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STEM enrichment programs and graduate school matriculation: the role of science identity salience

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Abstract

Improving the state of science education in the United States has become a national priority. One response to this problem has been the implementation of STEM enrichment programs designed to increase the number of students that enter graduate programs in science. Current research indicates enrichment programs have positive effects for student performance, degree completion, interest in science and graduate enrollment. Moreover, research suggests that beyond improving performance in STEM, and providing access to research experience and faculty mentoring, enrichment programs may also increase the degree to which students identify as scientists. However, researchers investigating the role of science identity on student outcomes have focused primarily on subjective outcomes, leaving a critical question of whether science identity also influences objective outcomes such as whether students attend graduate school. Using identity theory, this study addresses this issue by investigating science identity as a mechanism linking enrichment program participation to matriculation into graduate science programs. Quantitative results from a panel study of 694 students indicate that science identity salience, along with research experience and college GPA, mediate the effect of enrichment program participation on graduate school matriculation. Further, results indicate that although the social psychological process by which science identity salience develops operates independently from student GPA, science identity amplifies the effect of achievement on graduate school matriculation. These results indicate that policies seeking to increase the efficacy of enrichment programs and increase representation in STEM graduate programs should be sensitive to the social and academic aspects of STEM education.

Keywords

STEM enrichment programs; Science identity; Underrepresented minorities; Graduate school matriculation

1 Introduction

Since the 1980s, American educators, scientists and policy makers have become increasingly concerned with the state of science, technology, engineering and math (STEM) education in the United States. Central to these concerns is the worry that the US educational system is not producing an adequate number of skilled graduates in STEM fields

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to address future scientific problems and maintain US global leadership in STEM (Beasley and Fischer 2012; Jackson 2006; National Academy of Science 2007; National Institutes of Health (NIH) 2006). Further, given the increasing importance of science and technology to the modern economy, science and engineering occupations are expected to be a major area for future job growth and will continue to represent one of the fastest growing and highest paying occupational sectors of the US economy (Bureau of Labor Statistics 2012).

Moreover, an increasingly diverse US population could have an adverse effect on STEM leadership because racial minorities have been historically underrepresented in science graduate programs which are often a pre-requisite for high paying technical jobs in STEM related fields. For instance, in 2009, Black and Latino students represented 15 and 13 % of undergraduate students, but constituted just 12 and 6 % of post-graduate students respectively. In terms of completing graduate degrees, Black and Latino students represented just 7.6 % of all doctoral degree recipients in core STEM disciplines of engineering, physical sciences, geosciences, mathematics, computer science, and life sciences in 2009 (National Science Foundation 2012). Given that Black and Latino Americans are predicted to comprise over 40 % of the US population by 2,045 (US Census Bureau 2012), it is imperative to increase participation and improve STEM outcomes among these students to ensure that the nation has an adequate number of qualified scientists.

One major component of federal policy efforts to improve STEM education and increase minority and female representation are enrichment programs designed to increase the number of STEM undergraduates that attend graduate school. A recent report by the Government Accountability Office (GAO) found that in 2010 there were 209 federal programs that targeted STEM education including 167 college-based enrichment programs designed to provide mentoring and research experience to aspiring scientists, and 65 programs targeted specifically towards traditionally underrepresented groups such as females, racial minorities, and economically disadvantaged students (GAO 2012). Taken together, these efforts represented nearly three billion dollars of federal support for STEM education.

Given the importance of STEM enrichment programs for federal education policy, it is important for scholars, policy-makers, educators, and administrators to understand the mechanisms by which these programs help increase participation in STEM. Recently scholars have noted that in addition to improving students' academic performance and providing students access to research experience and faculty mentors, the success of STEM enrichment programs is also enhanced by social psychological processes by which students come to identify as scientists (Carlone and Johnson 2007; Egan et al. 2012; Lee 1998, 2002; Merolla et al. 2012). To date, most studies investigating how the development and level of a science identity links enrichment program participation to improved student outcomes have focused on attitudinal outcomes. This research provides evidence that students who participate in STEM enrichment programs are more likely to identify with science, exhibit positive attitudes toward science, and maintain an interest in a STEM career. Fewer studies, however, have investigated whether science identity also impacts the probability that students will matriculate to graduate school. The current research addresses this issue by investigating whether identification with science—beyond its effect on subjective outcomes—can also help explain the effects of STEM enrichment programs on student matriculation into graduate school.

2 Theoretical background: identity theory

To understand the links between STEM enrichment programs, science identity, and graduate school matriculation, the current study draws on identity theory (Stryker 1980; Burke and

Stets 2009). Identity theory postulates that every individual in modern society has multiple role identities which correspond to the different social roles they fill. Identity theory differentiates role identities based on specific social roles (e.g., a science student), from social identities based on group identification and social characteristics (e.g., racial or national identity) (Tajfel and Turner 1986) and person identities based on specific personal traits (e.g., a nice person) (Burke and Stets 2009; Hazari et al. 2010). Identity theory seeks to explain why some individuals will choose to enact a particular role identity over another when there is a choice, or in this case, why some individuals choose to enter a science graduate program when others do not.

According to identity theory, each individual’s multiple role identities are structured hierarchically, and when individuals have a choice to enact one identity over another, the choice is based on identity salience. Identity salience describes the relative placement of a particular role identity relative to an individual’s other role identities. A role identity that ranks higher in an individual’s identity salience hierarchy has a greater probability to be enacted across a wide range of situations and is more likely to be maintained over time (Serpe 1987; Serpe and Stryker 2011). Identity salience in turn is a function of commitment to a particular identity. Identity theory defines commitment as the perceived costs associated with abandoning a particular social role due to the loss of social relationships associated with the role. Thus, identity theory links individual behavior to social structure by asserting that individuals with more satisfying social ties to a particular social role will be more likely to enact that role identity in situations when there is a choice (Serpe 1987; Serpe and Stryker 1987, 1993, 2011; Stryker 1980).

Recent work in identity theory has described how identity processes link structured social relationships and individual behavioral choice. Stryker et al. (2005) conceive of three levels of social structure, asserting that an individual’s positioning in relation to these structures impacts the probabilities that they will enter particular social relationships, develop salience of specific role identities, and enact particular social roles. Large social structures represent basic status characteristics such as race, class or gender, which structure the probability that individuals will participate in specific social institutions and enter into particular social relationships. According to the theory, large social structures do not directly influence role behaviors; however, large social structures affect individual behavior indirectly by shaping the likelihood that individuals will enter specific intermediate and proximate social structures such as particular universities or academic departments. Intermediate social structures are conceptualized as relatively large groups of individuals such as persons affiliated with a specific high school, neighborhood or university. Similar to large social structures, identity theory postulates that intermediate social structures serve as important boundaries that shape the likelihood that specific social relationships will develop. Finally, proximate social structures are social structures closest to individuals and represent the interactional contexts within which individuals generally enact role identities such as informal peer study groups, science clubs, or STEM enrichment programs. Through social relationships within proximate social structures, individuals develop commitment to specific role identities.

In essence, identity theory conceptualizes a hierarchy of social structures wherein large and intermediate social structures provide boundaries that shape the likelihood that individuals will enter certain proximate social structures. These proximate structures then affect the probability that particular social relationships will develop. Social relationships centered around a particular social role lead to higher identity salience of the specific role, which then makes enactment of that role more likely (Merolla et al. 2012; Serpe and Stryker 2011; Stryker et al. 2005).

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We argue that this account of how social structure shapes behavioral choice can help shed light on how large social structures and their attendant characteristics lead to variation in science participation. Abundant empirical evidence shows basic status characteristics such as race, gender and socio-economic status affect the probabilities that students will enter college, major in STEM, and persist in STEM majors (Gamoran 1987; Goyette and Mullen 2006; Grandy 1998; Maple and Stage 1991; Sirin 2005). However, identity theory suggests that simply being white or male (large social structural characteristics) does not directly lead to a salient science identity. Instead, these characteristics serve to increase the chances that students will enter intermediate and proximate social structures that are based around STEM, which make the choice to pursue a STEM career more likely. Thus, we argue that one reason for minority underrepresentation in science is that white, male and high SES students generally have more access to intermediate and proximate social structures based on a science identity compared to underrepresented minority and female students. Moreover, given that students who enter college with higher levels of science identity salience may be more likely to seek out opportunities for interactions based around science, differences in science identity salience may accumulate over the course of students' collegiate years leading to a cumulative advantage for students who begin college with strong science identities (Egan et al. 2012).

Following this approach, we conceptualize STEM enrichment programs as proximate social structures conducive to the development of a science identity. As noted, proximate social structures represent the interactional context in which role identities are enacted. Although enrichment programs are funded at the institutional level with some flexibility in how specific programs are administered, one commonality is that programs place students in a social network of other science students and faculty and students must maintain a STEM major to remain enrolled in the programs. Thus, enrichment programs serve as proximate social structures because they provide access to social relationships and interactions based on science and these relationships are contingent on the maintenance of a science identity.

This conceptualization suggests that one important function of STEM enrichment programs —beyond improving student performance—is to provide students with social relationships based on a science identity. As such, participation in STEM enrichment programs should lead to higher levels of science identity salience. Higher levels of science identity salience should in turn lead to an increased likelihood that students will enter a STEM graduate program.

3 Literature review

3.1 STEM enrichment programs and academic outcomes

STEM enrichment programs are designed to improve student outcomes in STEM fields, with many programs targeted to improve outcomes for traditionally underrepresented minority groups, females, and/or economically disadvantaged students. STEM enrichment programs vary in their scope, funding source, desired outcomes, and implementation. However, nearly all of these programs are designed to cultivate talent and interest in science, increase retention for STEM undergraduates, and increase the probability that students will matriculate into graduate programs in STEM (GAO 2012). Research on the effectiveness of STEM enrichment programs has generally shown that students who participate in enrichment programs are more likely than students with similar academic backgrounds to sustain an interest in STEM, perform better in their courses, complete STEM degrees and attend graduate school (Alfred et al. 2005; Barlow and Villarejo 2004; Maton and Hrabowski 2004; Maton et al. 2000).

Numerous studies identify undergraduate research experience as an important mechanism linking participation in enrichment programs to student outcomes. This research shows that enrichment program participants are more likely to gain research experience, and among enrichment program participants, students involved in research projects are more likely to matriculate into graduate school and maintain an interest in STEM careers compared to participants who do not engage in research projects (Barlow and Villarejo 2004; Carter et al. 2009; Jones et al. 2010; Schultz et al. 2011). Moreover, evidence indicates that among students with research experience, students who gain such experience in an enrichment program are more likely to attend graduate school than students who gain research experience outside the auspices of a formal enrichment program (Russell et al. 2007).

Another aspect of STEM enrichment programs related to research experience is faculty mentoring. Although most undergraduate research experiences occur under the guidance of a mentor, some research has looked more closely at the nature of mentoring relationships. This research indicates that undergraduate students who have faculty mentors are more likely to matriculate to graduate school and high achieving students commonly cite mentoring relationships as critical factors in their success (Freeman 1999; Lee 1999; Tsui 2007). Further, some evidence indicates that mentoring relationships may be particularly important for female and/or minority students who may feel less welcome in STEM environments where the faculty and students are predominately white and male (Darke et al. 2002; Fadigan and Hammrich 2004; Jacobi 1991).

In sum, research on STEM enrichment programs has generally shown positive effects for these programs on a number of student outcomes. There is ample evidence that students who participate in enrichment programs sustain their interest in STEM, perform better in their courses, and are more likely to attend graduate school. Moreover, research indicates that enrichment programs facilitate student success in STEM programs by providing opportunities for students to gain research experience and cultivate relationships with faculty mentors. Here we extend research on STEM enrichment programs by asking whether increased science identity salience is another way in which STEM enrichment programs make participants more likely to enter STEM graduate programs.

3.2 Science identity and STEM outcomes

Numerous studies have supported the contention that persistence in STEM education not only requires mastering the technical skills needed to be a scientist, but also entails a social psychological process by which students begin to see science as a salient part of their identities (Carlone and Johnson 2007; Egan et al. 2012; Hanson 1996; Hazari et al. 2010; Johnson et al. 2011; Lee 1998, 2002; Merolla et al. 2012; Syed et al. 2011). Research on the role of science identity underscores the importance of social interactions that allow students to be recognized—and to recognize themselves—as scientists, as experiences that make students more likely to translate their skills into STEM careers. Evidence further indicates that these processes may be amplified for female and/or minority students who may encounter a “chilly climate” in which their opinions and efforts are discounted in scientific domains that are culturally constructed as masculine or white (Brickhouse and Potter 2001; Lee 1998, 2002).

The bulk of research on the links between science identity and student outcomes has been conducted using advanced graduate students or students engaged in enrichment programs. This research shows a clear impact of science identity on students who have few substantial differences in terms of competency in science as gauged by academic records (Carlone and Johnson 2007; Ong 2005). Thus, this research suggests that female and minority underrepresentation in STEM is not due to a lack of skill or ability in science among these students. Instead, underrepresentation is likely linked to a lack of satisfying social relationships within STEM pursuits that lead students to disidentify with science. To date, most studies linking science identity to student outcomes have focused on attitudinal outcomes such as student interest in science or student intention to continue in scientific pursuits rather than behavioral outcomes such as entering a STEM graduate program (Lee 1998, 2002; Merolla et al. 2012).

3.3 STEM enrichment programs, science identity and student outcomes

Given the links between science identity and interest in science, it is important to understand whether participation in STEM enrichment programs also increases student identification with science. Unfortunately, this relationship has been understudied in the extant literature. Some evidence of this link comes from retrospective reports of enrichment program participants' perceptions of these programs (Hakim 1998; Hunter et al. 2007; Kardash 2000; Lamb 1999; Lam et al. 2003; NIH 2006; Russell et al. 2007; Seymour et al. 2004; Villarejo et al. 2008). Narratives of enrichment program participants indicate that they perceive program benefits beyond improved academic performance. Specifically, participants often remark that access to social relationships with faculty and other peers in the program made them feel more comfortable in scientific domains and enabled them to turn their skills in STEM into a STEM career. For instance, Maton et al. (2000) note that the most commonly reported positive aspect of training programs for participants in the Meyerhoff Program was being a part of the program community and having the chance to interact and develop relationships with other science students (see also: Maton and Hrabowski 2004).

Fewer studies have specifically linked program participation to science identity salience. However, studies that have focused on this relationship have found that STEM enrichment program participation can increase the salience of a science identity. These studies also support the idea that STEM enrichment programs have an effect on science identity because these programs provide students with social relationships based around scientific pursuits (Lee 1998, 2002; Merolla et al. 2012). For instance, Lee (2002) finds that students who report more satisfying relationships with others involved in scientific pursuits are more likely to see themselves as scientists and to express an interest in engaging in more science based activities. Egan et al. (2012) also show that experiences with structured research is associated with higher levels of identification with science.

Several studies have shown that science identity measures can serve as mediators of the effects of enrichment program participation on attitudinal outcomes (Chemers et al. 2011; Merolla et al. 2012;). Thus, empirical evidence indicates that science identity is an important aspect of sustained interest in science and science related fields, and may mediate enrichment program effects on such subjective outcomes. However, few studies to date have explicitly investigated whether science identity salience also links STEM enrichment programs to behavioral outcomes such as graduate school matriculation.

In sum, current research indicates that participation in STEM enrichment programs increases student identification with science. Moreover, research has found that identification with science is associated with attitudinal outcomes such as student interest and intention to pursue graduate school and science careers. However, a critical question remains as to whether science identity is related to the decision to enter a STEM graduate program, and whether science identity functions as a mechanism linking enrichment program participation to graduate school matriculation.

4 Hypotheses

This paper investigates the impact of STEM enrichment programs on student matriculation to graduate school. Using identity theory, we ask whether participation in STEM enrichment programs leads to increased student identification with science, and whether student identification with science is associated with graduate school matriculation. This study conceptualizes STEM enrichment programs as proximate social structures (Merolla et al. 2012), which represent networks of social relationships that are close to individuals and are the context in which specific role identities are enacted. As noted above, abundant empirical evidence indicates that differences in basic status characteristics (e.g., race, class, gender) are related to different levels of access to specific intermediate (e.g., universities, majors) and proximate social structures (e.g., mentoring, study groups). As such, we view STEM enrichment programs as interventions that increase the salience of a science identity for female, minority and economically disadvantaged students. Higher levels of identity salience should in turn lead to a greater probability of graduate school matriculation. The hypotheses below formalize our expectations.

Hypothesis 1 STEM enrichment program participation will be associated with matriculation to graduate school.

Hypothesis 2 STEM enrichment program participation will be associated with (a) increased science identity salience, (b) higher college GPA, (c) more research experience, (d) higher student intention for a scientific career, and (e) more mentoring.

Hypothesis 3 (a) Science identity salience, (b) college GPA, (c) research experience, (d) student intention for a scientific career, and (e) mentoring will mediate the relationship between enrichment program participation and graduate school enrollment.

5 Data and methods

5.1 Participants

The data for this research come from *The Science Study*, a national panel study of undergraduate science majors. *The Science Study* panel was recruited in the fall semester of 2005 via an online screening survey publicized through announcements to directors of NIH STEM enrichment programs in numerous colleges and universities across the US. From respondents that completed the online survey, 805 eligible undergraduate students were selected into the panel, of which about 40 % were participating in a STEM enrichment program. Students were solicited to complete online surveys once per semester through the winter semester of 2011. 111 students never reported any of the four outcomes described below, and are not included in the analyses yielding an analytic sample of 694. Missing data were adjusted using multiple imputation and all results are averaged over the five imputed datasets.

One aspect of *The Science Study* panel that complicates the analyses below is that students varied in their class status (first-year student, sophomore, junior, senior) at the onset of the study. As such, some students reported either graduate school matriculation or leaving the science pipeline early on in the course of the study (but not necessarily early on in their academic careers) and other students remained in the panel as undergraduate students for numerous waves of data collection. We chose to deal with this aspect of the data by constructing a datafile in which each student has one row of data, but the observed graduate school matriculation status and some of the mediating variables (see below) come from different waves of data collection for different students, depending on when they reported ending their studies or entering graduate school. That is, whereas one student’s outcome may come from wave two; another student’s outcome may come from wave four. This strategy allows us to maintain the time ordering of the independent and mediating variables and include students from all class levels at baseline. All models control for an indicator of the wave of data collection in which the student's outcome was observed.

5.2 Measures

The outcome variable for this study is matriculation to graduate school in STEM. Table 1 shows the distribution of four possible outcomes for students in *The Science Study* panel. 31.70 % of the sample matriculated to graduate school in a STEM field. The national average for graduate school matriculation is 21.70 % (Snyder and Dillow 2012: 591). The relatively high number of sample members entering graduate school reflects the fact that *The Science Study* panel is composed of high achieving, motivated students that the NIH targets for its training programs. Of the students that did not matriculate to graduate school, 48.41 % reported stopping their educational pursuits for employment and 19.74 % reported changing to a non-STEM major. Only 1 student reported leaving college and did not report employment as their primary activity.

The main independent variable for this study is STEM enrichment program participation. The majority of students in *The Science Study* panel participated in one of two NIH funded enrichment programs—*Research Initiative in Science Education (RISE)*, or *Minority Access to Research Careers (MARC)*—although a smaller number of students were involved in other programs. Both *RISE* and *MARC* are programs that focus on recruiting and training science students from underrepresented groups. Student participation in STEM enrichment programs can vary semester to semester over the course of their college careers. To capture variation in the level of degree of participation, this variable is coded as the percentage of semesters during which a respondent reported participating in a STEM program as of the semester prior to matriculating to graduate school or leaving the science pipeline. Alternate specifications of the participation variable were explored including the cumulative number of semesters of participation in an enrichment program and a binary indicator for any participation. In all cases, results were substantively identical to those reported below.

We utilize five mediating variables that have been shown to serve as a link between enrichment program participation and graduate school matriculation. All continuous mediating variables are taken from the semester prior to the student's observed outcome. *Science Identity Salience* is a composite variable computed as a student's average response to four questions. Specifically, respondents were asked, "Think about meeting a (co-worker, the friend of a close friend, a person of the opposite sex, the friend of a family member) for the first time, how likely would you be to tell this person about your desire to be a scientist?" Alpha reliability of this measure is .94. This measure of identity salience has been established as psychometrically valid and is a standard measure for researchers using identity theory (cf. Lee 1998, 2002; Merolla et al. 2012; Serpe 1987; Serpe and Stryker 1987; Stryker and Serpe 1982, 1994; Stryker et al. 2005). *College GPA* is students' self-reported undergraduate GPA. *Research Experience*, similar to program participation, is specified as the percentage of semesters that the student reported participating in research. *Intention for STEM career* is the student's response to the question "On a scale of 0–10, please rate the degree to which you plan to pursue a science related research career." Finally, *Faculty Mentor* is the percentage of semesters that the student reported having a faculty mentor over the course of the study.

One difficulty for research on STEM enrichment programs is that student participation in enrichment programs is not random, but instead is correlated with of the same factors that lead to student success. Scholars have uncovered numerous interrelated correlates of persistence in STEM, which can be categorized as family background characteristics/socio-economic status (SES), academic history, and level of interest in STEM. Given the ubiquity of these factors in the literature on STEM persistence, models predicting matriculation to graduate school should control for these background factors to ensure estimates are robust to the effects of these factors.

Most research literature indicates that students from families with higher incomes and more highly educated parents are more likely to persist in education compared to their less advantaged counterparts (Goyette and Mullen 2006; Grandy 1998; Lee 2005; Paulsen and St. John 2002; Sirin 2005; Vartanian et al. 2007). Here we utilize five variables indexing students' socio-economic backgrounds. *Parents' Graduate Degree* is a binary variable that compares students who reported that at least one of their parents had a graduate degree to all other students; 22.9 % of students reported having a parent with a graduate degree. *Low Family Income* is a binary variable that compares students with family incomes less than $50,000 (the median income in the sample) to all other students; 28 % of students reported coming from families with low family incomes. Because family resources are allocated to multiple siblings in a family unit and research shows that students from larger families have worse educational outcomes, a self-reported measure of number of siblings is also used as an indicator of SES (Blake 1989; Downey 1995; Booth and Kee 2009). The mean number of siblings in the sample is 2.33. *English* is a binary item that compares students who spoke English as their first language to students who did not speak English as their first language; 75.5 % of students reported speaking English as their first language. *First Generation Student* is a binary variable that compares students who reported being first generation college students to all others; 19.5 % of the sample reported being a first generation college student.

Another important precursor to persistence in science education is academic preparation and course taking in high school. The research literature shows that those students who are successful in STEM tend to have better grades in high school and take more rigorous high school courses such as Advanced Placement (AP) courses (Adelman 2006; Bonous-Hammarth 2000; Espinosa 2011; Gamoran 1987; Grandy 1998; Maple and Stage 1991). Three items are used to account for differences in academic preparation prior to college. *AP classes* is a binary item that compares students who reported taking AP classes in high school to students who did not take AP classes; 55 % of the sample reported taking AP classes during high school. *Standardized Test* is a standardized measure of students' self-reported scores on either the SAT or ACT. The original ordinal variables were designed to have responses corresponding to national quintiles on these exams. The SAT and ACT items were then combined and standardized with students who reported taking both tests being assigned the mean value of their two scores; as a standardized variable the mean of this item is 0. *HS GPA* is a self-reported measure of each student's high school GPA, with a mean of 3.5.

Race is indexed with two dummy variables. *Black* is coded "1" for Black students and "0" for all others and *Latino* is coded "1" for Latino students and "0" for all others. 50.6 % of the sample is Black and 37.9 % of the sample is Latino. *Female* compares female students to their male counterparts; 71.3 % of the sample is female. Student's major is indexed using three binary variables. *Biological Science major* is coded "1" for biological science majors, *natural science major* is coded "1" for natural science majors, and *math/engineering* is coded "1" for math and engineering majors. About 90 % of the sample were enrolled in these disciplines; the remaining 10 % of the sample were majors in behavioral or social sciences such as psychology, sociology or economics. Models estimated without behavioral and social science majors yielded substantively identical results to those reported here.

Two additional control variables are included in models below. *Initial Intention for STEM career* is a baseline measure of the intention item described above. Finally, *Upper Division*

Student compares students who were either juniors or seniors at baseline to lower division students; 70.6 % of students were upper division students at baseline.

6 Results

6.1 Bivariate analyses

Table 2 presents means/percentages for all independent variables for the full sample and by graduate school matriculation status. Table 2 shows, consistent with Hypothesis 1, that matriculating students have significantly higher average levels of program participation than non-matriculating students. Specifically, matriculating students averaged participation in 29 % of semesters, whereas non-matriculating students averaged participation in 21 % of their undergraduate semesters. This finding reiterates the pattern shown in numerous studies cited above that participants in STEM enrichment programs have a greater chance of attending STEM graduate programs. In addition, matriculating students have higher college GPAs, higher levels of science identity salience, higher levels of intention, are more likely to participate in research, and are more likely to have faculty mentors than non-matriculating students. These patterns are consistent with our expectations and with past research which has shown these factors to be important precursors to graduate school in STEM. There were fewer differences in family and academic backgrounds among *The Science Study* sample. This pattern is likely due to the restricted variability on these variables due to the nature of the sample consisting of mainly high achieving, mostly minority female STEM majors. Nevertheless, Table 2 indicates that students who matriculated to graduate programs had higher levels of intention for STEM careers at baseline, and unexpectedly were more likely to come from lower income families and families with more siblings.

Table 3 shows bivariate correlations among program participation and the five mediating variables. Consistent with Hypotheses 2a–e, participation in STEM programs has a significant positive association with each of the mediating variables. Program participation has particularly strong associations with research experience (r = .496) and faculty mentoring (r = .512). These associations indicate that students who participate in enrichment programs are likely to gain more research experience and are more likely to have faculty mentors than students who do not participate in enrichment programs. Program participation shares smaller associations with the other mediating variables, yet maintains positive and significant associations with college GPA (r = .144), science identity salience (r = .123) and intention for a STEM career (r = .159). Notably, only two of the 15 associations among these variables are not significant. College GPA is not associated with either science identity salience (r = .013, $p > .05$) or intention to pursue a STEM career (r = .040, $p > .05$). This pattern suggests that students' desires for STEM careers and their levels of science identity salience are independent of their abilities to complete STEM tasks or perform well in courses. College GPA does have a significant association with faculty mentoring (r = .180) and research experience (r = .163).

6.2 Multivariate analyses

Table 4 presents logit coefficients and odds ratios (OR) from logistic regression models of STEM graduate school matriculation. Model 1 gives the effect of program participation only and shows a positive effect of program participation on the probability to enter a STEM graduate program (b = .009, $p < .001$, OR = 1.01). The participation variable is in a metric of percentage of semesters participating; thus this coefficient indicates that for every 1 % point increase in program participation, a student is about 1 % more likely to attend graduate school. If the average student takes about 10 semesters to complete an undergraduate degree, one semester of program participation (10 % of their undergraduate career) will lead to increased odds of graduate school entry of about 10 % (EXP (10 × .009) = 1.10).

Additionally, a student who participated in an enrichment program during half of his or her undergraduate career is about 56 % more likely to attend graduate school compared to a student who never participated (EXP (50 × .009) = 1.56). Further, model 1 indicates that a student who participated in a STEM program every semester during his or her undergraduate years is about 2.45 times more likely to enter a STEM graduate program than a student who never participated in an enrichment program (EXP (100 × .009) = 2.45. The positive effect of participation on graduate school entry is consistent with Hypothesis 1 and with past research showing that enrichment program participation is positively associated with graduate school matriculation.

Model 2 adds the control variables. Model 2 shows that among *The Science Study* sample members, none of the family or academic background variables have a statistically significance independent association with graduate school matriculation. We attribute this result to the specificity of *The Science Study* sample, which mostly consists of high achieving students with less variability in social background than a general sample of college students. However, including these variables in the multivariate model enhances our confidence that the effects of program participation and the mediating variables are not due to differences in background characteristics known to lead to high attainment in STEM fields.

Model 3 adds the mediating measures. Consistent with Hypotheses 3a–c, science identity salience, college GPA and research experience are significant predictors of graduate school matriculation. Each of these variables has a significant, positive effect on graduate school matriculation. Model 3 indicates that a one unit increase in science identity salience (b = .105, $p < .001$, OR = 1.11) is associated with 11 % greater odds of graduate school matriculation. This finding suggests that beyond the effects of science identity salience on attitudinal measures of interest and intention in STEM, science identity salience has an impact on the probability that students will transition to graduate school. The effect of GPA (b = .870, $p < .01$, OR = 2.39) indicates that a one unit increase in GPA is associated with a 139 % increase in the odds of graduate school matriculation. The effect of GPA is consistent with past research and is likely a reflection of GPA's role as a factor in graduate school admissions decisions. Research experience also has a significant positive effect on graduate school matriculation. The effect of research experience (b = .019, $p < .001$, OR = 1.02) indicates that a one percentage point increase in the proportion of semesters that a student participates in research is related to an increase in odds of graduate school attendance by 2 %. Similar to the program participation measure, a one-percentage increase in research experience is unlikely. An increase of 10 % corresponds to increased odds of graduate school entry of about 22 % (EXP (10×.002) = 1.22). A student who participated in research during half of his or her undergraduate career is about 171 % more likely to attend graduate school compared to a student that never participated (EXP (50×.002) = 2.71). Further, students who participated in research every semester during their undergraduate years are over seven times more likely to enter STEM graduate programs than students who never participated in enrichment programs (EXP (100 × .009) = 7.39). In addition, Model 3 indicates that the addition of the mediating variables reduces the effect of program participation to non-significance. This result provides evidence that science identity salience, college GPA, and research experience serve as mechanisms linking STEM enrichment programs to graduate school matriculation.

To augment these findings we also performed a modified Sobel test to confirm that science identity salience, college GPA and research experience served as mediators of enrichment program effects. The Sobel test provides a statistical significance test for the indirect effect, and a modified Sobel test adjusts the standard formulas for logistic regression (cf. Mackinnon and Dwyer 1993). These tests indicated a significant indirect effect of program participation through science identity salience (t = 2.09, $p < .05$) college GPA (t = 2.60, $p < .01$), and research experience (t = 4.52, $p < .001$). These results confirm the pattern seen in Table 4 and provide further support for Hypotheses 3a, b. In contrast to Hypotheses 3d–e, student intention for a scientific career and faculty mentoring were not significant predictors of matriculation to graduate school in STEM disciplines.

To determine whether science identity salience also acts as a moderator of the effects of the other mediating factors, interaction effects were estimated between science identity salience and research experience, and between identity salience and college GPA. Only one significant interaction effect was found, an interaction between science identity salience and college GPA. As shown in Model 4, this effect (b = .193, $p < .01$) indicates that the positive effect of college GPA is enhanced among students with higher levels of science identity salience. Figure 1 shows this effect graphically. Figure 1 plots the effect of college GPA for students with science identity salience levels below and above the median. Figure 1 shows that the slope of college GPA is steeper for those students with higher levels of science identity salience. This pattern indicates that beyond the direct positive effect of science identity salience, science identity salience also serves to enhance the effect of college GPA. That is, students with high GPAs are more likely to translate these GPAs into graduate school entry when they also have high levels of science identity salience.

As noted above, students in *The Science Study* sample were at different stages of their collegiate careers when data collection began. In essence, the measure of program participation is left censored because they may have participated in enrichment programs prior to the beginning of the study. To ensure that the results presented here are robust to this issue we estimated interaction effects with the upper-division variable and all of the independent and mediating variables. In addition, interaction effects were tested between all of the independent variables and the variable indexing the wave of data collection that the student’s outcome was observed. In no instances were significant interaction effects detected. The lack of interaction effects between the variables that index the student’s progress at baseline and the independent variables used in the models above indicate that left censoring of student participation does not influence our findings.

7 Discussion

This investigation of the effects of science identity salience on STEM graduate school matriculation makes three contributions to the extant literature on the role of science identity for persistence in STEM. First, the results reported here indicate that science identity salience, beyond its effect on subjective factors such as intention for a science career, also has a significant impact on graduate school matriculation. Previous research has shown that science identity salience is related to students’ feelings about science, interest in STEM and intention to continue in STEM (Chemers et al. 2011; Hazari et al. 2010; Lee 1998, 2002; Merolla et al. 2012). This study adds to this literature by showing that science identity also has implications for student matriculation into graduate school. Second, this research shows that science identity salience, along with college GPA and research experience, act as mediators of STEM enrichment program effects on graduate school matriculation. This pattern provides evidence that both social and academic factors are important considerations for student success in STEM. Finally, the findings indicate that science identity salience, beyond its direct impact on graduate school matriculation, also amplifies the effect of college GPA. Specifically, results show that students with high levels of science identity salience are more likely to translate high college GPAs into graduate school matriculation compared to students with lower levels of science identity salience. These findings add to a growing body of evidence pointing to the important role that social psychological processes play in STEM educational success. Central to a social psychological explanation of student persistence is the acknowledgement that beyond factors such as ability and achievement, students who embrace a science identity are more likely to maintain their aspirations to become scientists. Here we show that beyond the effect of identity process on subjective outcomes, students with higher levels of identity salience are also more likely to act on their intentions by pursuing a graduate degree in STEM.

A central tenet of identity theory is that the salience of specific role identities is malleable and responsive to changes in individual's social relationships (Serpe 1987; Serpe and Stryker 1987, 1993). This conceptualization implies that individuals' social relationships are influential for individual behavioral choices. This insight is important for understanding variation in STEM persistence. Most STEM majors develop their interest in science during K-12 education and tend to lose interest in science during their college years (Russell et al. 2007; Schultz et al. 2011). The results of the current study further support other research that indicates that students may lose interest in STEM not only because of the difficulty of the STEM curriculum, but also because of a lack of satisfying social relationships surrounding STEM pursuits (Carlone and Johnson 2007). Thus, colleges and universities that hope to increase retention of students in STEM should develop interventions that not only provide academic support but are also sensitive to the social aspects of student persistence in STEM. Specifically, interventions should be developed that seek to cultivate positive social relationships among STEM students.

This insight is particularly important in light of the inter-relations among science identity salience, student GPA and graduate school matriculation. Results here show that although college GPA and science identity salience were not associated, both science identity salience and GPA serve as mechanisms linking program participation to graduate school matriculation. This pattern indicates that the social psychological process by which science identity salience develops operates independently from student achievement. That is, it is not only high achieving students who develop high levels of identity salience. Further, we also find that science identity salience strengthens the link between college GPA and graduate school entry. These patterns are consistent with evidence from previous studies that high achieving students may not continue in STEM when these students are unable to find satisfying social relationships surrounding STEM pursuits. Students who are both high achieving and identify with science, however, are likely to continue their studies into graduate level work (Carlone and Johnson 2007; Ong 2005).

Beyond the role of science identity salience and GPA we also find that participation in undergraduate research is an important mechanism linking STEM enrichment programs and graduate school matriculation. This finding is consistent with a large amount of previous research which has identified research experience as one of the most important aspects of STEM enrichment programs (Carter et al. 2009; Jones et al. 2010; Russell et al. 2007; Schultz et al. 2011). Our findings corroborate this pattern by finding both that participants in STEM enrichment programs are more likely to participate in undergraduate research and those students who participate in undergraduate research are more likely to continue into graduate programs. It appears that expanding access to research experiences is one of the most potent avenues for educational policy makers to increase representation in STEM graduate programs.

Using identity theory, this study conceptualized STEM enrichment programs as proximate social structures, or social structures close to individuals that provide the context for the enactment of role identities. Research has consistently shown that white, male and high SES students have more access to intermediate and proximate social structures conducive to persistence in STEM education (Gamoran 1987; Goyette and Mullen 2006; Grandy 1998; Maple and Stage 1991; Sirin 2005). Findings from this study imply that one avenue to increase participation in STEM for historically under-represented groups is enrichment programs that provide these structures for female and underrepresented students who may not have consummate levels of access to such social networks. As noted, STEM enrichment programs receive substantial federal support. This research suggests that these dollars are well spent and that educators should continue to advocate for this type of investment in order for the US to retain its competitive edge in STEM. Future research with a more general student sample should directly address the claim that minority under-representation in STEM is due in part to a lack of access to proximate social structures that center on STEM pursuits.

Despite the contributions of the current study, there are several limitations that should be noted. First, the current study is based on a select sample of high achieving, mainly minority and female students. Although we believe that the patterns shown here would be seen in a general sample, empirical evidence is needed to determine the degree to which a general sample would mirror the sample utilized here. This limitation should be addressed in future studies given the preponderance of research on STEM enrichment programs that has relied on samples of students who are more likely to achieve degrees and enter graduate school than the general student body.

A second limitation of the current research is that the analysis did not specifically address the temporal nature of science identity. That is, it is likely that higher science identity salience observed among students who enter graduate programs is the result of a process in which science identity salience develops over the course of their collegiate careers. Thus, an important unanswered question remains as to how STEM enrichment programs alter the developmental trajectories of science identity salience and how these effects may be related to the level of science identity salience when students begin college. Given that many students who persist in their studies have a strong science identity early in their educational careers (Sadler et al. 2012; Egan et al. 2012), future research should more carefully address how enrollment in STEM enrichment programs affects the development of a science identity over time. Particularly important for this question is whether STEM programs accentuate science identities more for students with stronger science identities when they enter college, or if the effects of these programs are beneficial for all students regardless of their initial levels of science identity salience.

A third limitation to the current study is the possibility for selection bias. That is, like every observational study, the nature of the data cannot empirically rule out the possibility that students who had higher science identity salience were more likely to enter STEM enrichment programs as an alternate explanation for the pattern of mediation shown above. Although we control for an extensive set of covariates known to be important for both graduate school matriculation and program selection, including a baseline measure of student intention, selection bias cannot be completely ruled out with the current research design. Future studies should address this issue by using new innovative methods for assessing causal effects from observational studies (cf. Hernán et al. 2004). In addition, colleges and universities that house STEM enrichment programs should work to develop quasi-experimental designs that can better isolate the effects of enrichment programs from other observed and unobserved factors.

The current study shows that students' choices about whether to remain in STEM are shaped by structural forces that influence students' access to networks of social relationships based on STEM. The evidence presented indicates that students with access to these relationships in the form of enrichment programs are more likely to identify as scientists and are more likely to continue their education into graduate programs. Increasing participation in STEM remains a national priority. Given the likelihood of reduced federal spending on enrichment programs in the current fiscal climate, the current study offers hope that colleges and universities can design effective interventions that encourage more students to continue into graduate school in science. The current research suggests that colleges and universities should develop programs that not only enhance students' skills in the laboratory and in the classroom, but also create welcoming social environments that provide students interested in STEM with opportunities to develop meaningful social relationships centered around their interest in science.

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References

Adelman, C. The toolbox revisited. Paths to degree completion from high school through college. Washington, DC: U.S. Department of Education; 2006.

Alfred L, Atkins C, Lopez M, Chavez T, Avila V, Paolini P. A Science pipeline pathway for trainings underrepresented students in the biomedical Sciences. Journal of Women and Minorities in Science and Engineering. 2005; 11(1):45–60.

Barlow A, Villarejo M. Making a difference for minorities: Evaluation of an educational enrichment program. Journal of Research in Science Teaching. 2004; 41(9):861–881.

Beasley MA, Fischer MJ. Why they leave: The impact of stereotype threat on the attrition of women and minorities from science, math and engineering majors. Social Psychology of Education. 2012; 15(4):427–448.

Booth AL, Kee HJ. Birth order matters: The effect of family size and birth order on educational attainment. Journal of Population Economics. 2009; 22(2):367–397.

Brickhouse NW, Potter JT. Young women's scientific identity formation in an urban context. Journal of Research in Science Teaching. 2001; 38(8):965–980.

Bureau of Labor Statistics (BLS). Occupational outlook handbook. 2012. Retrieved September 15, 2012 from http://www.bls.gov/ooh/

Blake, J. Family size and achievement. Berkeley, CA: University of California Press; 1989.

Bonous-Hammarth M. Pathways to success: Affirming opportunities of science mathematics and engineering majors. Journal of Negro Education. 2000; 69:92–111.

Burke, P.; Stets, J. Identity theory. New York: Oxford University Press; 2009.

Carlone HB, Johnson A. Understanding the science experiences of successful women of color: Science identity as an analytic lens. Journal of Research in Science Teaching. 2007; 44(8):1187–1218.

Carter F, Mandell M, Maton K. The influence of on-campus, academic year undergraduate research on stem PhD outcomes: Evidence from the Meyerhoff Scholarship Program. Educational Evaluation and Policy Analysis. 2009; 31(4):441–462. [PubMed: 21785521]

Chemers MM, Zurbiggen E, Barbara Goza MS, Bearman S. The role of efficacy and identity in science career commitment among underrepresented minority students. Journal of Social Issues. 2011; 67(3):469–491.

Darke K, Clewell BC, Sevo R. Meeting the challenge: The impact of the national science foundation's program for women and girls. Journal of Women and Minorities in Science and Engineering. 2002; 8(3/4):1–20.

Downey D. When bigger is not better: Family size, parental resources and children's educational performance. American Sociological Review. 1995; 60(3):746–761.

Egan, MK.; Hurtado, S.; Garibay, J.; Herrera, F. Accentuating advantage: Developing Science identity during college. Paper presented at American Educational Research Association Conference; 2012.

Espinosa LL. Pipelines and pathways: Women of color in undergraduate stem majors and the college experiences that contribute to persistence. Harvard Educational Review. 2011; 82(2):209–240.

Fadigan KA, Hammrich PL. A longitudinal study of the educational and career trajectories of female participants of an urban informal science education program. Journal of Research in Science Teaching. 2004; 41(8):835–860.

Freeman K. No services needed?: The case of mentoring high achieving African American students. Peabody Journal of Education. 1999; 74(2):15–26.

Gamoran A. The stratification of high school learning opportunities. Sociology of Education. 1987; 60(3):135–155.

Government Accountability Office. Science, technology, engineering and mathematics education: Strategic planning needed to better manage overlapping programs across multiple agencies. Washington, DC: US Government Printing Office; 2012.

Goyette K, Mullen A. Who studies the arts and sciences? Social background and the choice and consequences of undergraduate field of study. Journal of Higher Education. 2006; 77(3):497–538.

Grandy J. Persistence in science of high-ability minority students: results of a longitudinal study. Journal of Higher Education. 1998; 69(6):589–620.

Hakim T. Soft assessment of undergraduate research: Reactions and student perspectives. Council on Undergraduate Research Quarterly. 1998; 18:189–192.

Hanson, SL. Lost talent. Philadelphia, PA: Temple University Press; 1996.

Hazari Z, Sommert G, Sadler PM, Shanahan MC. Connecting high school physics experiences, outcome expectations physics identity and physics career choice: A gender study. Journal of Research in Science Teaching. 2010; 47(8):978–1003.

Hernán M, Hernandez-Diaz S, Robins JM. A structural approach to selection bias. Epidemiology. 2004; 15(5):615–625. [PubMed: 15308962]

Be Hunter A, Laursen S, Seymour E. Becoming a scientist: The role of undergraduate research in students' cognitive, personal and professional development. Science Education. 2007; 91(1):36–74.

Jackson, SA. The quiet crisis: Falling short in producing American scientific and technical talent. Washington DC: Building Engineering and Science Talent; 2006.

Jacobi M. Mentoring and undergraduate academic success: A literature review. Review of Educational Research. 1991; 61(4):505–532.

Johnson A, Brown J, Carlone H, Cuervas A. Authoring identity amidst the treacherous terrain of science: A multiracial feminist examination of the journeys of three women of color in science. Journal of Research in Science Teaching. 2011; 48(4):339–366.

Jones M, Barlow A, Villarejo M. Importance of undergraduate research for minority persistence and achievement in biology. The Journal of Higher Education. 2010; 81(1):82–115.

Kardash CM. Evaluation of an undergraduate research experience: Perceptions of undergraduate interns and their faculty mentors. Journal of Educational Psychology. 2000; 92(1):191–201.

Lam P, Ugweke O, Mawasha R, Srivatsan T. An assessment of the McNair Program at the University of Akron. Journal of Women and Minorities in Science and Engineering. 2003; 9(1):103–117.

Lamb S. The Holmes scholars network: A network mentoring program of the Holmes Partnership. Peabody Journal of Education. 1999; 74(2):150–162.

Lee JT. Which kids can 'become' scientists? Effects of gender, self-concepts, and perceptions of scientists. Social Psychology Quarterly. 1998; 61(3):199–219.

Lee JT. More than ability: Gender and personal relationships influence science and technology involvement. Sociology of Education. 2002; 75(4):349–373.

Lee O. Science education with English language learners: Synthesis and research agenda. Review of Educational Research. 2005; 75(4):491–530.

Lee W. Striving toward effective retention: The effect of race on mentoring African American students. Peabody Journal of Education. 1999; 74(2):27–43.

Maple S, Stage F. Influences on the choice of math/science major by gender and ethnicity. American Educational Research Journal. 1991; 28(1):37–60.

Maton K, Hrabowski FA, Schmitt C. African American college students excelling in the science: College and post-college outcomes in the Meyerhoff scholars program. Journal of Research in Science and Teaching. 2000; 37(7):629–654.

Maton K, Hrabowski F. Increasing the number of African American PhDs in science and engineering: A strengths-based approach. American Psychologist. 2004; 59(6):547–556. [PubMed: 15367090]

Mackinnon D, Dwyer J. Estimating mediated effects in prevention studies. Evaluation Review. 1993; 17(2):144–158.

Merolla DM, Serpe RT, Stryker S, Schulz PW. Structural precursors to identity processes: The role of proximate social structures. Social Psychology Quarterly. 2012; 75(2):149–172.

National Science Foundation (NSF). Doctorate Recipients from US universities. Washington DC: National Science Foundation; 2012.

National Institutes of Health. Assessment of NIH minority research and training programs: Phase 3. Washington, DC: National Academies Press; 2006.

National Academy of Sciences, National Academy of Engineering, and the National Academy of Mathematics. Rising above the gathering storm: Energizing and employing America for a brighter future. Washington, DC: National Academies Press; 2007.

Ong M. Body projects of young women of color in physics: Intersections of gender, race and science. Social Problems. 2005; 52(4):593–617.

Paulsen M, St John EP. Social class and college costs: Examining the financial nexus between college choice and persistence. Journal of Higher Education. 2002; 73(2):189–236.

Russell SH, Hancock MP, McCullough J. Benefits of undergraduate research experiences. Science. 2007; 316:548–549. [PubMed: 17463273]

Sadler P, Sonnert G, Hazari Z, Tai R. Stability and volatility of STEM career interest in high school: A gender study. Science Education. 2012; 96(3):411–427.

Schultz PW, Hernandez PR, Woodcock A, Estrada M, Chance R, Aguilar M, et al. Patching the pipeline: Reducing educational disparities in the sciences through minority training programs. Journal of Educational Policy Analysis. 2011; 33(1):95–114.

Serpe RT. Stability and change in the self: A structural symbolic interaction perspective. Social Psychology Quarterly. 1987; 50(1):44–55.

Serpe, RT.; Stryker, S. The construction of self and the reconstruction of social relationships. In: Lawler, E.; Markovsky, B., editors. Advances in group processes: Theory and research. Vol. 4. Greenwich, Conn: JAI Press; 1987. p. 41-82.

Serpe, RT.; Stryker, S. Prior social ties and movement into new social relationships. In: Lawler, E.; Markovsky, B.; O'Brien, J., editors. Advances in group processes: Theory and research. Vol. 10. Greenwich, Conn: JAI Press; 1993. p. 283-304.

Serpe, RT.; Stryker, S. The symbolic interactionist perspective and identity theory. In: Schwartz, SJ.; Luyckx, K.; Vignoles, VL., editors. Handbook of identity theory and research. New York: Springer; 2011. p. 225-248.

Seymour E, Hunter AB, Laursen S, De Antoni T. Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three year study. Science Education. 2004; 88(4):493–534.

Sirin S. Socio-economic status and academic achievement: A meta-analytic review of research. Review of Educational Research. 2005; 75(3):417–453.

Snyder, TD.; Dillow, SA. Digest of educational statistics: 2011. Washington DC: National Center for Educational Statistics Institute of Education Sciences US Department of Education; 2012.

Stryker, S. Symbolic interactionism: A social structural view. Menlo Park CA: Benjamin/Cummings; 1980.

Stryker, S.; Serpe, RT. Commitment, identity salience, and role behavior: Theory and research example. In: Ickes, W.; Knowles, ES., editors. Personality, roles, and social behavior. New York: Springer; 1982. p. 199-218.

Stryker S, Serpe RT. Identity salience and psychological centrality: Equivalent, overlapping, or complementary concepts? Social Psychology Quarterly. 1994; 57(1):16–35.

Stryker S, Serpe R, Hunt M. Making good on a promise: The impact of larger social structures on commitment. Advances in Group Processes. 2005; 22:93–123.

Syed M, Azmitia M, Cooper CR. Identity and academic success among underrepresented ethnic minorities: An interdisciplinary review and integration. Journal of Social Issues. 2011; 67(3):442–468.

Tajfel, H.; Turner, JC. The social identity theory of inter-group behavior. In: Worchel, S.; Austin, LW., editors. Psychology of intergroup relations. Chicago: Nelson-Hall; 1986.

Tsui L. Effective strategies to increase diversity in STEM fields: A review of the research literature. The Journal of Negro Education. 2007; 76(4):666–681.

United States Census Bureau. United States Census Bureau report #np2012-t6. 2012. Percent of the projected population by race and Hispanic origin for the united states: 2015 to 2060.

Vartanian T, Karen D, Buck P, Cadge W. Early factors leading to college graduation for Asians and non-Asians in the United States. The Sociological Quarterly. 2007; 48(2):165–197.

Villarejo M, Barlow A, Kogan D, Veazey B, Sweeney J. Encouraging minority undergraduates to choose science careers: Career path survey results. CBE-Life Sciences Education. 2008; 7:394–409. [PubMed: 19047426]

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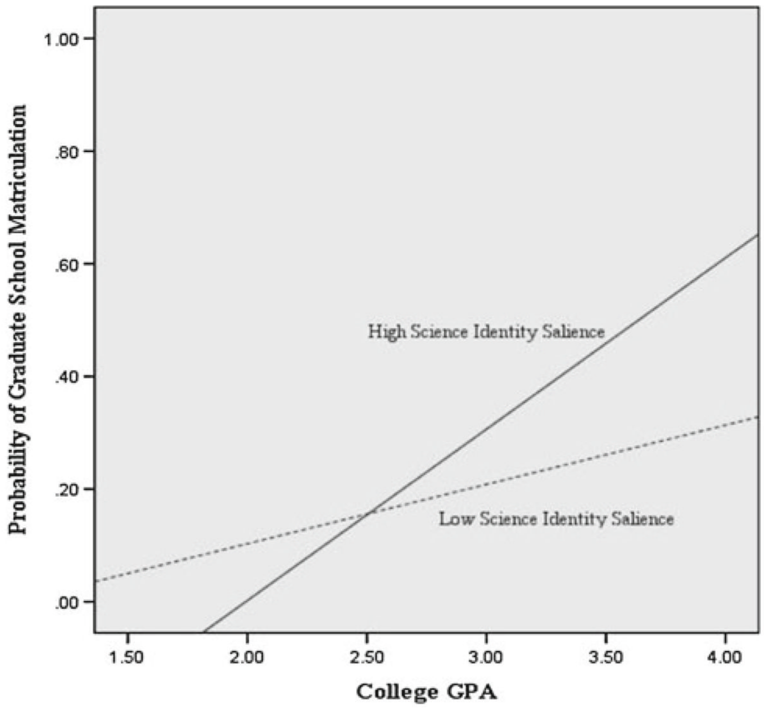

Fig. 1.
Probability of graduate school matriculation by college GPA and identity salience

Table 1

Frequency distribution for student outcomes (N = 694)

Outcome	Frequency	%
Matriculated to STEM graduate program	220	31.70
Left college for employment	336	48.41
Changed Major	137	19.74
Left college—not employed	1	0.14

Source The Science Study

Table 2

Descriptive statistics for independent variables in full sample and by graduate school matriculation status

Variable	Mean/percentage		
	Total	Did not matriculate	matriculated
	N = 694	N = 474	N = 220
Independent variable			
Program participation	23.60	21.10	29.19***
Mediating variables			
Science identity salience	7.07	6.76	7.74***
College GPA	3.29	3.24	3.39***
Research experience	43.24	36.75	57.19***
Intention for STEM career	7.38	7.00	8.00***
Faculty mentor	45.38	40.26	56.37***
Control variables			
Parents' graduate degree (1 = Yes)	22.80	21.10	26.40
Low income family (1 = Yes)	27.99	24.90	34.50**
Siblings	2.33	2.24	2.54*
English is first language (1 = Yes)	75.00	78.00	71.00
First generation student (1 = Yes)	19.00	19.00	21.00
Took AP classes	55.40	54.80	56.80
Standardized test composite	.00	.02	.05
High school GPA	3.50	3.48	3.54
Black (1 = Yes)	50.51	51.37	48.64
Hispanic (1 = Yes)	37.95	37.63	38.64
Female (1 = Yes)	71.30	63.50	69.00
Biological science major (1 = Yes)	64.94	65.55	63.60
Natural science major (1 = Yes)	22.94	21.56	25.91
Math/engineering major (1 = Yes)	2.30	2.75	1.60
Baseline intention for STEM career	8.36	8.23	8.65**
Upper division student (1 = Yes)	65.00	68.29	75.45

Source The Science Study

* $p < .05$;

** $p < .01$;

*** $p < .001$

Table 3

Correlations among STEM program participation and mediating variables (N = 694)

Variable	1	2	3	4	5	6
1. Program participation	1					
2. Science identity salience	.123	1				
3. College GPA	.144	*.013*	1			
4. Research experience	.496	.220	.163	1		
5. Intention for STEM career	.159	.307	*.040*	.207	1	
6. Faculty mentor	.512	.178	.180	.549	.223	1

Correlations in italics are not significant

Critical value for r: .088(p < .05); 115(p < .01); .146 (p < .001)

Source The Science Study

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Table 4

Coefficients and odds ratios from logistic regression model for graduate school matriculation (N = 694)

Variable	Model 1		Model 2		Model 3		Model 4	
	B	OR	B	OR	B	OR	B	OR
Independent variable								
Program participation	.009	1.01***	.008	1.01**	−.006	.99	.006	1.01
Mediating variables								
Science identity salience					.105	1.11**	−.540	.58
College GPA					.870	2.39**	−.311	.73
Research experience					.019	1.02***	.018	1.02***
Intention for STEM career					.056	1.06	.057	1.06
Faculty mentor					.003	1.00	.004	1.00
Science identity salience × college GPA							.193	1.21**
Control variables								
Parent has graduate degree (l = Yes)			.378	1.46	.257	1.29	.269	1.31
Lower income family (l = Yes)			.421	1.52*	.357	1.43	.362	1.44
Siblings			.084	1.09	.061	1.06	.064	1.07
English is first language (l = Yes)			−.189	.83	−.086	.92	−.071	.93
First generation student (l = Yes)			.104	1.11	.143	1.15	.111	1.12
Took AP classes			.090	1.09	.001	1.00	.015	1.02
Standardized test composite			.157	1.17	.100	1.11	.098	1.10
Black			−.056	.95	.213	1.24	.224	1.25
Hispanic			−.152	.86	.102	1.11	.092	1.10
Female			−.076	.93	−.125	.88	−.119	.89
Natural science major (l = Yes)			.237	1.27	.048	1.05	.008	1.01
Biological science major (l = Yes)			.075	1.08	−.005	1.00	−.014	.99
Mam/engineering major (l = Yes)			−.697	.50	−.828	.44	−.831	.44
Baseline intention for STEM career			.098	1.10 *	.025	1.03	.025	1.03
High school GPA			.290	1.34	−.004	1.00	.014	1.01
Upper division student (l = Yes)			.378	1.46	.411	1.51	.431	1.54

Source The Science Study

* $p < .05$;

** $p < .01$;

*** $p < .001$