014; NSB 2014).

Previous research has focused for a long time on prior academic preparation and achievement in attempts to understand gender inequality in entry to STEM fields (Hyde and Linn 2006; Ma 2011; Xie, Fang, and Shauman 2015), yet robust findings over time have concluded that no matter how prior achievement is measured, it can explain very little about the gender disparity in entry to STEM (Ma 2011; Riegle-Crumb et al. 2012; Xie and Shauman 2003; Wang 2013).

An integral part of these social-psychological factors related to STEM education is math and science identity, which researchers have recently defined as the sense that math and science are right for an individual and vice versa (Archer et al. 2012; Cech et al. 2011; Cole and Espinoza 2008; Perez, Cromley, and Kaplan 2014). The research often assumes that math and science identities are formed early in grade school and are highly influential in later educational and professional trajectories (Archer et al. 2012; Dabney, Chakraverty, and Tai 2013; Tai et al. 2006). However, we know little about whether these identities might evolve during college and how such changes might vary across gender and science, self-evaluation of one’s math and science abilities, aspirations toward a science-related career, and so forth (Cech et al. 2011; Correll 2001; Maltese and Tai 2011; Mau 2003; Wang 2013).

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rational groups, nor do we know much about the association of these changed identities with educational trajectories.

This study fills this gap by focusing on identity change related to science and college major. College students switch majors often, and in the case of STEM fields, there is a well-established literature on the “leaky pipeline,” describing and explaining how students leave STEM for non-STEM fields, yet there seems to be a lack of a dynamic view of switching between college majors. As Xie and Shauman (2003) pointed out, women are not only leaking from the pipeline, they are also switching to STEM fields after initially entering non-STEM fields, although this is not a well-traveled path. Focusing on the dynamic process of major switching into and out of STEM fields entails a more profound understanding of the evolving nature of math and science identities, which are foundational to STEM choice and attainment. Few studies have asked whether and how these identities might change and evolve during college, especially during the early years of college, when students are in the flux of making their college major decisions. This study focuses on math and science identities in college and examines their associations with major switching.

The research literature tends to treat gender and racial/ethnic disparities in STEM education separately. Women already constitute a majority of college students and graduates, and STEM fields are among the few in which they remain a minority (DiPrete and Buchmann 2013), except for life science. However, critical race theorists argue that the experiences of women of color cannot be sufficiently understood separately in terms of gender or race and advocate for an intersectional perspective (Collins 2015; Crenshaw 1989). The intersectional analysis of gender and race often lends more nuance to our understanding. As shown by a few studies using intersectional analysis, African American women often show a greater inclination than their white peers to enter STEM fields, and Asian women exhibit a higher persistence rate in STEM than white men (Hanson 2009; Irelan et al. 2018; Ma and Liu 2017). Therefore, an intersectional perspective (Collins 2015; Crenshaw 1989) is vital to choosing and persisting in a STEM major (Carlone and Johnson 2007; Chang et al. 2011). However, little is known about how math and science identities evolve and how the changes vary across gender and racial groups.

Research has consistently reported that women are less likely than men to identify with math and science, although they have effectively closed the gap with men in achievement test scores and in most math and science course participation in high school (Carlone and Johnson 2007; Correll 2001, 2004; Riegle-Crumb and King 2010). Studies have consistently documented that girls have lower self-confidence in their math ability, lower motivation to study math and science subjects, and less interest in pursuing STEM fields (Correll 2001, 2004; Riegle-Crumb and King 2010; Sadler et al. 2012; Wang, Eccles, and Kenny 2013). Even girls who earn good grades in science are less likely than boys to consider science as attractive (Miller, Blessing, and Schwartz 2006).

Researchers point out that social norms of who belongs in science and the masculine image of STEM fields are the main culprits for women’s lack of interest in these fields (Cvencek, Meltzoff, and Greenwald 2011; Kiefer and Sekaquaptewa 2007; Nosek et al. 2009). However, women as a group are not monolithic. Intersectional perspectives on gender and race in STEM education have generated more nuanced findings and raised new questions. Black women have been shown to have a stronger interest in math and science than white women (Hanson 2009; Ma and Liu 2017; Riegle-Crumb and King 2010). Asian women are particularly well represented in STEM (Lee and Zhou 2015; Xie

1. Do math and science identities evolve over the early years of college? How do these changes vary across gender and racial groups?

2. Are changes in math and science identities associated with switching majors between STEM and non-STEM fields? How sensitive are different gender and racial groups to changes in math and science identity?

To address these questions, we use data from the Pathways through College Study. The Pathways data are drawn from a longitudinal survey of three diverse institutions of higher education at which more students chose STEM majors than at average colleges and are thus particularly suitable to a study of dynamic processes in the STEM pipeline. The Pathways data contain rich longitudinal data tracking students’ changes in math and science identity over the first two years of college and their changes in college major, in addition to detailed information on their precollege and college experiences, including transcript data. What we found is that changes in science identity matter more than changes in math identity with regard to the decision to switch majors. Most notably, different gender and racial groups respond differently to a change in science identity. URM women are sensitive to a drop in science identity in terms of their leaking out of STEM, although at the beginning of college, their levels of science identity are higher than those of white women. We also found evidence that Asian students are the least sensitive to a drop in science identity. These findings have significant policy implications regarding STEM retention.

Literature Review

Gender and Racial Disparities in Math and Science Identities

Previous research has shown that math and science identities are vital to choosing and persisting in a STEM major (Carlone and Johnson 2007; Chang et al. 2011). However, little is known about how math and science identities evolve and how the changes vary across gender and racial groups.

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and Goyette 2003) and have surpassed all male groups in their persistence in earning a STEM bachelor’s degree (Ma and Liu 2017).

Competing explanatory frameworks have emerged in attempts to explain the participation and achievement of racial minorities in STEM education. Some have argued for a double jeopardy for racial minority women because the two statuses—being female and belonging to a minority race—burden them with added disadvantages (Clewell and Anderson 1991; Cross et al. 2017; Ro and Loya 2015). However, although double jeopardy may predict the impact of damage from being female and of a minority race, it does not necessarily dampen URM women’s personal interest and involvement in math and science. Sandra Hanson (2009) demonstrated the complex relationship of structural barriers and agentic attitudes and behaviors in her seminal book Swimming against the Tide: African American Girls and Science Education. Hanson found that African American girls do feel less welcome than their white peers in science, but they also show a greater interest in science occupations than their white peers. This finding is consistent with nationally representative data from the National Education Longitudinal Study showing that African American women are more likely to hope for or expect a science occupation at age 30.

The question is, Why do URM students continue to have a positive attitude toward science despite perceived structural barriers? Researchers and policy makers have underscored the fact that math and science fields promise good job opportunities and financial rewards (Chen and Soldner 2014; Ma 2010; NAS 2007). In addition, sociologists of science have long argued that math and science fields use more universal criteria of evaluation than other fields, which may be highly contingent upon social and cultural capital (Merton 1973; Xie and Killewald 2012). STEM education is unique in that it is often an admission ticket to STEM employment. In other words, minority students can access STEM jobs with a higher degree of certainty if they graduate with STEM rather than non-STEM degrees. It seems that low–socioeconomic status (SES) students, many of whom are racial minorities, are aware of this and intentionally choose STEM fields as a mobility strategy. Robust empirical evidence has shown that family SES plays a positive role in academic preparation and achievement, but once academics are controlled for, family SES play no direct role, or sometimes a negative role, in the pursuit of a STEM degree (Chen 2009; Ethington and Woffle 1988; Ma 2010). This highlights that disadvantaged youth often perceive STEM education as a means of achieving upward social mobility (Ireland et al. 2018; Lee and Zhou 2015; Xie and Goyette 2003).

The view that STEM fields use more universal criteria is often used to account for Asian Americans’ overrepresentation in science and engineering fields (Ma 2010; Xie and Goyette 2003). Because of a U.S. immigration policy that favored highly skilled professionals in STEM and medical fields, a disproportionate number of Asian immigrants arrived after World War II to work (Lee and Zhou 2015; Xie and Goyette 2003). Many of their children were socialized to identify with math and science early and were influenced by their parents to aspire to STEM careers. Other Asian American students, without parents in STEM fields, have been influenced by their coethnic community and culture, which value and identify with STEM fields (Hsin and Xie 2014; Lee and Zhou 2015; Ma and Lutz 2018; Sjaastad 2012).

Gender and Racial Disparities in Paths into and out of STEM

Researchers have concluded that over the past few decades, the growth of women in STEM has been driven largely by their increasing enrollment in postsecondary education (Xie et al. 2015). In other words, the number of women earning STEM degrees has increased, but the proportionate share of women in many STEM fields has not increased since the 1980s (DiPrete and Buchmann 2013; England and Li 2006). Women are still less likely to choose a STEM field as a college major and are more likely to switch out of STEM (Mann and DiPrete 2013; Riegle-Crumb et al. 2012; Xie and Shauman 2003). However, recent research has found gender convergence in the persistence to move from a bachelor’s degree to a PhD in the STEM pipeline (Miller and Wai 2015). In other words, once they have bachelor’s degrees, women do not leak out of STEM more than men. This has raised an important question: What is happening during the undergraduate years?

Much policy attention has been placed on students’ switching from STEM to non-STEM fields—the so-called leaky pipeline. Studies have often observed that women and URMs leave STEM at higher rates than their peers. Nevertheless, research with different data sets has shown that URM students are well represented initially in declaring STEM disciplines as their college majors (Ireland et al. 2018; Ma and Liu 2017; Riegle-Crumb and King 2010; Xie et al. 2015). However, although URM women are more likely than white women to major in STEM initially, they are ultimately still underrepresented, underscoring the leaky pipeline issue (Cech et al. 2011; Ma and Liu 2017; Seymour and Hewitt 1997; Smyth and Mc Ardle 2004).

To explain what accounts for the leaky pipeline, researchers have identified a number of influential factors, ranging from academic to attitudinal factors. High school academic preparation matters, especially course-taking patterns. In high school, girls are well represented in some science courses, such as biology, but remain underrepresented in physics (NSB 2012, 2014). However, we do not know much about which courses are more conducive to persistence in majors during college, where academic performance provides strong feedback to students about whether they are competent in their chosen field.
The leaky pipeline framework also focuses on attitudinal factors, such as loss of confidence and contracted aspirations (Burtnet 2005; Carlone and Johnson 2007; Cech et al. 2011). Steele (2011), in his groundbreaking framework on stereotype threat, discussed how college provides a contingency context, whereby stereotypes on race and gender can lead to a contraction of aspirations, particularly for URM students, who may initially declare STEM majors but contract their initial aspirations after having negative experiences. Research has often traced these negative experiences to institutional factors such as a chilly campus environment, including a lack of role models for women and minorities in STEM, and related negative experiences in STEM gateway courses (Barr, Gonzalez, and Wanat 2008; Crisp, Nora, and Taggart 2009; Ireland et al. 2018). Moreover, previous research has shown that STEM courses yield lower grades than non-STEM fields (Perez et al. 2014); these dampen one’s cumulative grade point average (GPA), which can pose a risk to students’ prospects for graduation, internships, graduate school applications, and future career opportunities.

However, there is another direction of change—a much less examined and less known process—which is switching into STEM. There can be multiple points of entry into STEM in college. The dominant path is to enter early by declaring a STEM major at the outset and then persisting throughout college; however, research shows that the nondominant path should not be neglected. In particular, women are more likely than men to follow the nondominant path, by claiming a non-STEM major at the outset and then switching into a STEM major later in college, and this pattern applies equally to women of all racial and ethnic backgrounds (Ma and Liu 2017; Xie and Shauman 2003). Researchers are less certain of how to make sense of this nondominant path. This counter-current in opposition to the “leaky pipeline” resonates with Steele’s (2011) argument that college provides a contingency context that shapes students’ aspirations. Steele’s original framework explains how college reinforces the stereotypes that lead to contracted aspirations, which in turn contribute to minorities’ “leaking from the pipeline”; however, the opposite could also occur—college could boost students’ aspirations and promote their chances of entering fields they had previously considered unlikely choices. The question is, What groups travel in this opposite direction, and what factors are associated with the pathway? In this research we take a deep dive into this question.

**Data and Methods**

**Data**

The Pathways data set drew on respondents from three institutions that are diverse in size, geography, and public/private status. It selected respondents using stratified probability samples of first-time, first-year students, so the sample is representative of the populations of entering students at the three institutions. These three institutions place special emphasis on STEM majors, so that their students are over-represented in STEM fields. As Figure 1 shows, the majority of gender and racial groups chose initial majors in STEM fields, except for white women, whose share in STEM is less than 35 percent. Students were first surveyed in fall 2014, during their first semester, and follow-up surveys were conducted every semester thereafter, until spring of their third year (Grodsky and Muller 2018). Each wave collected information on students’ majors, enabling one to track changes in majors. During the first and third waves, questions were asked about math and science identity. In other words, the data from the two time-points chronicle changes in math and science identity during the early years of college. Therefore, the Pathways data are uniquely suited to our study, which examines math and science identity changes and traces students’ paths into and out of STEM fields. With an oversample of STEM majors, the Pathways data also enable a close examination of different racial and gender groups in the process of switching majors.

**Changes in Math and Science Identity**

The main independent variables are students’ changes in math and science identity in college. During their first term in fall 2014, students were asked how strongly they agreed or disagreed with the statements “I am someone who sees myself as a math person” and “I am someone who sees myself as a science person.” Respondents rated their answers on a scale of 1 (“strongly disagree”) to 5 (“strongly agree”). We used these items to measure students’ initial math and science identities in fall 2014. In fall 2015, students were asked the same questions. By subtracting students’ initial identities in 2014 from their newly reported identities in 2015, we created two variables to measure students’ changes in math and science identity after spending one year in college. As Table 1 shows, their science and math identities continued evolving after they entered college. As the full sample, more than 27 percent of students had stronger math identities after one year in college, while another 20.3 percent of students developed weaker identities. Similar trends occurred with changes in science identity.

**STEM Majors**

There is inconsistency among federal agencies over which fields are considered STEM. The National Science Foundation includes social sciences such as sociology and anthropology, while social science is excluded by U.S. Immigration and Customs Enforcement from its qualifications for special visas for STEM foreign workers (Gonzalez and Kuenzi 2012). Although women in the United States have garnered the majority of social science degrees since the 1980s, they remain significantly underrepresented in natural science and engineering fields (DiPrete and
Buchmann 2013; Xie and Killewald 2012). Therefore, as our aim is to understand the processes behind the underrepresentation of women and racial minorities in STEM, we chose to limit the definition of STEM to the natural sciences and engineering.

Significant heterogeneity exists within STEM fields. In this research, we differentiate life-STEM (L-STEM) from physical STEM (P-STEM) (which includes the physical sciences, math, computer science, and engineering) because women are overrepresented in L-STEM but severely underrepresented in P-STEM. The sample size does not allow such a distinction for major switching in a multivariate analysis, but we have included a descriptive analysis to produce interesting patterns about within-STEM differences.

To code students’ switching of majors in college, we first took note of the majors they reported in each of the five rounds of surveys, from their first term in fall 2014 to the spring of their third year. We classified each major into one of two categories: STEM or non-STEM. We identified changes in majors by seeing whether respondents reported their majors as non-STEM in a later round of the survey after they had first reported STEM majors or vice versa. For a small group of students who switched majors more than once, we determined their major status by comparing the majors they first reported and the majors they last reported. For example, if a respondent was first in physics and changed to economics, then finally changed back to physics, we classified this respondent as still a STEM major. As seen in Table 1, 13.5 percent of students in the full sample switched majors between STEM and non-STEM during the first five semesters in college. Specifically, 18 percent of the 1,022 students who initially majored in STEM dropped out of STEM later. Of the 728 students with initial majors in non-STEM, 7.1 percent of them switched to STEM majors.

Covariates

For this research we adopted an intersectional perspective on gender and race, which are the primary categories of interest. The Pathways data coded race in three major categories: white, Asian, and URMs (including black, Hispanic, and Native American groups). Because of the relatively small sample size, the data cannot further distinguish groups to maintain student anonymity. We also used the mother’s and father’s highest education levels to serve as a proxy for SES. Other control variables include high school academic background, including courses in math and science. We used the highest math course taken in high school and a series of dummy variables to indicate whether students had also taken biology, chemistry, or physics. College-level variables include cumulative GPA, measured in fall 2015, and grit. Given that our central inquiry was to examine students’

Figure 1. Initial majors of gender and racial groups.
Note: Majors in L-STEM include the biological and biomedical sciences. Majors in P-STEM include physical science, computer and information science, engineering, and mathematics and statistics. Other majors (including social science) are counted as non-STEM. STEM = science, technology, engineering, and mathematics.
persistence in their initial majors, the variable “grit” was used to measure students’ perseverance, calculated as the sum of the scores on the following three self-rating scales: “I am someone who . . . makes plans and follows through with them,” “I am someone who . . . perseveres until the task is finished,” and “I am someone who . . . does a thorough job.” Each scale ranged from 1 to 5, with 5 indicating the highest level of grit.

Analytic Strategy

The analyses are presented in two parts, corresponding to the two research questions. The first part examines how gender and racial disparities in math and science identities evolve during the early years of college. The second part examines the role played by changes in math and science identity, along with other covariates, in the process leading to a switch in STEM majors. This part looks at switching in both directions, including exit and entry. Our descriptive analysis examines gender and racial disparities in P-STEM, L-STEM, and non-STEM fields, but our multivariate analysis cannot further differentiate STEM fields, because of the limited sample size; it examines only the divide between STEM and non-STEM.

One issue in using the longitudinal data is sample attrition. In fall 2014, 2,651 students participated in the study. However, in fall 2015, only 1,750 students participated. We conducted a supplementary analysis, shown in Table A1 in

| Table 1. Descriptive Statistics. |
|----------------------------------|
| Variable                        | Full Sample | Students with Initial Majors in STEM | Students with Initial Majors in Non-STEM |
|                                 | Mean/Proportion/SD | Mean/Proportion/SD | Mean/Proportion/SD |
| Change in math identity         | \(0.082/0.810\) | \(0.013/0.767\) | \(0.179/0.857\) |
| Two-unit increase or greater    | \(0.047/0.039\) | \(0.039/0.059\) | \(0.026/0.267\) |
| One-unit increase               | \(0.229/0.202\) | \(0.202/0.267\) | \(0.139/0.139\) |
| No change                       | \(0.521/0.534\) | \(0.534/0.503\) | \(0.503/0.503\) |
| One-unit decrease               | \(0.166/0.186\) | \(0.186/0.139\) | \(0.139/0.139\) |
| Two-unit decrease or greater    | \(0.037/0.039\) | \(0.039/0.033\) | \(0.033/0.033\) |
| Change in science identity      | \(0.031/0.786\) | \(-0.004/0.737\) | \(0.081/0.853\) |
| Two-unit increase or greater    | \(0.042/0.034\) | \(0.034/0.052\) | \(0.021/0.213\) |
| One-unit increase               | \(0.205/0.199\) | \(0.199/0.213\) | \(0.213/0.213\) |
| No change                       | \(0.536/0.533\) | \(0.533/0.540\) | \(0.540/0.540\) |
| One-unit decrease               | \(0.180/0.199\) | \(0.199/0.154\) | \(0.154/0.154\) |
| Two-unit decrease or greater    | \(0.037/0.035\) | \(0.035/0.041\) | \(0.041/0.041\) |
| Switch in major                 | \(0.135/0.180\) | \(0.180/0.071\) | \(0.071/0.071\) |
| Race/ethnicity                  |              |              |              |
| White                           | \(0.668/0.540\) | \(0.540/0.848\) | \(0.848/0.848\) |
| Asian                           | \(0.166/0.244\) | \(0.244/0.056\) | \(0.056/0.056\) |
| URM                             | \(0.166/0.216\) | \(0.216/0.096\) | \(0.096/0.096\) |
| Gender                          |              |              |              |
| Female                          | \(0.542/0.466\) | \(0.466/0.650\) | \(0.650/0.650\) |
| Male                            | \(0.458/0.534\) | \(0.534/0.350\) | \(0.350/0.350\) |
| Mother’s education              | \(6.426/2.502\) | \(6.455/2.628\) | \(6.386/2.316\) |
| Father’s education              | \(6.240/2.458\) | \(6.333/2.562\) | \(6.080/2.296\) |
| HS math                         | \(2.816/0.931\) | \(3.039/0.805\) | \(2.502/1.002\) |
| HS chemistry                    | \(0.954/0.210\) | \(0.972/0.166\) | \(0.929/0.258\) |
| HS biology                      | \(0.971/0.167\) | \(0.975/0.158\) | \(0.967/0.179\) |
| HS physics                      | \(0.668/0.469\) | \(0.749/0.432\) | \(0.554/0.496\) |
| Initial math identity           | \(3.254/1.280\) | \(3.478/1.208\) | \(2.951/1.317\) |
| Initial science identity        | \(3.538/1.131\) | \(3.879/0.945\) | \(3.060/1.198\) |
| Grit                            | \(12.151/1.679\) | \(12.139/1.693\) | \(12.169/1.660\) |
| Cumulative GPA (2015)           | \(3.132/0.592\) | \(3.115/0.581\) | \(3.156/0.607\) |
| n                               | \(1,750/1,750\) | \(1,022/1,022\) | \(728/728\) |

Note: The table reports means (with standard deviations) or proportions. The variable “switch in major” indicates whether a student switched majors between a STEM and a non-STEM field. GPA = grade point average; HS = high school; URM = underrepresented minority; STEM = science, technology, engineering, and mathematics.
the Appendix, comparing the characteristics between students who left the survey in fall 2015 and those who stayed. The analysis showed that students who left the survey were similar to students who stayed in terms of their parents’ education levels, their high school science courses, and their initial science identities. However, students who left the survey tended to have lower levels of initial math identity, took fewer math courses in high school, and had lower grit scores. In other words, the longitudinal sample of students who participated in both waves of surveys could have been positively selected in terms of academics and nonacademic factors such as grit. As shown in Table A2, we used multiple imputation to correct for this potential bias. We then used the new sample to rerun the regressions and found that the estimates in the imputed full sample did not vary much from those in the longitudinal sample and, as a result, did not affect our major findings.

Therefore, we limited our analytical sample to the 1,750 students who finished both waves of the survey in 2014 and in 2015. We ran separate logistic regression models for exit from STEM and entry into STEM. The exit model was based on the sample size of those with initial majors in STEM \((n = 1,022)\) and the entry model on the sample size of those with initial majors in non-STEM \((n = 728)\). The purpose of these logistic models was to evaluate the role math and science identities played, particularly changes in students’ math and science identities, and to determine to what degree they contributed to gender and racial disparities in major switching into and out of STEM fields. We paid particular attention to the extent to which identity changes may have had different associations with major changes for the various gender and racial groups, so we included interaction terms between science identity changes and gender and racial groups, and calculated the marginal effect of identity changes on major switching into and out of STEM fields for each gender and racial group.

**Findings**

**Gender and Racial Disparities in Entering and Leaving STEM Fields**

Figure 1 shows the distribution of the initial majors of the six gender/racial groups in three major categories: L-STEM, P-STEM, and non-STEM. White men have the highest concentration in non-STEM majors: nearly 66 percent of them initially majored in non-STEM, compared with fewer than 15 percent of Asian women and 26 percent of URM women. In STEM fields, the minority women’s initial concentration in L-STEM dwarfs that of both white men and women; more than 67 percent of the Asian women and half of the URM women chose their initial majors in L-STEM. Asian men are another group that shows a heavy concentration in L-STEM. In P-STEM, a stronger gender divide appears: white men show the highest tendency to enter, followed by URM men, and Asian men rank a distant third. Among women, URM women have the highest tendency to enter P-STEM, followed by Asian women and then white women. Overall, these findings corroborate earlier research that questions the notion of white male dominance in STEM and provides additional evidence that minority men and women have high levels of interest in both L-STEM and P-STEM, at least in terms of entering the field.

In terms of switching majors, there is a clear pattern of a higher likelihood of women’s leaving STEM, for all groups. Figure 2 shows that URM women top the chart in their tendency to leave STEM: more than 34 percent of URM women left their initial L-STEM fields for non-STEM fields, followed by 25 percent of white women and 22 percent of Asian women. Given that Asian women have the highest concentration in L-STEM as their initial major (67 percent) and that only 22 percent of them left, Asian women’s representation and persistence in L-STEM is quite remarkable. In P-STEM, again, more than 34 percent of URM women left their initial majors for non-STEM, followed by 27 percent of Asian women and 19 percent of white women. This is a classic pattern of women’s leaking from the STEM pipeline. The gender divide in leaking is more apparent in P-STEM than in L-STEM: only 6.9 percent of URM men and 11 percent of Asian and white men left P-STEM.

The opposite movement, namely, leaving a non-STEM field for STEM, is much less likely to happen, but still shows interesting results. Nineteen percent of Asian women and 15 percent of Asian men left their non-STEM fields for STEM, followed by 13 percent of URM men. In contrast, URM women were least likely to switch to STEM, with only 4.88 percent of them leaving their initial non-STEM fields. Overall, women account for more than half of the students switching from non-STEM fields to STEM. In other words, although women tend to leave STEM, some also switch in. The literature has widely documented the former pattern, but little is known regarding the latter. Although those who switch from STEM to non-STEM fields are more than three times the number of those who move in the opposite direction, it is important to note the tributary path of switching from non-STEM to STEM.

**Changes in Math and Science Identity and in College Majors**

Figure 3A shows the bivariate relations between changes in science identity and changes in college major. The students who later switched to non-STEM fields show decreases in science identity after one year of college. Conversely, students who later switched into STEM show increases in science identity after one year of college. This suggests a strong correlation between changes in science identity and the switching of majors; however, such a correlation is not readily discernible in Figure 3B. Most notably, those switching out of STEM, on average, maintained their math identities...
but experienced drastic declines in science identity. There seems to be a lack of correlation between a change in math identity and the switching of majors.

**Math and Science Identity Changes across Gender and Racial Groups**

Table 2 shows changes in math and science identity between the start of the first year and a year later across the six gender and racial groups. For math identity, the gender divide is salient: all of the male groups have stronger math and science identities than the female groups. For science identity, white women have the lowest level, although they slightly increased their science identities after their first year of college. That is to say, white women have the lowest science identity to start with, and they remain the lowest. All the other groups, including Asian women and URM women, have significantly stronger science identities than white women. However, URM women saw their science identities decline in college, and this decrease is statistically significant compared with that of white women. Notably, although URM women experienced decreases, their science identities still remained stronger than those of the white women who showed an improvement in their science identities in college. This is consistent with the literature, which reports that URM women show higher levels of interest in and engagement with science than their white peers, but it is worrisome that their enthusiasm for science is tempered after college. Surprisingly, Asian men are the only male group that experiences a decrease in science identity during college. Although both URM women and Asian men experience some loss of science identity, the impact of the loss is quite different for these groups. The analysis in the next section presents the details.

When it comes to changes in math identity, Asian men and women are the only groups that experience decreases. The previous bivariate analysis of changes in math identity and changes in college major does not show much of a correlation, and it remains to be seen whether a change in math identity matters in the multivariate analysis.

**Multivariate Analysis of College Major Switching**

Now we move to our next major research question: how are changes in math and science identities associated with students’ switching of majors, and how does this association vary across gender and racial groups? As with the descriptive analysis of group disparity, our logistic models use white women as the reference group. Table 3 presents the results.

Models 1 to 3 examine the factors that affect switching from a STEM to a non-STEM major. The analytical sample consists of 1,022 students whose initial majors were in STEM. Model 1 is the baseline model; it includes only gender and racial groups, with white women as the reference
group. The odds of white men to leave STEM are nearly 50 percent less than those of white women. Conversely, the odds of URM women to leave STEM are 84 percent more than those of white women. Model 2 adds independent variables concerning experiences before college. After including variables for parental education and high school courses, the model shows that the tendency of white men to stay in STEM remains, but the tendency for URM women to leave STEM becomes nonsignificant. We also find that the high school courses are associated with their later switching of college majors. Those who do not take high school physics or chemistry classes are more likely to switch to non-STEM majors later in college, except that biology classes seem not to matter. Model 3 adds independent variables that describe students’ experiences in college. Here, we find that students’ cumulative GPAs play an important role at the end of the first academic year in college. The lower their cumulative GPAs, the more likely it is that students will switch from STEM to non-STEM fields. The results show that a one-unit increase in cumulative GPA is associated with a 46 percent reduction in the odds of leaving STEM.

The key independent variables in our research, math and science identity, present very interesting findings. As expected, the higher the initial level of math and science identity, the less likely it is that a student will leave STEM. When it comes to changes in identity, only a change in science identity matters; a change in math identity is not statistically significant for the outcome of leaving STEM. In particular, a one-unit increase in science identity is associated with a 45 percent decrease in the odds of leaving STEM.

Models 4 to 6 examine the switching of majors in the opposite direction. The salient role of a change in science identity emerges again: a one-unit increase in science identity would increase the odds of entering STEM from a non-STEM field twofold. In other words, we find that science identity continues to play a vital role in understanding changes of majors after controlling for high school and college experiences. A change in science identity emerges as the outstanding factor that influences the switching of majors, and the direction of the change in identity corresponds with the direction of change in majors: the greater the positive change a student undergoes in feelings about science during the first two years of college, the more likely it is that the student will switch from a non-STEM to a STEM major; the greater the negative change a student undergoes during the same period, the more likely it is that the student will leak out of STEM.

**The Differential Associations for Gender and Racial Groups**

To be consistent with our theoretical framework on intersectional perspectives, we added interaction terms between gender and racial groups and science identity change. Table 4 presents the results for the association between changes in science identity and the probability of exit from or entry into STEM for each gender and racial group. Asian women stand out as among the least sensitive to a decline in science identity: their probability of exiting from STEM remains relatively low (.17) even when they show a one-unit decrease in science identity. Conversely, when URM women experience a one-unit decrease in science identity, their probability of leaving STEM jumps to .42, the highest across all groups. Similarly, white women’s probability of leaving STEM increases to .35 when they experience a one-unit drop in science identity. Although for both white men and women and URM women, a decrease in science identity is significantly associated with leaving STEM, it is notable that only URM women and Asian men experienced significant decreases in their science identities during college (see Table 2). However, Asian men are not sensitive to a drop science identity in terms of leaving STEM, as shown Table 4. As a result, URM women are the most vulnerable group in terms of both experiencing a decrease in science identity and sensitive to that decrease.
On the other hand, Table 4 also examines the opposite movement, namely, switching into a STEM from a non-STEM field. Asian men who show a one-unit increase in science identity will, on average, have a probability of .24 of switching into STEM from a non-STEM field. In other words, Asian men are quite sensitive to increases in their science identities in terms of switching into STEM from a non-STEM field but are not responsive to decreases in their science identities in terms of leaving STEM. Although URM women are the most vulnerable to science identity change when they consider leaving STEM, they are not as sensitive to science identity change when thinking of switching into STEM. In fact, a one-unit increase in science identity is associated with a probability of only .07 of switching to STEM from non-STEM for URM women, compared with .15 for white women.

We emphasize that these findings are about associations, not causations of college major switching. Although it is beyond the scope of this analysis to treat science identity change as an exogenous variable, we still conducted some supplementary analysis to check for robustness. In Table A4 (Appendix), we reran the logistic regressions for Table 3 and omitted the observations of students who switched majors before a change in science identity could be measured. Table A4 shows that the significant association between science identity change and the probability of a student’s leaving STEM still holds after deleting the observations of students who left STEM in wave 2. This table also shows similar findings for the opposite movement of switching from non-STEM to STEM. This corroborates that our findings on the role of science identity change are robust.
Discussion

College students change majors often, most notably between STEM and non-STEM majors. What is missing from our understanding is the role of changes in math and science identities—those social psychological factors researchers highlight as key to understanding STEM choice and attainment (Xie et al. 2015). This study contributes to our knowledge about how math and science identities evolve in college for different gender and racial groups and about how changes in those identities are associated with switching majors. It examines this process by focusing on two-way switching between STEM and non-STEM fields. The intersectional analysis of gender and race and the division of STEM fields into L-STEM and P-STEM illuminate complex patterns above and beyond those in the conventional literature on STEM education.

Using longitudinal data from three universities that track students’ changes in math and science identity over the first two years of college, along with their changes in college major, this research provides new evidence that minority students have a tremendous interest in, and inclination to enter, STEM fields. The inclination of minority women, including Asian women and URM women, who were initially represented in L-STEM, dwarfed that of both white men and women. URM women had the highest tendency among all female groups to enter P-STEM. The minority women—Asians and URMs—had a higher level of science identity on average than their white peers when they entered college. This resonates with previous research that has documented enthusiasm for STEM education among minority students (Ireland et al. 2018; Ma and Liu 2017; Riegle-Crumb and King 2010); however, what this study highlights is that URM women experience a drop in science identity a year later. What happens next is the unfortunate but familiar story of leakage from the STEM pipeline. There is a clear pattern of a gender divide: women have a higher likelihood of leaving STEM, but the leakage is more apparent in P-STEM than in L-STEM. Most notably, a drop in science identity hits URM women the hardest in terms of switching out of STEM, closely followed by white women. It is important to note that URM women, despite the double jeopardy their race and gender backgrounds may have incurred before college, do have a significantly higher science identity than their white peers, but the double jeopardy continues to work against them in college and takes a toll on their science identities, which means, for some, leaving STEM altogether.

Our study also shows the strong representation and remarkable persistence of Asian women in L-STEM, who seem to be the least sensitive to changes in science identity. Asian men were the only male group that experienced a decline in science identity in college, but they seemed to stay with STEM, and an increase in science identity in this group was positively associated with switching into STEM. The literature on Asian American educational and occupational choices points out that parental pressure to major in STEM, coethnic and community role models in STEM, and positive stereotypes of Asian as being good at math and science, emanating from their teachers and peers, may all contribute to this special impetus to enter and remain in STEM (Lee and Zhou 2015; Ma 2010; Ma and Lutz 2018; Xie and Goyette 2003). Our findings on Asian students—their similarities to and differences from other minorities—underscore the need to include Asian students in our investigations of STEM education. The similarities between Asian and URM students highlight their strong interest in STEM, while the differences between them may imply the differential support they get in their pursuit of STEM education.

This study demonstrated that changes in science identity closely align with changes in college major and matter more than changes in math identity when it comes to understanding why students switch into and out of STEM fields. Earlier work has shown that a strong math background, such as coursework in high school, is necessary but not sufficient to

| Probability of Leaving STEM | Probability of Switching to STEM |
|-----------------------------|---------------------------------|
| One-Unit Decrease in Science Identity | One-Unit Increase in Science Identity | Differencea | One-Unit Decrease in Science Identity | One-Unit Increase in Science Identity | Differencea |
| White female .35 | .13 | -.22*** | .02 | .15 | .13*** |
| White male .24 | .08 | -.14*** | .03 | .09 | .06* |
| Asian female .17 | .13 | -.04 | .18 | .18 | 0 |
| Asian male .22 | .11 | -.11 | .02 | .24 | .22* |
| URM female .42 | .13 | -.29*** | .05 | .07 | .02 |
| URM male .15 | .09 | -.06 | .02 | .19 | .17 |

Note: The table reports the average marginal effects rather than the marginal effects at the mean. STEM = science, technology, engineering, and mathematics; URM = underrepresented minority.

a. Difference in predicted probabilities between a one-unit increase in science identity and a one-unit decrease in science identity.

*p < .05. ***p < .001.
predict the choice, because nowadays math is regarded as a key indicator of academic competitiveness regardless of the field, for example, in college admissions (Ma and Lutz 2018; Riegle-Crumb and Grodsky 2010). This article underscores the central role of science identity as an indicator of an inclination and commitment to STEM. This finding calls for a better understanding of how science identity changes and what accounts for the phenomenon. The limitations of our data prevented us from conducting a causal analysis of science identity change; future studies could use an experimental design that focuses on understanding the causal processes behind college students’ changes in science identity and college major.

Our research findings also generate some implications for practitioners of higher education. To foster positive changes in science identity, higher education educators and staff members need to provide better support to help students transition, as switching into STEM fields is an important pathway for women and minority students. To reduce the decline in science identity, faculty and staff members could provide better support, particularly to those who have already exhibited strong science identities, and try to prevent leakage out of STEM fields. As URM women are the only group identified in this study to exhibit a strong science identity at the start of college but experience a significant decline during their first two years, and as they seem to be especially sensitive to a decline in science identity, higher education faculty members and administrators need to closely monitor their science identities and provide them with special support. The Pathways data have an oversampling of STEM majors, so URM women at other institutions, who do not enjoy a critical mass of peers like the students in the Pathways data, may confront an even more chilling environment. Therefore, institutional leaders and policy makers should feel an urgent need to cultivate and nourish the science identities of URM women.

Appendix

Table A1. Comparing Mean Values of Characteristics between Students Who Left the Survey and Those Who Did Not.

| Characteristic                      | Students Who Finished Only the First Survey Wave in 2014 | Students Who Finished Both Survey Waves in 2014 and 2015 | Difference |
|------------------------------------|----------------------------------------------------------|----------------------------------------------------------|------------|
| Mother’s education                 | 6.35                                                     | 6.43                                                     | –.08       |
| Father’s education                 | 6.14                                                     | 6.24                                                     | –.10       |
| High school math                   | 2.74                                                     | 2.82                                                     | –.07*      |
| High school chemistry              | .96                                                      | .95                                                      | .00        |
| High school biology                | .97                                                      | .97                                                      | .00        |
| High school physics                | .67                                                      | .67                                                      | .00        |
| Science identity in 2014           | 3.17                                                     | 3.25                                                     | –.08*      |
| Math identity in 2014              | 3.61                                                     | 3.54                                                     | .07        |
| Grit                               | 11.85                                                    | 12.15                                                    | –.30***    |

Source: Pathways data.

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

Table A2. Logistic Regressions with Multiple Imputation versus Logit Model without Multiple Imputation.

| Characteristic         | From STEM to Non-STEM with Multiple Imputation | From Non-STEM to STEM with Multiple Imputation | From STEM to Non-STEM without Multiple Imputation | From Non-STEM to STEM without Multiple Imputation |
|------------------------|-----------------------------------------------|-----------------------------------------------|-------------------------------------------------|--------------------------------------------------|
|                        | (1)                                           | (2)                                           | (3)                                             | (4)                                              |
| White male             | .475*** (.105)                                | .851 (.271)                                   | .542* (.141)                                    | .818 (.310)                                      |
| Asian female           | .750 (.188)                                   | 3.331* (.928)                                 | .521* (.158)                                    | 3.541 (.2384)                                   |
| Asian male             | .474** (.129)                                 | 1.525 (.943)                                  | .588* (.196)                                    | 1.809 (.1323)                                   |
| URM female             | 1.054 (.255)                                  | .501 (.384)                                   | 1.227 (.347)                                    | .783 (.617)                                      |
| URM male               | .375** (.117)                                 | 1.103 (.636)                                  | .391** (.151)                                   | 1.261 (.843)                                    |
| Mother’s education     | .985 (.0356)                                  | 1.009 (.0676)                                 | 1.000 (.0445)                                   | 1.031 (.0796)                                   |
| Father’s education     | .965 (.0353)                                  | 1.042 (.0708)                                 | .928 (.0421)                                    | 1.048 (.0837)                                   |
| HS math                | .945 (.0887)                                  | 1.139 (.174)                                  | 1.003 (.117)                                    | 1.153 (.204)                                    |
| Chemistry              | .584 (.226)                                   | .491 (244)                                    | .411* (.184)                                    | .372 (.195)                                      |
| Biology                | 1.121 (.550)                                  | .557 (.320)                                   | 1.307 (.809)                                    | .383 (.241)                                      |
| Physics                | .559*** (.0903)                               | 1.378 (.427)                                  | .516*** (.101)                                  | 1.102 (.381)                                    |

(continued)
Table A2. (continued)

|                          | Logit Model with Multiple Imputation | Logit Model without Multiple Imputation |
|--------------------------|--------------------------------------|----------------------------------------|
|                          | From STEM to Non-STEM | From Non-STEM to STEM | From STEM to Non-STEM | From Non-STEM to STEM |
|                          | (1) | (2) | (3) | (4) |
| Grit                    | .966 (.0431) | .934 (.0768) | .978 (.0532) | .922 (.0853) |
| Initial math identity (2014) | .804*** (.0626) | 1.436*** (.200) | .743*** (.0643) | 1.248 (.192) |
| Initial science identity (2014) | .553*** (.0493) | 1.771*** (.272) | .553*** (.0570) | 2.030*** (.363) |
| Change in science identity | .543*** (.0649) | 2.077*** (.429) | .547*** (.0610) | 2.203*** (.473) |
| Change in math identity  | .908 (.113) | 1.048 (.199) | .892 (.101) | .991 (.186) |
| Cumulative GPA (2015)    | .647*** (.0755) | .809 (.173) | .541*** (.0865) | .725 (.184) |
| **n**                   | 1,592 | 1,059 | 1,022 | 728 |

Note: Odds ratios are presented with standard errors in parentheses. GPA = grade point average; HS = high school; STEM = science, technology, engineering, and mathematics; URM = underrepresented minority.

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

Table A3. Gender Differences in Major Trajectories.

|                          | Remained in Non-STEM | Remained in STEM | Switched to Non-STEM | Switched to STEM | Total |
|--------------------------|----------------------|------------------|----------------------|------------------|-------|
| Female                   | 444                  | 361              | 115                  | 29               | 949   |
| Percentage               | 65.68                | 43.08            | 62.50                | 55.77            | 54.23 |
| Male                     | 232                  | 477              | 69                   | 23               | 801   |
| Percentage               | 34.32                | 56.92            | 37.50                | 44.23            | 45.77 |
| Total                    | 676                  | 838              | 184                  | 52               | 1,750 |
| Percentage               | 100.00               | 100.00           | 100.00               | 100.00           | 100.00 |

Source: Pathways data.

Note: STEM = science, technology, engineering, and mathematics.

Table A4. Logistic Regressions by Excluding Students Who Switched Major during Wave 2 of the Survey.

|                          | From STEM to non-STEM | From non-STEM to STEM |
|--------------------------|------------------------|-----------------------|
|                          | (1) | (2) |
| Initial math identity (2014) | .716*** (.0671) | 1.284 (.210) |
| Initial science identity (2014) | .524*** (.0585) | 2.052*** (.387) |
| Change of science identity | .503*** (.0604) | 1.920*** (.443) |
| Change of math identity    | .885 (.107) | 1.071 (.220) |
| White male                | .553* (.155) | .979 (.390) |
| Asian female              | .537 (.175) | 5.027* (3.418) |
| Asian male                | .647 (.229) | .748 (.834) |
| URM female                | 1.170 (.356) | 1.008 (.800) |
| URM male                  | .354* (.153) | 1.647 (1.096) |
| Mother’s education        | .996 (.0476) | 1.041 (0.852) |
| Father’s education        | .915 (.0446) | 1.054 (.0887) |
| HS math                   | .912 (.115) | 1.274 (.237) |
| Chemistry                 | .491 (.240) | .379 (.212) |
| Biology                   | 1.554 (.1097) | .766 (.591) |
| Physics                   | .570** (.120) | .879 (3.18) |
| Grit                      | 1.014 (.0603) | .948 (.0929) |
| Cumulative GPA (2015)      | .518*** (.0885) | .653 (.176) |
| Constant                  | 226.0*** (277.4) | .0150* (.0256) |
| Observations              | 992 | 721 |

Note: For this table we reran logistic regressions by excluding the students who switched major in wave 2 (spring 2015) of the survey. Model 1 excludes the students who switched to non-STEM in wave 2; model 2 excludes the students who switched to STEM in wave 2. Odds ratios are reported. GPA = grade point average; HS = high school; STEM = science, technology, engineering, and mathematics; URM = underrepresented minority.

* p < .05, ** p < .01, *** p < .001.
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References

Archer, Louise, Jennifer DeWitt, Jonathan Osborne, Justin Dillon, Beatrice Willis, and Billy Wong. 2012. “Science Aspirations, Capital, and Family Habitus: How Families Shape Children’s Engagement and Identification with Science.” American Educational Research Journal 49(5):881–908.

Barr, Donald A., Maria Elena Gonzalez, and Stanley F. Wanat. 2008. “The Leaky Pipeline: Factors Associated with Early Decline in Interest in Premedical Studies among Underrepresented Minority Undergraduate Students.” Academic Medicine 83(5): 503–11.

Burtner, Joan. 2005. “The Use of Discriminant Analysis to Investigate the Influence of Non-cognitive Factors on Engineering School Persistence.” Journal of Engineering Education 94(3):335–38.

Carlone, Heidi B., and Angela Johnson. 2007. “Understanding the Science Experiences of Successful Women of Color: Science Identity as an Analytic Lens.” Journal of Research in Science Teaching 44(8):1187–1218.

Cech, Erin, Brian Rubineau, Susan Silbey, and Caroll Seron. 2011. “Professional Role Confidence and Gendered Persistence in Engineering.” American Sociological Review 76(5):641–66.

Chang, Mitchell J., M. Kevin Eagan, Monica H. Lin, and Sylvia Hurtado. 2011. “Considering the Impact of Racial Stigmas and Science Identity: Persistence among Biomedical and Behavioral Science Aspirants.” Journal of Higher Education 82(5):564–96.

Chen, Xianglei. 2009. “Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education.” Stats in Brief. NCES 2009-161. Washington, DC: National Center for Education Statistics.

Chen, Xianglei, and Matthew Soldner. 2014. “STEM Attraction: College Students’ Paths into and out of STEM Fields.” Washington, DC: National Center for Education Statistics.

Clewell, Beatriz Chu, and Bernice Anderson. 1991. “Women of Color in Mathematics, Science & Engineering: A Review of the Literature.” Washington, DC: Center for Women Policy Studies.

Cole, Darnell, and Araceli Espinoza. 2008. “Examining the Academic Success of Latino Students in Science Technology Engineering and Mathematics (STEM) Majors.” Journal of College Student Development 49(4):285–300.

Collins, Patricia Hill. 2015. “Intersectionality’s Definitional Dilemmas.” Annual Review of Sociology 41:1–20.

Correll, Shelley J. 2001. “Gender and the Career Choice Process: The Role of Biased Self-Assessments.” American Journal of Sociology 106(6):1691–1730.

Correll, Shelley J. 2004. “Constraints into Preferences: Gender, Status, and Emerging Career Aspirations.” American Sociological Review 69(1):93–113.

Crenshaw, Kimberlé. 1989. “Demarginalizing the Intersection of Race and sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics.” University of Chicago Legal Forum 1989:Article 8.

Crisp, Gloria, Amaury Nora, and Amanda Taggart. 2009. “Student Characteristics, Pre-college, College, and Environmental Factors as Predictors of Majoring in and Earning a STEM Degree: An Analysis of Students Attending a Hispanic Serving Institution.” American Educational Research Journal 2009,46(4):924–42.

Cross, Kelly J., Kathryn B. H. Clancy, Ruby Mendenhall, Princess Imoukhuede, and Jennifer R. Amos. 2017. “The Double Bind of Race and Gender: A Look into the Experiences of Women of Color in Engineering.” Presented at the American Society of Engineering Education Annual Conference & Exposition, Columbus, Ohio, June 24–28.

Cvencek, Dario, Andrew N. Melzoff, and Anthony G. Greenwald. 2011. “Math–Gender Stereotypes in Elementary School Children.” Child Development 82(3):766–79.

Dabney, Katherine P., Devasmita Chakraverty, and Robert H. Tai. 2013. “The Association of Family Influence and Initial Interest in Science.” Science Education 97(3):395–409.

DiPrete, Thomas A., and Claudia Buchmann. 2013. “The Rise of Women: The Growing Gender Gap in Education and What It Means for American Schools.” New York: Russell Sage.

England, Paula, and Su Li. 2006. “Desegregation Stallied: The Changing Gender Composition of College Majors, 1971–2002.” Gender & Society 20(5):657–77.

Ethington, Corinna A., and Lee M. Woffle. 1988. “Women’s Selection of Quantitative Undergraduate Fields of Study: Direct and Indirect Influences.” American Educational Research Journal 25(2):157–75.

Gonzalez, Heather B., and Jeffrey J. Kuenzi. 2012. “Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer.” Washington, DC: Congressional Research Service, Library of Congress.

Grotsky, Eric, and Chandra Muller. 2018. “Pathways through College Study” [Data set]. Madison: University of Wisconsin.

Hanson, Sandra L. 2009. Swimming against the Tide: African American Girls and Science Education. Philadelphia: Temple University Press.

Hsin, Amy, and Yu Xie. 2014. “Explaining Asian Americans’ Academic Advantage over Whites.” Proceedings of the National Academy of Sciences 111(23):8416–21.

Hyde, Janet Shibley, and Marcia C. Linn. 2006. “Gender Similarities in Mathematics and Science.” Science 314(5799):599–600.

Ireland, Danyelle T., Kimberley Edelin Freeman, Cynthia E. Winston-Proctor, Kendra D. DeLaine, Stacey McDonald Lowe, and Kamilah M. Woodson. 2018. “(Un)Hidden Figures: A Synthesis of Research Examining the Intersectional Experiences of Black Women and Girls in STEM Education.” Review of Research in Education 42(1):226–54.

Kiefer, Amy K., and Denise Sekaquaptewa. 2007. “Implicit Stereotypes, Gender Identification, and Math-Related Outcomes: A Prospective Study of Female College Students.” Psychological Science 18(1):13–18.

Lee, Jennifer, and Min Zhou. 2015. “The Asian American Achievement Paradox.” New York: Russell Sage.
Ma, Yingyi. 2010. “Model Minority, Model for Whom?—
An Investigation of Asian American Students in Science/ 
Engineering.” AAPI Nexus 8:43–73.

Ma, Yingyi. 2011. “College Major Choice, Occupational Structure 
and Demographic Patterning by Gender, Race and Nativity.”
Social Science Journal 48(1):112–29.

Ma, Yingyi, and Yan Liu. 2017. “Entry and Degree Attainment in 
STEM: The Intersection of Gender and Race/Ethnicity.” Social 
Sciences 6(3):89.

Ma, Yingyi, and Amy Lutz. 2018. “Jumping on the STEM Train: 
Differences in Key Milestones in the STEM Pipeline between 
Children of Immigrants and Natives in the United States.”
Research in the Sociology of Education 20:129–54.

Maltese, Adam V., and Robert H. Tai. 2011. “Pipeline Persistence: 
Examining the Association of Educational Experiences with 
Earned Degrees in STEM among US Students.” Science 
Education 95(5):877–907.

Mann, Allison, and Thomas A. DiPrete. 2013. “Trends in Gender 
Segregation in the Choice of Science and Engineering Majors.”
Social Science Research 42(6):1519–41.

Mau, Wei-Cheng. 2003. “Factors That Influence Persistence in 
Science and Engineering Career Aspirations.” Career 
Development Quarterly 51(3):234–43.

Merton, Robert K. 1973. The Sociology of Science: Theoretical 
and Empirical Investigations. Chicago: University of Chicago Press.

Miller, David L., and Jonathan Wai. 2015. “The Bachelor’s to Ph.D. 
STEM Pipeline No Longer Leaks More Women Than Men: A 
30-Year Analysis.” Frontiers in Psychology 6:37.

Miller, Patricia H., Jennifer Slawinski Blessing, and Stephanie 
Schwartz. 2006. “Gender Differences in High-School Students’ 
Views about Science.” International Journal of Science Education 
28(4):363–81.

NSA (National Academy of Science). 2007. “Rising above the 
Gathering Storm: Energizing and Employing America for a 
Brighter Economic Future.” Washington, DC: National Academies Press.

NSB (National Science Board). 2012. “Science and Engineering 
Indicators 2012.” Retrieved March 7, 2021. http://www.nsf.gov/statistics/seind12/.

NSB (National Science Board). 2014. “Science and Engineering 
Indicators 2014.” Retrieved March 7, 2021. http://www.nsf.gov/statistics/seind14/.

Nosek, Brian A., Frederick L. Smyth, Natarajan Sriram, Nicole 
M. Lindner, Thierry Devos, Alfonso Ayala, Yoav Bar-
Anan, et al. 2009. “National Differences in Gender–Science 
Stereotypes Predict National Sex Differences in Science and 
Math Achievement.” Proceedings of the National Academy of 
Sciences 106(26):10593–97.

Perez, Tony, Jennifer G. Cromley, and Avi Kaplan. 2014. “The 
Role of Identity Development, Values, and Costs in College 
STEM Retention.” Journal of Educational Psychology 
106(1):315–29.

Riegle-Crumb, Catherine, and Eric Grodsky. 2010. “Racial-Ethnic 
Differences at the Intersection of Math Course-Taking and 
Achievement.” Sociology of Education 83(3):248–70

Riegle-Crumb, Catherine, and Barbara King. 2010. “Questioning 
a White Male Advantage in STEM: Examining Disparities in 
College Major by Gender and Race/Ethnicity.” Educational 
Researcher 39(9):656–64.

Riegle-Crumb, Catherine, Barbara King, Eric Grodsky, and 
Chandra Muller. 2012. “The More Things Change, the More 
They Stay the Same? Prior Achievement Fails to Explain 
Gender Inequality in Entry into STEM College Majors over 
Time.” American Educational Research Journal 49(6): 
1048–73.

Ro, Hyun K., and Karla I. Loya. 2015. “The Effect of Gender 
and Race Intersectionality on Student Learning Outcomes in 
Engineering.” Review of Higher Education 38(3):359–96.

Sadler, Philip M., Gerhard Sonnert, Zahra Hazari, and Robert Tai. 
2012. “Stability and Volatility of STEM Career Interest in 
High School: A Gender Study.” Science Education 96(3): 
411–27.

Seymour, Elaine, and Nancy M. Hewitt. 1997. Talking about 
Leaving. Boulder, CO: Westview.

Sjaastad, Jørgen. 2012. “Sources of Inspiration: The Role of 
Significant Persons in Young People’s Choice of Science in Higher Education.” International Journal of Science Education 34(1):1615–36.

Smyth, Frederick L., and John J. McArdle. 2004. “Ethnic and 
Gender Differences in Science Graduation at Selective 
Colleges with Implications for Admission Policy and College 
Choice.” Research in Higher Education 45:353–81.

Steele, Claude M. 2011. Whistling Vivaldi: How Stereotypes Affect 
Us and What We Can Do. New York: W. W. Norton.

Tai, Robert H., Christine Qi Liu, Adam V. Maltese, and Xitao 
Fan. 2006. “Planning Early for Careers in Science.” Science 
312(5777):1143–44.

Wang, Ming-Te, Jacquelynne S. Eccles, and Sarah Kenny. 2013. “Not 
Lack of Ability but More Choice: Individual and Gender Differences 
in Choice of Careers in Science, Technology, Engineering, and 
Mathematics.” Psychological Science 24(5):770–75.

Wang, Xueli. 2013. “Why Students Choose STEM Majors: 
Motivation, High School Learning, and Postsecondary 
Context of Support.” American Educational Research Journal 
50(5):1081–1121.

Xie, Yu, Michael Fang, and Kimberlee Shauman. 2015. “STEM 
Education.” Annual Review of Sociology 41:1–27.

Xie, Yu, and Kimberly Goyette. 2003. “Social Mobility and the 
Educational Choices of Asian Americans.” Social Science 
Research 32(3):467–98.

Xie, Yu, and Alexandra A. Killewald. 2012. Is American Science in 
Decline? Cambridge, MA: Harvard University Press.

Xie, Yu, and Kimberlee A. Shauman. 2003. Women in Science: 
Career Processes and Outcomes. Cambridge, MA: Harvard University Press.

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