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Priming the Pump or the Sieve: Institutional Contexts and URM STEM Degree Attainments

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Association for Institutional Research Annual Forum
June 2012
New Orleans, LA

This study was made possible by the support of the National Institute of General Medical Sciences, NIH Grant Numbers 1 R01 GMO71968-01 and R01 GMO71968-05 as well as the National Science Foundation, NSF Grant Number 0757076. This independent research and the views expressed here do not indicate endorsement by the sponsors.

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A recent report, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*, states that most of the growth in the new jobs will require science and technology skills, and that "those groups that are most underrepresented in S&E are also the fastest growing the general population" (National Academy of Sciences, 2011, p. 3). The proportion of underrepresented minorities in science and engineering would need to triple to match their share in the population. In an effort to achieve long-term parity in the preparation of a diverse workforce, they recommend a near term, reasonable goal of improving institutional efforts to double the number of underrepresented minorities receiving undergraduate STEM degrees. In February 2012, President's Council of Advisors on Science and Technology (PCAST) released *Engage to Excel*, a report that sets an ambitious goal of producing one million additional college graduates with degrees in STEM over the next decade. However, they report that currently fewer than 40% of students who enter college intending to major in a STEM field complete a degree in STEM. More importantly, some institutions are much more likely to attain this goal than others contingent on whether they are better situated to prime the pump or continue to divert talented and motivated students to other fields. Perhaps sensing government support is likely to increase, both AAU and APLU institutions have embarked on new STEM initiatives that will require assessment of success shaped by faculty and institutional contexts.

For decades, retention theorists (Astin, 1993; Bean, 1980; Spady,1970; Tinto, 1975, 1997) have collectively hypothesized that student degree progress and completion are influenced by social and academic integration within an institution. More recent integration theories have also posited other aspects of the institutional environment play a role in retention for underrepresented students such as climate and practices fostered by institutional agents (Nora, 2003, Nora, Barlow, & Crisp, 2005). Although these contributions have been substantial to examining persistence and degree attainment within a single institution, these models have under-theorized institutional differences that are of prime interest to policymakers (Titus, 2006b). Moreover, so much of the literature attributes college success in science to K-12 preparation (PCAST, 2010), and students' early interests in science. While a focus on individual motivations and abilities is important, significant postsecondary institutional factors continue to divert talented students from graduating with science majors and ultimately pursuing scientific careers.

The purpose of this study is to identify the faculty and institutional characteristics that contribute to higher rates of STEM degree completion, particularly among underrepresented group, controlling for students' entering characteristics. Our approach is distinct in that we begin with an essential premise: Institutional contexts matter, and just as great innovations are fostered in the right environment (Johnson, 2010), developing talent in science must also have the right kind of environment. Muesus (2011) conducted a qualitative study of three PWIs with high-than average URM degree productivity. He found four institutional factors play a crucial role in student success: strong networking values, commitment to targeted support for URM students, belief in a "humanizing" the educational process, and an institutional ethos of responsibility for individual student success. Hubbard and Stage (2010) identified institutions that were highly productive in URM STEM degrees using relative predictions based on origins of URM scientists. They found most of the institutions that rose to the top to be HBCUs. Perna, Gasman, Gary, Lundy-Wagner, and Drezner (2010), conducted a single-institution case study of Spelman to examine why it is successful in Black women's STEM degree attainment. They identified several important components of the environment: availability of undergraduate research opportunities, faculty encouragement, academic support resources, a cooperative peer culture, smaller class sizes and access to faculty. These studies suggest particular environments are more effective for Black students, but have not tracked individual STEM aspirants from college entry to understand how productive these types of institutions are relative to others.

However, an interesting paradox has emerged regarding selective institutions: Significantly higher retention rates for all students (controlling for student GPA and SAT scores) are evident at more selective institutions (Bowen, Chingos & McPherson, 2009), but fewer students are retained in STEM majors in the first year and to the fourth year of college (Chang, Eagan, Lin & Hurtado, 2011; Espinosa, 2011). Thus, institutions with the most student talent and institutional resources appear to produce far fewer STEM graduates than expected when one accounts for students' initial degree intentions. Bronfenbrenner's theory (1979, 1995) of human development in micro, meso, and macro contexts provides a useful multiple person-context framework for understanding that students and their interactions with faculty are situated in classrooms or interventions that are also located in distinct, normative institutional contexts. To understand how the latter supports the development of science talent, we include data on student peers, faculty attitudes and behaviors, and programmatic commitment to innovation in undergraduate science initiatives.

Key Variables Influencing Retention in STEM

Much of the research on students' likelihood of completing a degree in a STEM field focuses on individual characteristics and pre-college preparation. After considering students' experiences before and during college, research has found that a strong high school curriculum, high standardized test scores, and earning high grades in high school are the three most important predictors of completing a bachelor's degree in a STEM field (AAAS, 2001; Adelman, 2006; Bonous-Hammarth, 2000, 2006; Chang, Cerna, Han, & Saenz, 2008; Elliott, Strenta, Adair, Matier, & Scott, 1996; Museus et al., 2011; National Academies, 2011). Advanced courses in mathematics and science in particular prepare students for the rigor of college-level STEM courses and provide them with the academic confidence to be successful in college (Chang et al., 2008; Denson, Avery, & Schell, 2010; Ellington, 2006). URM students are more likely to attend under-resourced high schools (Adelman, 2006) and less likely to have access to Advanced Placement (AP) courses (May & Chubin, 2003), which Elliott et al. (1996) found to negatively predict Black students' likelihood of earning a bachelor's degree in a STEM field. STEM degree aspirations are also positively associated with likelihood of completing a STEM degree (Chang et al., 2008; Maltese & Tai, 2010), a finding with significant implications for URM students who express STEM degree aspirations at rates equal to or exceeding their White and Asian American peers.

In addition to pre-college characteristics and experiences, research on URM students in STEM looks at issues related to classroom climate and experiences of invalidation within these disciplines. Many STEM faculty utilize teacher-centered pedagogies that are distant and focused on lecture and rote memorization, often replicating the same pedagogies faculty experienced when they had been students in STEM fields (Seymour & Hewitt, 1997). Vogt (2008) found that perceived faculty distance in engineering courses negatively affected both academic confidence and self-efficacy, which then negatively impacted students' GPA. Johnson (2007b) found for women of color in the sciences that large lecture environments where asking questions was discouraged and professors often did not even recognize students in their own classes discouraged these women from persisting in the sciences. Teacher-centered pedagogies are especially evident in introductory STEM courses (referred to “gatekeeper” courses); Gasiewski, Eagan, Garcia, Hurtado, and Chang (2012) used the results of a mixed-methods study on these courses to describe a composite image of the conditions within a “gatekeeper” course, shifting the focus to the pedagogical decisions made by “gatekeeper” faculty as the source of these classroom conditions.

Researchers concerned about students’ disinterest and disengagement with STEM in college, especially that of URM students and women, have argued for a shift toward student-centered pedagogies that foster a more supportive environment and connect classroom content to its applicability in the “real world.” Several studies have pointed toward faculty concern and subsequent perceived responsibility for student success as a crucial component behind their motivation to provide a more welcoming, supportive environment (Fries-Britt, Younger, & Hall, 2010; Museus & Liverman, 2010; Perna, Gasman, Gary, Lundy-Wagner, & Drezner, 2010). These studies also identified faculty efforts to create more collaborative as opposed to competitive environments as important, especially for women and URM students. Connecting content to its application in professional contexts or demonstrating its relevance to students’ lives or values has also been shown to improve the STEM classroom experience. Davis and Finelli (2007) found incorporating “real world” context to an introductory engineering computing course reduced the grade gap between White and Asian students and their URM peers as well as between men and women. They also found incorporating service-learning into an introductory engineering course increased students’ satisfaction with the course, an important finding with implications for the altruistically-motivated scientist (Carlone & Johnson, 2007). Finally, researchers have argued that collaborative learning, as opposed to the traditional passive approach in STEM classrooms, retains students’ interest and motivation in their classes and improves educational outcomes (Cabrera, Crissman, Bernal, Nora, Terenzini, & Pascarella, 2002). Continued introduction of student-centered pedagogies improves the classroom environment for all students, especially women and URM students, in the crucial early years when students primarily take introductory courses (Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012).

In addition to faculty who utilize student-centered pedagogies, faculty who engage students, especially URM students, in research as undergraduates make a positive difference in students' likelihood of completing a STEM degree. Undergraduate research experiences enhance students' science identity (Hurtado et al., 2009) and provide students with an idea of what a scientific research career entails (Kinkead, 2003; Lopatto, 2004). Espinosa (2011) found participation in undergraduate research was positively related to retention in a STEM degree for women of color, and Jones, Barlow, and Villarejo (2010) observed that participation in undergraduate research was especially significant for Hispanic and African American students toward biology degree completion in their study of one minority STEM retention program at a research university. Research experiences also strengthen students' commitment to graduate study (Kardash, 2000; Sabatini, 1997; Strayhorn, 2010) and increase their likelihood of enrolling in graduate school (Barlow & Villarejo, 2004; Bauer & Bennett, 2003; Eagan et al., 2010).

While most researchers agree that undergraduate research experiences are a crucial tool institutions can utilize to improve STEM degree completion rates, some scholars have argued that this success is potentially conditional. Schwartz (2012), studying the nature of faculty-student mentoring relationships within undergraduate research experiences at a technical college offering two-year science degrees, found that while participation in undergraduate research did positively benefit the students of color who participated, these benefits came at tremendous emotional, professional, and financial costs to the faculty involved. Schwartz cautioned that, at institutions with low commitments to research, faculty may find the costs to themselves to be so great as to outweigh the benefits their students receive from participation. Taraban and Logue (2012) argued that the benefits of undergraduate research experiences are possibly conditional themselves; in their study of a large public research university, they found these benefits, measured as five constructs representing cognitive outcomes, depended on students' GPA, level of participation in research, and number of credits completed. In particular students with lower GPAs and lower participation in research experienced a decline in benefits from research participation as they continued through college while their peers with higher GPAs and greater participation experienced an increase in benefits. Jones, Barlow, and Villarejo (2010), in their aforementioned study, also examined the timing and duration of research participation in their study and found participation early in college and for longer periods of time led to higher probabilities of persistence and performance in biology. Increasing the duration and early student participation in undergraduate research would require more pervasive use of this practice among faculty at an institution, extending beyond programs that are only able to serve limited numbers of targeted students. The current study examines differences between institutions in degree attainments and the pervasiveness of STEM faculty involvement in undergraduate research, as some institutions may be closer to making such opportunities widely available to STEM aspirants.

In addition to undergraduate research opportunities, many universities provide targeted retention programs that focus either on STEM students or URM students as a way to increase students' likelihood of completing a STEM degree. Often undergraduate research is integrated into these programs (Jones, Barlow, & Villarejo, 2010). Targeted retention programs provide a space for students to develop peer support networks as well as STEM-related extracurricular activities, two factors that positively contribute to the retention of URM students in STEM degree programs (Palmer, Maramba, & Dancy, 2011). Several studies have highlighted individual retention programs that have improved STEM educational outcomes for URM students. Barlow and Villarejo (2004) found an academic intervention program for URM biology majors at a large, public research university improved participants' persistence in math and science courses and their probability of graduating with a biology degree. In particular, they found the incorporation of undergraduate research into this program to even more significantly raise graduation rates (also Jones, Barlow, & Villarejo, 2010). Slovacek, Whittinghill, Flenoury, and Wiseman (2012) confirmed these findings for students of color in science at a public master's comprehensive university—participation in a targeted retention program improved students' GPAs and likelihood of science degree completion—and Allen and Bir (2011) found a summer bridge program at an HBCU improved students' first-year retention and GPAs, though the program was not STEM-specific. A few studies, however, reached a different conclusion regarding the impact of retention programs on students' academic performance. Johnson (2007a), in a study of a minority science retention program at a large public research university, and Good, Halpin, and Halpin (2002), in a study of African American engineering students in a minority engineering retention program, both found participation in these programs improved students' likelihood of degree completion but did not find any impact on GPA. Regardless, these studies demonstrate how URM-targeted retention programs can play an important role in URM STEM retention and degree completion.

Studies that consider the institutional context for predicting general bachelor's degree completion typically include traditional institutional characteristics such as size, control, selectivity, and institutional type. The size of an institution is generally negatively related to degree completion (Oseguera, 2005); this is likely due to the impersonal nature of a large campus, especially with regard to the opportunity for student-faculty interaction. For URM students, student-faculty interaction with faculty of similar racial and ethnic backgrounds is an important factor in persistence and retention—Hubbard and Stage (2010) found predominantly White institutions with higher proportions of racial/ethnic minority faculty were significantly more likely to produce equitable educational outcomes among URM students and their White and Asian peers. Institutional control has also been shown to be a significant factor; students attending private institutions are more likely to complete bachelor's degrees than their peers at public institutions (Oseguera, 2005), and women are more likely to be retained in STEM programs in private as opposed to public institutions (Espinosa, 2011). Espinosa also found that women of color were more likely to be retained in STEM programs when attending institutions with higher proportions of STEM majors overall. As the probability of completing a bachelor's degree in general and completing a STEM bachelor's degree in particular varies by institutional characteristics, faculty and administrators at different types of institutions face a variety of considerations when implementing strategies to improve degree completion.

Selectivity has been found to have a positive impact on students' likelihood for bachelor's degree completion. Alon and Tienda (2005) tested the "mismatch" hypothesis and found that students who enrolled in more selective institutions had a higher likelihood of attaining a college degree, a finding confirmed by other scholars with a variety of nationally-based samples of college students (Titus, 2004, 2006b; Kim, 2007; DeAngelo, Franke, Hurtado, Pryor, & Tran, 2011). Studies have also found higher tuition to be directly related to higher graduation rates (Dowd, 2004; Titus, 2006a), though higher tuition may be a proxy for selectivity as more selective and elite institutions charge students higher tuition. Related to tuition, level of expenditures, particularly per-student expenditures, have been found to increase probability of graduation as well (Cragg, 2009; Gansemer-Topf & Schuh, 2006; Oseguera, 2005; Titus, 2006a), though, again, expenditures per capita reflect institutional resources, and thus is another proxy for selectivity as more selective and elite institutions tend to have higher levels of resources.

Similar to the results for all students, selectivity has been found to positively impact URM students' likelihood for bachelor's degree completion. Bowen and Bok (1998) studied a number of outcomes for Black undergraduates who attended elite institutions and found that enrollment at highly selective institutions predicted an increased likelihood of degree completion, higher future earnings, enhanced leadership outcomes, and improved satisfaction with the college experience. Melguizo (2008) also found that African American and Hispanic students are more likely to complete bachelor's degrees at more selective institutions, and confirmed this finding for students of color in the Gates Millennium Scholars program (Melguizo, 2010). All of these studies used single-level analytical models, however, potentially mis-estimating the effects of selectivity.

Despite the positive effects of selectivity on degree completion, this finding may not apply to retention and degree completion in STEM fields. For instance, Espinosa (2011) found selectivity was negatively related to retention in STEM fields for women of color to the fourth year of college. Chang, et al., (2008) found that students attending more selective institutions were slightly but significantly more likely to depart from biomedical and behavioral sciences majors in their first year of college than their peers attending less selective universities. This finding was further supported in a subsequent multilevel study of all URM STEM aspirants to the fourth year of college (Chang, et al., 2010)—they were less likely to be retained in STEM majors at more selective institutions. Although these studies employed multilevel models, neither of these studies could be extended to the fifth or sixth year of college to determine if students actually completed STEM degrees. Smyth and McArdle (2004), analyzed the College and Beyond data (Bowen and Bok, 1998), retesting earlier findings of the original authors by employing multilevel models and found selectivity made no difference in STEM degree completion; they concluded single-level models overestimate the effects of selectivity. Although these studies captured important long-term outcomes (beyond the sixth year), the difficulty is that both rely on a data base that had only four public institutions of moderate selectivity among 24 elite private liberal arts colleges and universities.

Bowen, Chingos, & McPherrson’s (2009) subsequent study corrected for this limitation by focusing primarily on variation of completion rates among 21 public research intensive universities and 28 state system institutions. They found that Black, Hispanic, and low-income students are more likely to complete their degrees at selective institutions. The effects of attending a selective institution were even higher for Hispanic students, and they conclude there is a massive under-match problem—where these students attend lower selectivity institutions than they are qualified to attend that also result in lower rates of completion. While they did not study STEM by race/ethnicity, they found 67% of life sciences majors, 58% of math and physical science majors, and 44% of engineers completed their degrees in four years. An additional 48% of engineers completed their degree in five years, and this is the highest percentage compared with students in all other fields of study. Thus, time to degree varies across all fields but is also evident among students in STEM. The current study addresses time to degree, baccalaureate completion, and completion in STEM fields.

Tracking STEM Aspirants Over Time

A key feature of our study is that we began tracking the cohort who entered as freshman in 2004 through degree completion. For every institution where there was a URM STEM degree aspirant, we also tracked non-URM degree aspirants (White and Asian) at over 600 institutions that participated in The Freshman Survey, administered through the Cooperative Institutional Research Program at the Higher Education Research Institute (HERI). These data were subsequently merged with student level data from the National Student Clearinghouse in 2010 and 2011. As a backdrop to the study, we provide completion rates for aspiring scientists based on these data.

Figure 1 shows the degree completion rates of STEM aspirants based on four, five, and six year degree completions in STEM. Overall, less than a quarter (22%) of STEM aspirants completed a degree in four years, nearly 36% completed in five years, and 40.4 % finished in six years. Asian Americans, however, had the highest completion rates, as 29% completed in four years and over half (52.4%) completed a STEM degree in six years. By contrast, only 9% of African Americans and about 12% of Latina/o and Native Americans completed a STEM degree in four years. However, by the fifth year, twice as many URMs completed a STEM degree. This finding may have much to do with the type of STEM degree, as engineers typically take five years. By the sixth year, 29% of Latina/os, about one quarter of Native Americans, and 21.8% of African Americans completed a STEM degree. It remains important to investigate both the entering characteristics of students and also institutional contexts that lead to degree completion, which is the focus on this multi-institutional study.

---Insert Figure 1 about here---

Method

Data

This study examines the individual characteristics and college contexts that jointly predict students' completion of a bachelor's degree in STEM relative to not completing a degree or completing a bachelor's degree in a non-STEM field. Drawing from a national sample of students and institutions, we analyzed the student- and institution-level predictors of students' likelihood to complete a bachelor's degree in STEM within five years of entering college. Our baseline sample came from the Cooperative Institutional Research Program's (CIRP) 2004 Freshman Survey, which was administered by the Higher Education Research Institute (HERI). In 2004 during orientation or the first few weeks of the fall term, more than 420,000 first-time students 720 colleges and universities completed a four-page questionnaire that asked them about their demographic and academic backgrounds, their high school activities, their educational and career ambitions, and expectations of college. The National Institutes of Health (NIH) provided funds to target minority-serving institutions and institutions with NIH-sponsored undergraduate research programs to expand the traditional sample of colleges and universities that participate in the Freshman Survey. These funds provided an opportunity to administer the Freshman Survey to campuses that typically do not collect such data on their students.

In 2010 we collected degree and enrollment data for this baseline sample from the National Student Clearinghouse (NSC). The NSC has collected enrollment and completion data on students for 15 years, and currently more than 3,700 colleges and universities in the U.S. provide data to the NSC. These data from the NSC provided information about students' enrollment patterns, whether they completed a degree within six years of enrollment, and the discipline of their degree. Merging respondents from the 2004 Freshman Survey with data from the NSC resulted in a dataset containing 210,056 first-time, full-time students from 361 colleges and universities. From this sample, we identified all students who reported on the 2004 Freshman Survey that they intended to major in a STEM discipline (see Appendix A for all majors defined as STEM), which included 63,031 students across 361 four-year colleges and universities. Not all institutions that participate in the NSC provided degree information that includes the discipline of students' degree; thus, after removing cases that did not include discipline, our sample was further reduced to 58,292 students across 353 institutions.

To supplement the student-level data, we incorporated several additional datasets that provided information about the institutional context students encountered. Throughout 2011 we administered a survey of Best Practices in STEM (BPS) to STEM deans and department chairs at institutions in our student sample. The BPS survey collected information about the extent to which campuses provided undergraduate research opportunities, outreach and retention programs to targeted groups, faculty development programs for STEM faculty, and the funding sources of these programs. Additionally, we aggregated data from the 2007 and 2010 administrations of the CIRP Faculty Survey to provide contextual information about faculty attitudes and instructional strategies on each campus. Faculty provided information about the extent to which they engaged undergraduates in research, used student-centered pedagogy in their courses, and graded on a curve, among other measures. We merged in institutional characteristics from the Integrated Postsecondary Educational Data System (IPEDS) and aggregated several student-level variables to the institution.

When combining with the 2004 Freshman Survey responses, the 2010 NSC data, and the various sources providing contextual information about campuses environments, we had a large, unique, and unprecedented dataset to examine STEM completion. After accounting for non-response to the BPS and faculty surveys, our final analytic sample included 54,562 STEM aspirants across 293 four-year colleges and universities. In addition to examining STEM completion likelihoods of all students, we also examined STEM completion rates among URM students. The URM dataset included 8,852 Black, Latino, and Native American STEM aspirants across 273 institutions.

Variables

Student-level characteristics. The dependent variable in this study was a three-part categorical variable corresponding to students' degree status four, five, and six years after enrolling in college: completed a STEM bachelor's degree, completed a bachelor's degree in a non-STEM field, or had not completed a degree. We derived this dependent variable from NSC data by cross-referencing students' bachelor's degree status (i.e., graduated or not graduated) with their bachelor's degree major. In the analyses, we used "completed a STEM degree" as the reference group so that we can compare STEM degree graduates to non-STEM graduates and to students who were either still enrolled or had left their original institution. Thus, the dependent variables model potential institutional accountability for STEM productivity. .

The analyses accounted for several student-level independent variables, including demographic characteristics, prior academic preparation, educational and career aspirations, and pre-college experiences. (Appendix B contains the variable and scales in our analyses). Among the demographic characteristics, we included dummy variables representing Black, Asian American, Latino, and Native American with White as the reference group. We also accounted for gender (male as the reference group) and father's education, and we included several dummy variables representing family income (middle income as the reference group). We measured prior academic preparation with several variables: high school GPA, standardized test scores (SAT composite with ACT equivalent conversions), and the years of study students completed in high school in biological science and mathematics. We included several high school experiences in the model to examine the relationship between STEM completion and the frequency with which students felt overwhelmed by all they had to do, socialized with a student from a different racial or ethnic group, and the hours per week they spent studying or doing homework in high school.

We also examined a set of aspirations and expectations students had upon enrolling in college. We considered whether they expected to transfer to another institution as an indicator of initial student commitment. Additionally, the model accounted for two constructs representing students' academic self-concept and social self-concept at college entry, constructs created using Item Response Theory techniques (Sharkness et al., 2010). The model included dummy variables representing students' aspirations for a medical degree, Ph.D. or Ed.D., masters degree, and law degree with bachelor's degree as the reference group. Given Carlone and Johnson's (2007) work on the importance of having a strong identity in science, we included a factor representing students' STEM identity at college entry. We created this construct using principal axis factoring with promax rotation, and the items comprising this factor included the following four items: goal of wanting to make a theoretical contribution to science, wanting to be recognized as an authority in the field, wanting to be recognized for contributions to the field, and wanting to find a cure to a health problem. Chang et al. (2011) provide additional information about this factor and found a positive relationship between STEM identity and first-year biomedical and behavioral science major persistence. Finally, the last set of predictors included at the student level included dummy variables representing students' intended major, and biological sciences aspirants comprised the reference group.

Institution-level characteristics. The analyses also accounted for a number of institutional characteristics and opportunities available to undergraduate students in STEM. For example, we control for institutional selectivity, control, and whether the institution is classified as an HBCU. We measured selectivity as the average SAT scores (or ACT-equivalent scores) of entering students in 2004 and re-scaled this variable so that a one-unit change corresponds to a 100-point change in average SAT scores. We used dichotomous variables to represent an institution's status as private (compared to public) and an HBCU (compared to a PWI or Hispanic-Serving Institution). We also examined the predictive power of Carnegie classification (liberal arts and research institutions compared with masters comprehensive) and size of peer cohorts in STEM using the proportion of undergraduate students in STEM disciplines.

To provide information about how completion in STEM may be influenced by the faculty campus context, we aggregated several variables from the 2010 and 2007 CIRP Faculty Survey. Given the importance of authentic discovery experiences in college (PCAST, 2012), we examined the relationship between STEM completion and the percentage of faculty who involve undergraduate in their research. Additionally, we considered aggregate STEM faculty pedagogical practices, including the proportion of STEM faculty who grade on a curve and faculty's use of student-centered pedagogy. The latter represents a construct of several items describing professors' instructional strategies in the classroom (See Higher Education Research Institute, 2011), including faculty's use of class discussions, cooperative learning, experiential learning, and group projects, among other techniques.

In addition to data from IPEDS and the CIRP Faculty Survey, we aggregated variables from the student data and incorporated measures from the BPS survey reported by deans and department chairs. From the BPS survey, we included four items in the model representing the extent to which institutions offered undergraduate research opportunities to freshmen, provided targeted financial aid to STEM students, administered high school STEM outreach programs, and provided research opportunities to all undergraduates. To capture the peer environment, using the student data, we created a measure representing the proportion of students aspiring to a medical degree.

Analyses

Before handling cases with missing data or running univariate or multivariate statistics, we weighted the data to represent a national sample of full-time, first-time entering STEM aspirants in 2004. This weighting scheme involved a three-step process. First, we weighted students within institutions by gender so that the male and female respondent counts matched the population of first-time, full-time men and women within each institution. Second, to address non-participation by institutions in the U.S., we weighted by gender within each stratification cell. Finally, the two weights were multiplied so that, when applied to the data, the weighted sample represented the population of first-time, full-time students who entered college in the U.S. in 2004. See DeAngelo et al. (2011) for additional information about the weighting procedure).

After weighting the data, we addressed cases with missing values by using multiple imputation. Missing data provide a source of variation (Sinharay, Stern, & Russell, 2001), and providing a single imputation for missing values does not account for this possible variance. Little and Rubin (2002) suggest that multiple imputation provides a more precise estimate of standard errors of parameter estimates. We used the multivariate normal approach available in STATA 11 to execute the multiple imputation procedure. DeAngelo et al. (2011) provide additional details about the multiple imputation procedure.

We examined our data with univariate descriptive statistics after addressing issues with missing data. Next, we analyzed the data using multinomial hierarchical generalized linear modeling (HGLM). Multinomial HGLM represented the most appropriate analytic technique given our categorical, unranked outcome and the clustered nature of our data. Multinomial HGLM partitions the variance between individuals (students) and groups (institutions) in analyses with multi-level data and a categorical outcome variable (Raudenbush & Bryk, 2002). Studies that employ single-level statistical techniques, such as logistic regression, on multi-level data do not account for the unique clustering effect of the complex sample design, which increases the risk of making a Type I statistical error by erroneously concluding the significance of a parameter estimate (Raudenbush & Bryk).

To justify the use of multinomial HGLM, the outcome variable must vary significantly across groups. We examined null models (i.e., models without any independent variables) to examine the extent to which our outcomes of four-, five-, and six-year STEM completion varied across institutions. These null models showed that the between-institution variance component in the outcome significantly varied cross institutions. Given this significant variation and our interest in the examining how institutional contexts both directly affect students STEM completion likelihood and moderate individual-level relationships, we proceeded with the use of multinomial HGLM.

Limitations

While the longitudinal assessment of STEM degrees is extremely useful, several limitations are in order. First, student aspirants in STEM in 2004 may have been less sure about their major but simply may have had good experiences in STEM in high school. Only in particular fields can we be more certain that students were on the science-track. For example, entering engineering aspirants are likely to have been admitted to Schools of Engineering when they took the 2004 survey. In the particular case of physics, chemistry, or mathematics aspirants, fewer students initially choose these intended major categories and are less likely to choose these on a whim. We simply have to take students on their word regarding their initial interests, although participating institutions in the Freshman Survey can also do a check regarding institutional records that collect these data. We encourage institutions to use that information whenever possible to merge with National Clearinghouse data to evaluate their own STEM productivity. A second limitation is that the 2010-11 NCS data had not captured students' term-to-term academic major. NCS is beginning to collect such information now, which will allow improved accuracy of understanding the mobility and sustained commitment to STEM among students in higher education.

A third limitation is that, ideally, longitudinal studies will include college experience data. Other college experience studies have used smaller scale studies on retention in STEM (Chang et al., 2010; Espinosa, 2011), but the downside is that data could only be collected to the fourth year of college and on a smaller sample size that would not easily permit differences by race and intended major. Instead, we have opted to capture conditional effects based on institutional differences with a larger sample size. The present study focused on the individual level and macro-level phenomenon in Bronfrenbrenner's framework and provides a substantial backdrop for investigating mezzo-level experiences with faculty and peers, in and out of the classroom, and program effects in the future.

The study is also limited by its use of secondary data analysis, as we are limited by the variables and their definitions on the 2004 CIRP Freshman Survey. Specifically, the 2004 Freshman Survey lacked important measures of academic preparation, including the types of math courses taken and the extent to which students completed Advanced Placement or honors courses in high school. Additionally, 89% of Deans and Department chairs responded to the BPS survey, which required us to eliminate approximately 30 campuses and 2,000 students from our initial STEM student sample. Similarly, approximately 20 institutions did not participate in either of the HERI Faculty Surveys, which required us to eliminate those colleges and universities and the roughly 1,000 students enrolled at those campuses.

Finally, because we surveyed all STEM deans and department chairs within our institutional sample, we had many institutions that contained more than one response about the extent to which they provided various opportunities to students and faculty. Given the potential variation with these responses within institutions, we conducted sensitivity analyses in our statistical modeling. We analyzed three separate institutional models: the lowest value for each BPS response within an institution; the average value for each BPS response within each institution; and the largest value for each BPS response within each institution. We found similar results across the three different datasets (least, average, greatest); thus, the results we report in our findings correspond to the model choosing the average values from the BPS variables.

Results

Descriptive Statistics

Appendix C provides descriptive statistics for variables in the model, and the results show that 21.9% of STEM aspirants earned a STEM degree in four years, 35.9% in five years, and 40.5% in six years. Additionally, 13.7% of STEM aspirants earned a bachelor's degree in a non-STEM field within 4 years, 23.3% within five years, and 26.8% within six years. The racial breakdown of the sample included 2.2% Native American, 11.4% Black, 6.8% Latino, 13% Asian American or Pacific Islander, and 64% White. The sample included slightly more men

(51.2%) than women. Roughly 23% of students reported having medical degree aspirations with 22% of STEM aspirants planning to pursue a Ph.D. or Ed.D. Students had strong pre-college preparation, as the average composite SAT score was 1180, and students averaged four years of math in high school and roughly two years of biology.

STEM Completion versus Non-STEM Completion-All Students

Table 1 shows the HGLM results for STEM completion compared to non-STEM completion across four, five, and six years. We present and interpret the results such that higher scores on the independent variable reflect increased probabilities of earning a STEM bachelor's degree relative to a bachelor's degree in a non-STEM field. We report delta-p statistics for only those coefficients significant at the $p < 0.05$ threshold (Petersen, 1985; Cruce, 2009). We begin with the four-year results and then discuss how the five- and six-year results compare to the four-year benchmark.

Four-year completion. Two institutional variables significantly predicted students' likelihood to earn a bachelor's degree in STEM relative to a bachelor's degree in a non-STEM field within four years. Greater concentrations of students planning to pursue a medical degree predicted significantly lower likelihoods of earning a STEM degree within four years. Specifically, a 10 percentage point increase in the proportion of premedical undergraduates predicted a 2.4 percentage point decrease in STEM aspirants' likelihood to graduate with a STEM degree relative to a non-STEM degree. Additionally, students enrolled at larger institutions had significantly lower probabilities of earning a four-year STEM bachelor's degree. A 10% increase in the number of undergraduate full-time equivalent (FTE) students at an institution predicted an 8.8 percentage point drop in students' probability of earning a STEM degree. Thus, the size and character of the college peer group has distinct effect on completing a STEM degree.

In addition to the institutional variables, several background characteristics significantly predicted STEM aspirants' probability of earning a STEM degree compared to a degree in a non-STEM field. Latino students were 4.6 percentage points less likely than their White counterparts to complete a four-year STEM degree. By contrast, Asian American and Pacific Islander students had a significantly higher likelihood of completing a STEM degree relative to their White classmates (6.9 percentage points). It is important to note also, all things being equal, that Black students were not significantly more or less likely to complete in STEM than White students.. Students who marked "other race" were 7.4 percentage points more likely than White students to earn a STEM bachelor's degree in four years. Gender also had a significant relationship with four-year STEM completion, as women were 4.5 percentage points less likely than men to complete a STEM degree; although this effect varied significantly across institutions, we did not detect a moderating effect from institutional selectivity. Finally, native English speakers had an 8.6 percentage-point lower probability of earning a STEM bachelor's degree relative to their non-native English-speaking peers. This may well be a proxy for foreign students in the freshman class, many of which come to the U.S. motivated to succeed with specific career goals.

Students' pre-college preparation significantly predicted their likelihood of completing a STEM degree in four years. For every one-unit increase in students' high school grade point average, they experienced a 5.5 percentage point increase in their probability of earning a STEM bachelor's degree. This effect varied significantly across institutions, and we found that being at an institution where faculty relied more heavily on student-centered pedagogies significantly enhanced the relationship of high school GPA and STEM completion. In other words, high-achieving STEM aspirants were even more likely to complete in STEM when they encountered a campus context that emphasized student-centered pedagogy. Additionally, every 100-point increase in students' SAT composite scores translated into a 5.3 percentage point increase in their probability of completing a bachelor's degree in STEM within four years. Similarly, taking more years of math and biology in high school as predicted significantly higher rates of STEM completion in four years.

Two of the three pre-college experiences tested in the model exerted a significant influence on STEM completion. Students who reported feeling more overwhelmed by all they had to do in high school had significantly lower STEM completion probabilities. By contrast, spending more time studying and doing homework in high school predicted an increased likelihood to complete a STEM bachelor's degree relative to a non-STEM degree.

Students' entering aspirations and expectations for college had particular salience in predicting whether they earned a four-year bachelor's degree in a STEM field or a non-STEM field. Having a strong academic self-concept predicted a significantly increased likelihood of earning a four-year STEM degree; every one standard deviation (S.D.=10) increase in students' academic self-concept predicted a seven percentage point increase in students' probability of earning a STEM degree. By contrast, having a stronger social self-concept predicted significantly lower STEM completion probabilities. Each standard deviation increase of social self-concept predicted a 7 percentage point decrease in students' probability of earning a STEM degree.

Students who reported aspirations for a medical degree were 12.4 percentage points more likely to complete a STEM degree in four years compared to their peers who indicated aspirations for a bachelor's degree, and this effect varied significantly across institutions.

Premedical aspirants enrolled at institutions where faculty more regularly graded on a curve were significantly less likely to earn a STEM degree compared to their premedical peers at institutions where curve grading was utilized less frequently. Likewise, premedical students attending more selective institutions had significantly lower STEM completion rates than their peers at less selective institutions. For every 100-point increase in average SAT scores at an institution, premedical students experienced a 3.8 percentage point decrease in their probability to complete a STEM degree within four years. Students with aspirations for a Ph.D. or Ed.D. were 5.8 percentage points more likely to earn a STEM bachelor's degree compared to their classmates who reported having bachelor's degree aspirations. By contrast, STEM aspirants with plans for a law degree had a 24 percentage point lower probability of completing in STEM relative to their peers with bachelor's degree aspirations. Finally, students who had a stronger STEM identity upon college entry had an increased likelihood of earning a STEM degree in four years. Specifically, a one standard deviation increase in students' STEM identity predicted a 1.4 percentage point increase in their probability to earn a STEM degree relative to a non-STEM bachelor's degree.

Finally, we saw significant variation in STEM completion across intended STEM major. Engineering students were 14 percentage points more likely to earn a STEM degree in four years relative to their peers in the life sciences. Similarly, students in the physical sciences had a 5.5 percentage point advantage in their STEM completion probability compared to those in the life sciences. Nursing and health technology aspirants were 23.6 percentage points more likely than their classmates in the life sciences to complete a STEM degree in four years. Students planning to major in computer science were 10.4 percentage points more likely to earn a STEM degree in four years, and students intending to pursue a major in pre-med, pre-pharmacy, pre-dental, or pre-vet were 6.5 percentage points less likely to complete a STEM degree in four years compared to their peers in the life sciences.

Five-year completion. Many of the same variables that predicted completing a STEM degree relative to a non-STEM degree in four years had similar predictive power when considering five-year completion. Size of the undergraduate institution had a notable drop in predictive power, as a 10% increase in the number of FTE undergraduates corresponded with a 6.3 percentage point drop in students STEM completion probability. Whereas Latino students were significantly less likely than their White classmates to complete a STEM degree in four years, we detected no significant differences in STEM completion between Latino and White students after five years. Students who marked “other race” increased their advantage in STEM completion over White students, as their probability increased from 7.4 percentage points after four years to 9.7 percentage points after five years.

SAT composite scores became slightly less salient in predicting five-year STEM completion. Whereas a 100-point increase in composite SAT scores predicted a 5.3 percentage point increase in students’ four-year STEM completion probability, a 100-point increase in SAT scores predicted a 4.4 percentage point increase in STEM completion likelihood after five years. We detected similar, albeit slightly smaller, drops in the predictive power of years of high school math and biology.

The strength of the relationship between aspiring for a medical degree and completing in STEM decreased from four to five years, as those students with medical degree aspirations were 10.2 percentage points more likely to complete a STEM degree within five years. Similarly, the magnitude of the effect of planning to pursue a law degree on STEM completion declined from four to five years, as those students with law degree aspirations were 18.5 percentage points less likely to earn a five-year STEM degree. Engineering students increased their STEM completion advantage over their peers in the life sciences, as they were 17.6 percentage points more likely to earn a STEM degree after five years. By contrast, the advantage for physical science, health technology and nursing, and computer science aspirants declined relative to their classmates in the life sciences.

Six-year completion. Partly due to the fact that the STEM completion rates from five to six years only increased by approximately five percentage points, the predictive power of most variables remained consistent when analyzing students' six-year completion likelihoods. The salience of institutional size continued to decline, as a 10% increase in the number of FTE undergraduates translated into a 4.1 percentage point drop in students' probability of earning a STEM degree. Also, women went from being 4.5 percentage points less likely than men to complete a STEM degree in four year to being just 2.1 percentage points less likely than men to complete in six years. Additionally, we found that women at more selective institutions are significantly less likely to complete a STEM degree within six years. Specifically, for every 100-point increase in institutional selectivity, women experience a 1.4 percentage point decline in their STEM completion probability. Similarly, the predictive power of medical degree aspirations dropped when considering that variable's relationship with six-year STEM completion. Medical degree aspirants were 8.9 percentage points more likely than their peers with bachelor's degree aspirations to complete a STEM degree in six years. The salience of curve grading also declined for medical degree aspirants between the four- and six-year models.

STEM Completion versus No Completion

Four-year completion. Table 2 shows the results of the HGLM analyses comparing STEM completion with students who were not completing a bachelor's degree for four, five, and six years. Students enrolled at private colleges and universities had a 15.3 percentage point advantage over their peers in public institutions in their STEM completion probability. STEM aspirants who attended research institutions were 7.6 percentage points less likely to complete a STEM degree in four years compared to their counterparts at masters comprehensive universities. By contrast, students enrolled at institutions where more faculty involved undergraduates in their research had significantly increased probabilities of earning a STEM degree. Denser concentrations of STEM undergraduates predicted significantly lower STEM completion rates, as a 10 percentage point increase in the proportion of undergraduates in STEM majors predicted a 2.8 percentage point drop in students' likelihood of completing a STEM bachelor's degree in four years (an affect that is not significant at five and six-year completion data). Larger institutions had significantly better STEM completion rates than smaller institutions, as a 10% increase in the number of undergraduate FTE students corresponded to a 4.1 percentage point increase in institutions' STEM completion rate. Finally, more selective institutions had significantly higher STEM completion rates than less selective institution, as a 100-point increase in institutional selectivity translated into a 10.8 percentage point increase in students' probability of earning a bachelor's degree in STEM relative to no bachelor's degree.

Nearly all of the background characteristics tested in the model had a significant influence on four-year STEM completion. URM students had significantly lower probabilities of earning a STEM degree within four years compared to their White peers. Specifically, Native American students were 8.6 percentage points less likely, Latino students were 5.3 percentage points less likely, and Black students were 14.4 percentage points less likely than White students to earn a STEM degree in four years. The effect associated with Blacks is dependent upon context, as Black students at HBCUs fared significantly better than their Black peers at predominantly White institutions and Hispanic serving institutions. Specifically, Black students at HBCUs were 11.3 percentage points more likely to complete a STEM degree within four years relative to their Black classmates at non-HBCUs. Asian American students (delta-p = 3.1%) and students marking “other race” (delta-p=4.3%) were significantly more likely than White students to complete a STEM degree within four years. Women had a 5.7 percentage point edge over men in terms of their four-year STEM degree completion probability. Native English speakers had a 3.8 percentage point lower probability of completing a STEM degree compared to non-native English speakers.

In addition to race and gender, income had a significant influence on students’ likelihood of earning a STEM degree within four years. Students from families making under $25,000 were 4.1 percentage points less likely to complete a STEM degree compared to students with family incomes between $50,000 and $99,999. Similarly, students from families earning between $25,000 and $49,000 had a 2.4 percentage point lower probability of earning a STEM degree within four years. Coming from a family making between $100,000 and $199,999 gave students a 1.8 percentage point advantage in their likelihood of earning a STEM degree relative to their peers in the middle income category. In addition to income, we found that father’s education significantly and positively predicted students’ STEM completion likelihood.

Students’ prior preparation and pre-college experiences significantly predicted their probabilities of completing a STEM degree within four years. Earning higher high school grades predicted a significantly greater likelihood of earning a STEM degree. Similarly, higher SAT scores improved students’ chances of completing a STEM degree, as a 100-point increase in students’ composite SAT scores predicted a 4.6 percentage point increase in their probability of completing a STEM bachelor’s degree in four years. Taking more years of math and science in high school made students significantly more likely to earn a STEM degree. Students who felt overwhelmed in high school or reported more frequently socializing with others from a different racial or ethnic group had significantly lower probabilities of earning a STEM degree within four years. By contrast, students who spent more time studying and doing homework in high school had significantly better odds of completing a STEM degree.

Having high educational expectations upon college entry predicted significantly greater odds of completing a STEM degree in four years. Students who planned to pursue a medical degree were 6.1 percentage points more likely to earn a STEM degree compared to their peers who aspired to a bachelor's degree; however, we found that this effect varied across institutions. Medical degree aspirants attending campuses where faculty more frequently graded on a curve had lower STEM completion likelihoods. By contrast, medical degree aspirants at more selective institutions had significantly higher probabilities of completing a STEM degree. Students with plans for a masters degree had a 2 percentage point probability advantage over their classmates who aspired to a bachelor's degree. Although respondents with aspirations for a Ph.D. or Ed.D. did not significantly differ from their peers with bachelor's degree aspirations, the findings show that those students with law degree plans had an 8.8 percentage point lower probability of earning a STEM degree within four years.

A few other aspirations and expectations predicted students' likelihood of earning a four-year degree in STEM relative to not earning a bachelor's degree. Students expecting to transfer to another college had a 1.7 percentage point lower probability of earning a STEM degree in four years. By contrast, respondents with a stronger academic self-concept had a significantly higher likelihood of completing a four-year STEM degree, as a one standard deviation increase in academic self-concept corresponded to a 4 percentage point increase in students' STEM completion probability. Respondents with higher scores on social self-concept were significantly less likely to earn a STEM degree, as a one standard deviation in this construct translated into a 2 percentage point lower probability of completing a degree in STEM. Students who planned to live on campus during college had a 3.5 percentage point higher probability of completing a STEM degree.

Finally, the results show that students' intended major significantly affected their likelihood of earning a STEM degree in four years. Engineering aspirants were 7.5 percentage points less likely than their peers in the life sciences to complete a STEM degree in four years. Likewise, students planning to pursue pre-med, pre-pharmacy, pre-dental, and pre-vet programs were 7.6 percentage points less likely to finish a STEM degree in four years than their classmates in the life sciences. By contrast, respondents with plans for a major in health technology or nursing had a 4.8 percentage point advantage in their probability to earn a STEM degree in four years.

Five-year completion. We observed a number of differences between our four- and five-year STEM completion models. Although it did not significantly predict students' STEM completion likelihood for four years, the concentration of premedical undergraduates at an institution significantly and positively predicted students' probability of earning a STEM degree within five years. The significant difference in STEM completion rates between public and private institutions that we found for four years became non-significant when considering five-year STEM completion. Similarly, the significant effects from higher concentrations of STEM undergraduates, institutional size, and the proportion of faculty involving undergraduates in research became non-significant in the five-year model.

Among the background characteristics, Native American students fell further behind their White counterparts when considering five-year STEM completion, as the gap between Native American and White students went from 8.6 to 14.1 percentage points from four to five years. By contrast, the model showed no significant differences between White and Black students. The gap between White and Latino students remained consistent whereas differences between White and Asian American students became non-significant across the four- and five-year models. The effect for gender remained consistent, with women outpacing men in five-year STEM completion; however, the five-year model shows that women at more selective institutions complete at higher rates than their female peers at less selective institutions. Disparities in STEM completion across income remained similar from four to five years with the exception that students from the lowest income bracket (below $25,000) became even less likely than their middle-income peers to complete a STEM degree in five years.

Measures of students' pre-college academic preparation and experiences remained relatively consistent across the four- and five-year models. High school GPA became slightly more salient in predicting students' STEM completion likelihood whereas SAT composite scores became less important. The effect of high school biology on STEM completion became non-significant.

The relationship between students' expectation of transferring to another institution and their STEM completion probability was reduced by nearly half from the four-year to the five-year model; however, students with plans to transfer continued to have a significantly lower likelihood to earn a STEM degree in five years. Medical degree aspirants' advantage over their peers with bachelor's degree aspirations decreased in the five-year model, but students with medical degree aspirations continued to have a 4.7 percentage point higher probability of completing a STEM degree in five years relative to their peers with bachelor's degree aspirations. The conditional effect of faculty grading on a curve became non-significant; however, the effect of selectivity switched directions. Whereas medical degree aspirants at more selective institutions were even more likely to complete a STEM degree in four years when compared against their peers at less selective institutions, attending a more selective institution actually hurt medical degree aspirants' probability of completing a STEM degree in five years. Additionally, the relationship between planning to live on campus and STEM completion strengthened between the four- and five-year models, as planning to live on campus predicted a 6.2 percentage point higher probability of completing a STEM degree within five years.

Finally, most of the academic major differences detected in the four-year model became non-significant in the five-year model. Specifically, engineering aspirants, and health technology and nursing applicants were not significantly different in their five-year STEM completion probabilities than their life sciences peers. The negative effect of planning to pursue a pre-med, pre-dental, pre-pharmacy, or pre-vet program on STEM completion persisted into the five year model, but the magnitude weakened such these students were 5.7 percentage points less likely than their life sciences classmates to complete a STEM degree in five years.

Six-year completion. Comparing the six-year model to the four- and five-year models shows many consistent effects. In the six year model, we found that institutional size and the proportion of faculty engaging undergraduates in research significantly and positively predicted STEM completion, which matched the findings from the four-year model but differed from the non-significant effects of these variables found in the five-year model. The strength of the relationship between selectivity and STEM completion dropped sharply from the five- to six-year models, as a 100-point increase in institutional selectivity predicted an 8 percentage point increase in STEM completion rates.

The differences across race persisted in the six-year model, and the significant gap in STEM completion between White and Black students re-emerged with Black students having an 18.1 percentage point lower probability of earning a STEM degree within six years. Additionally, the gap between White and Asian American students re-emerged in the six year model, with Asian American students having a 3 percentage point advantage over their White classmates. The relationship between income and STEM completion remained consistent from the five- to six-year models.

Several measures of students' pre-college experience and entering aspirations changed between the five- and six-year models. The negative effect of expecting to transfer to another institution became non-significant when predicting six-year completion. The salience of aspiring for a medical degree continued to decrease as we extended our time-to-degree for STEM completion, as medical degree aspirants were 2.6 percentage points more likely to earn a STEM degree in six years compared to their peers with bachelor's degree aspirations. Similarly, the salience of intending to pursue a law degree dropped another two points in the six-year model, with law school aspirants have a 7.5 percentage point lower likelihood of completing a STEM degree. We found no changes between the five- and six-year models regarding students' intended academic major.

Underrepresented Racial Minority Students and STEM Completion

After building STEM completion models for the full sample of students, we examined identical statistical models on a sub-sample of URM students. These analyses demonstrate how the salience of certain predictors might be different for URM students compared to the entire sample. To simplify the discussion, we present only the findings from the six-year models.

Six-year STEM versus non-STEM completion. The findings in Table 3 show that just one institutional variable differentiated URM students who completed a STEM degree versus a non-STEM degree in six years. Having a denser concentration of premedical undergraduates significantly reduced URM STEM aspirants' probability of earning a STEM degree in six years. Specifically, a 10 percentage point increase in the proportion of undergraduate with plans for medical school resulted in a 4 percentage point reduction in URM STEM students' probability of earning a STEM bachelor's degree.

The findings show that just two background variables significantly predicted six-year STEM versus non-STEM completion. URM women were 5.2 percentage points less likely than men to earn a STEM degree relative to a non-STEM degree. Additionally, students whose fathers had more education were significantly more likely to earn their bachelor's degree in STEM rather than in a non-STEM field.

Similar to the models for the full sample, pre-college preparation significantly predicted URM students' probability of completing their bachelor's degree in STEM. Higher high school GPAs predicted a significantly greater likelihood of degreeing in STEM, and this effect was strengthened for students who attended campuses where faculty relied more heavily on student-centered pedagogy. Likewise, a 100-point increase in SAT composite scores predicted a 6.2 percentage point increase in URM STEM aspirants' likelihood to degree in STEM rather than in a non-STEM field. Unlike in the model for the full sample, we did not detect significant effects of years of high school math and biology on URM STEM students' likelihood to earn their bachelor's degree in STEM.

URM students who felt more overwhelmed in high school had lower probabilities of earning a bachelor's degree in a STEM field compared to a non-STEM field. By contrast, those students who reported spending more time studying and doing homework in high school had significantly improved probabilities of completing their bachelor's degree in a STEM discipline. URM students with a stronger academic self-concept were significantly more likely to complete their bachelor's degree in STEM; by contrast, respondents with a stronger social self-concept had significantly reduced odds of earning their degree in a STEM field. URM students with intentions to pursue a medical degree were 11.5 percentage points more likely to complete their degrees in STEM, but attending more selective institutions reduced the positive effects of aspiring for a medical degree. In other words, medical aspirants' advantage in terms of completing their bachelor's degree in STEM was reduced for those individuals at more selective colleges and universities. URM students with plans for a law degree were 31.7 percentage points less likely to earn their bachelor's degree in a STEM field compared to their peers with intentions for a bachelor's degree. Students who planned to live on campus were significantly less likely to earn their bachelor's degree in STEM. Finally, just one academic major had significantly better odds at completing their bachelor's degree in a STEM field: engineering aspirants were 18.6 percentage points more likely than their classmates in the life science to complete a STEM degree within six years.

Six-year STEM completion versus no completion. Several institutional variables significantly predicted URM students' likelihood to earn a STEM bachelor's degree relative to not earning a bachelor's degree in any field. Attending an institution where more faculty involved undergraduates in research significantly and positively predicted URM STEM aspirants' odds of earning a STEM bachelor's degree. Likewise, students attending more selective institutions had higher STEM completion probabilities, as a 100-point increase in institutional selectivity corresponded with a 6.6 percentage point increase in the probability of earning a STEM degree. URM STEM aspirants attending institutions that offered STEM outreach programs to high school students were 5.3 percentage points less likely to complete a bachelor's degree in STEM.

Among students' background characteristics, we found that Native American students were 8 percentage points less likely to earn a degree in STEM compared to their Latino classmates. Women outperformed men in STEM completion by 5.2 percentage points. Students who were native English speakers had an 8.5 percentage point lower probability of earning a degree in STEM when compared with their non-native English speaking peers. Additionally, having a father with more education significantly and positively predicted URM students' likelihood of earning a bachelor's degree in STEM.

Pre-college preparation and pre-college experiences significantly predicted URM students' probability of earning a STEM degree within six years. Students who earned higher high school GPAs had significantly better odds of earning a STEM degree, as did those individuals with higher composite SAT scores. A 100-point increase in SAT scores translated into a 4.6 percentage point increase in a student's probability of earning a STEM degree. Additionally, URM students who spent more time in high school studying or doing homework were significantly more likely to complete a STEM bachelor's degree.

Academic self-concept appeared particularly salient for URM STEM aspirants, as students with a stronger academic self-concept were significantly more likely to complete a bachelor's degree in STEM. By contrast, respondents with stronger social self-concepts had significantly reduced likelihoods of earning a STEM degree. Unlike in the models for the full sample, URM students who aspired to earn a medical degree were not significantly different from their peers who wanted to earn a bachelor's degree in terms of their six-year STEM completion likelihood; however, law school aspirants were 14.4 percentage points less likely to complete a STEM bachelor's degree compared to their peers with aspirations for only a bachelor's degree. Students who planned to live on campus were 9 percentage points more likely to complete a STEM degree within six years. Finally, URM students who intended to major in health technology or nursing were 8.5 percentage points less likely to complete a STEM bachelor's degree relative to their life sciences classmates.

Conclusion

While the results here confirm previous studies regarding the importance of students' preparation (grades, test scores, and coursework) and their predispositions (academic self-concept, aspirations) to retention and early degree completion in STEM, we offer several new findings that should provide insights into programming efforts and future assessments. First, while minority females (and all females) are more likely to complete degrees, they are less likely to be among STEM completers—switching to other fields. This suggests continued efforts are necessary to retain talented women in STEM. Retaining more low-income students and students of color at their first college to degree completion is key to improving STEM completion, for they are equally likely to be represented in STEM among completers based on their initial aspirations. These findings provide reinforcing evidence for targeted, programmatic efforts that not only increases baccalaureate attainments but can also increase the number of STEM graduates. Beyond these demographics, higher academic (rather than social) self-concept is evidenced among STEM completers and initial STEM identity played a small but significant role among completers. Surprisingly, minority students who entered with a stronger STEM identity were not more likely to be retained, indicating perhaps that we are diverting students to other fields that have a strong personal commitment. Medical degree aspirations and advanced degree aspirations were also key among entering students, however, contextual influences create unique conditions that influence STEM degree attainments.

Previous studies have not had the rich information at the individual level and also a large institutional sample to test and settle debates about institutional effects. Our study provides evidence that contexts do, indeed, matter and offers insight into conditional effects that have implications for increasing STEM degree productivity. To settle the debate about selective institutions, we show that both sides of the debate have some validity and, more importantly, selective institutions are in a prime position to increase STEM degree productivity due to both the talent they attract and the resources they can expend on students in STEM. Specifically, selectivity has a clear effect on degree completion, but graduates are not more likely to complete in STEM at selective institutions. This finding confirms earlier studies we have conducted at the Higher Education Research Institute on both degree completion and STEM retention. All things being equal, URMs are more likely to complete college at a selective institution but are not significantly more likely to be retained in STEM. Black students entering selective institutions were less likely to complete in four or five years but are just as likely to have completed a degree in STEM by the sixth year. If we could increase more URM degree completions, we can increase URM STEM completions as they are equally likely to be represented among completers.

The conditional effects we identified reinforce the notion that supportive environments can make a difference in student success in STEM. These macro-level findings take on more significance when they can be tied to mezzo-level contexts, where teaching and learning occurs. Specifically, high-achieving minority students were not only more likely to stay in STEM but also be retained in college if more faculty used student-centered pedagogy. In contrast, high numbers of faculty that grade on a curve hurt premed aspirants—they were less likely to finish STEM in four years. Further, URM premeds who have the best chance at completion were less likely to stay in STEM at selective colleges. Further, we find evidence for a premed phenomenon, a high percentage of peers competing for medical school preparation results in a higher numbers of student shifting out of STEM. Thus, highly motivated and talented students shift out of STEM altogether when competition is increased in the classroom. Instead of reinforcing the sieve-like effects of this phenomenon, institutions have to recognize ways to engage in talent recovery in STEM. The recent PCAST report (2012) calls for reform and use of evidence-based teaching practices in STEM. Another promising practice that has been identified is student engagement in undergraduate research and authentic discovery experiences. Higher numbers of STEM faculty who report they involve undergraduates in research also results in retention in college and STEM , but students who attended such institutions were equally likely to be among both STEM and non-STEM completers. More research is needed to understand how faculty engage students in research, as there is substantial variation in student experiences with faculty in research projects, impacting students' decisions about staying in STEM.

Variation among STEM field aspirants was also related to time to degree. Engineering aspirants, by the fifth year of college, were significantly more likely to be retained in STEM and such was the case for minority engineers (relative to bioscience majors) by the sixth year. This speaks to initiatives and the supportive environment that this field is able to generate, allowing more time for degree completion. Initial health technology and nursing majors were more likely to stay in college to degree completion, and were equally likely to be among STEM completers relative to other bioscience aspirants. In both field specific cases, it may well be that students are picking specific programs where they have a chance to fulfill career goals (and departments choose them) which may form more cohesive intellectual communities. Across campuses, collaborative examination of practices may help to identify ways certain departments are more successful and can work together to raise the level of productivity of STEM degrees beginning with coursework, support services, and counseling. New initiatives by AAU and APLU reflect great interest in “demonstration campuses” that can make transformations in these and other areas to increase the productivity of STEM degrees. Campuses will need to soon engage in self-study and gear up efforts if we hope to produce a million more STEM graduates in the next decade.

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Appendix A

List of Majors Defined as STEM

1. General Biology
2. Biochemistry/Biophysics
3. Botany
4. Environmental Science
5. Marine (Life) Science
6. Microbiology/Bacterial Biology
7. Zoology
8. Other Biological Science
9. Aeronautical/Astronautical Engineering
10. Civil Engineering
11. Chemical Engineering
12. Computer Engineering
13. Electrical Engineering
14. Industrial Engineering
15. Mechanical Engineering
16. Other Engineering
17. Astronomy
18. Atmospheric Science
19. Chemistry
20. Earth Science
21. Marine Science
22. Mathematics
23. Physics
24. Statistics
25. Other Physical Science
26. Health Technology
27. Medicine/Dentistry/Veterinary Medicine
28. Nursing
29. Pharmacy
30. Agriculture
31. Computer Science

Appendix B
Table of Measures

Variable Name	Coding Scheme
Dependent Variable	
STEM Completion	1=Completed bachelor's degree in STEM; 2=Completed bachelor's degree in a non-STEM field; 3=Did not complete a bachelor's degree (measured at 4, 5, and 6 years)
Institutional Characteristics	
Percentage of pre-med students (10)	Continuous
Control: Private	1=public, 2=private
Institutional type: Research (ref. masters comp.)	0=no, 1=yes
Institutional type: Liberal arts (ref. masters comp.)	0=no, 1=yes
Percentage of undergraduates in STEM (10)	Continuous
HBCU	0=no, 1=yes
Undergraduate FTE enrollment (log)	Continuous
Percentage of STEM faculty involving undergraduates in research	Continuous
Average extent that STEM faculty grade on a curve	Continuous
Avg. STEM faculty score on student-centered pedagogy construct	Continuous
Selectivity (100)	Continuous
Institution offers undergraduate research opportunities to freshmen	0=not at all to 2=to a great extent
Institution provides targeted financial aid to STEM students	0=no, 1=yes
Institution has high school STEM outreach programs	1=not at all to 3=to a great extent
Institution offers undergraduates research opportunities	1=not at all to 3=to a great extent
Background Characteristics	
Native American	0=no, 1=yes
Black	0=no, 1=yes
Latino	0=no, 1=yes
Asian American or Pacific Islander	0=no, 1=yes
Other Race	0=no, 1=yes

Sex: Female	1=male, 2=female
Low Income (Under $25K)	0=no, 1=yes
Low-middle income ($25K to $49,999)	0=no, 1=yes
High Middle Income ($100K-$199,999)	0=no, 1=yes
High Income ($200K+)	0=no, 1=yes
Student Native English Speaker?	0=no, 1=yes
Father's education	1=grammar school or less to 8=graduate degree
Prior Preparation	
Average High School Grade	1=D to 8=A or A+
SAT composite score	Continuous
Years of HS study: Math	1=None to 7=Five or more
Years of HS study: Biological sciences	1=None to 7=Five or more
Pre-College Experiences	
Felt Overwhelmed by All I Had to Do	1=not at all to 3=frequently
Socialized w/Diff Ethnic Group	1=not at all to 3=frequently
Studying or Homework	1=none to 8=over 20 hours
Entering Aspirations and Expectations	
Transfer to Another College	1=no chance to 4=very good chance
Academic self-concept construct	Continuous
Social self-concept construct	Continuous
Medical Degree Aspiration	0=no, 1=yes
Masters Degree Aspiration	0=no, 1=yes
Ph.D./Ed.D. aspiration	0=no, 1=yes
Law Degree Aspiration	0=no, 1=yes
Plan to live on campus	0=no, 1=yes
STEM Identity	Continuous

Intended Major	
Engineering Major	0=no, 1=yes
Physical Sciences Major	0=no, 1=yes
Math/Stat Major	0=no, 1=yes
Health technology/nursing major	0=no, 1=yes
Pre-med/pharm/dental/vet major	0=no, 1=yes
Computer Science Major	0=no, 1=yes

Appendix C

Descriptive Statistics

	Mean	S.D.	Min.	Max.
Institutional Characteristics				
Percentage of pre-med students (10)	2.50	1.20	0.00	6.20
Control: Private	0.70	0.46	0.00	1.00
Institutional type: Research (ref. masters comp.)	0.22	0.41	0.00	1.00
Institutional type: Liberal arts (ref. masters comp.)	0.37	0.48	0.00	1.00
Percentage of undergraduates in STEM (10)	1.23	1.03	0.00	9.13
HBCU	0.04	0.21	0.00	1.00
Undergraduate FTE enrollment (log)	8.08	0.89	6.28	10.35
Percentage of STEM faculty involving undergraduates in research (10)	5.80	2.60	0.00	9.50
Average extent that STEM faculty grade on a curve	1.81	0.47	1.00	3.75
Avg. STEM faculty score on student-centered pedagogy construct	-0.02	0.41	-1.46	1.34
Selectivity (100)	11.18	1.45	5.15	14.45
Institution offers undergraduate research opportunities to freshmen	1.68	0.47	0.00	2.00
Institution provides targeted financial aid to STEM students	0.88	0.30	0.00	1.00
Institution has high school STEM outreach programs	1.95	0.61	1.00	3.00
Institution offers undergraduates research opportunities	2.57	0.55	1.00	3.00
Background Characteristics				
Native American	0.02	0.14	0.00	1.00
Black	0.09	0.28	0.00	1.00
Latino	0.06	0.24	0.00	1.00
Asian American or Pacific Islander	0.13	0.34	0.00	1.00
Other Race	0.02	0.13	0.00	1.00
Sex: Female	0.50	0.50	0.00	1.00
Low Income (Under $25K)	0.11	0.31	0.00	1.00
Low-middle income ($25K to $49,999)	0.18	0.38	0.00	1.00
High Middle Income ($100K-$199,999)	0.25	0.43	0.00	1.00
High Income ($200K+)	0.10	0.29	0.00	1.00
Student Native English Speaker?	0.90	0.30	0.00	1.00
Father's education	5.53	2.01	1.00	8.00
Prior Preparation				
Average High School Grade	6.69	1.32	1.00	8.00
SAT composite score (100)	11.80	1.79	4.40	16.00
Years of HS study: Math	5.98	0.54	1.00	7.00
Years of HS study: Biological sciences	3.72	1.01	1.00	7.00

Pre-College Experiences				
Felt Overwhelmed by All I Had to Do	2.10	0.62	1.00	3.00
Socialized w/Diff Ethnic Group	2.66	0.53	1.00	3.00
Studying or Homework	4.38	1.58	1.00	8.00
Entering Aspirations and Expectations				
Transfer to Another College	3.19	0.90	1.00	4.00
Academic self-concept construct	51.59	8.02	12.65	66.92
Social self-concept construct	47.67	9.33	18.06	68.14
Medical Degree Aspiration	0.23	0.42	0.00	1.00
Masters Degree Aspiration	0.30	0.46	0.00	1.00
Ph.D./Ed.D. aspiration	0.22	0.42	0.00	1.00
Law Degree Aspiration	0.01	0.09	0.00	1.00
Plan to live on campus	0.83	0.38	0.00	1.00
STEM Identity	0.00	1.00	-2.22	2.22
Intended Major				
Engineering Major	0.29	0.45	0.00	1.00
Physical Sciences Major	0.08	0.27	0.00	1.00
Math/Stat Major	0.03	0.16	0.00	1.00
Health technology/nursing major	0.12	0.32	0.00	1.00
Pre-med/pharm/dental/vet major	0.19	0.39	0.00	1.00
Computer Science Major	0.04	0.20	0.00	1.00

Table 1

HGLM Results for STEM Completion versus non-STEM Completion

	Four-Year STEM Completion				Five-Year STEM Completion				Six-Year STEM Completion			
	Coef.	S.E.	Sig.	Delta-P	Coef.	S.E.	Sig.	Delta-P	Coef.	S.E.	Sig.	Delta-P
Institutional Characteristics												
Intercept	1.26	0.68			0.6	0.61			0.35	0.52		
Percentage of pre-med students (10)	-0.10	0.04	*	-2.4%	-0.09	0.04	*	-2.1%	-0.11	0.03	***	-2.6%
Control: Private	0.09	0.12		2.1%	0.07	0.1			0.14	0.10		
Institutional type: Research (ref. masters comp.)	-0.09	0.13		-2.1%	-0.07	0.1			-0.04	0.10		
Institutional type: Liberal arts (ref. masters comp.)	-0.19	0.13		-4.6%	-0.1	0.11			-0.01	0.11		
Percentage of undergraduates in STEM (10)	0.02	0.04		0.5%	0.03	0.04			0.02	0.05		
HBCU	-0.24	0.59		-5.8%	0.14	0.53			0.24	0.45		
Undergraduate FTE enrollment (log)	-0.36	0.10	***	-8.8%	-0.26	0.08	***	-6.3%	-0.17	0.07	**	-4.1%
Percentage of STEM faculty involving undergraduates in research	0.01	0.19		0.2%	-0.05	0.16			-0.04	0.16		
Pct. Of STEM faculty who grade on a curve	0.18	0.13		4.1%	0.08	0.11			0.09	0.10		
Avg. STEM faculty score on student-centered pedagogy construct	-0.07	0.12		-1.7%	-0.1	0.1			-0.08	0.09		
Selectivity (100)	-0.02	0.07		-0.5%	0.05	0.05			0.05	0.04		
Institution offers undergraduate research opportunities to freshmen	0.13	0.12		3.0%	0.1	0.09			0.06	0.09		
Institution provides targeted financial aid to STEM students	-0.25	0.19		-6.0%	-0.15	0.12			-0.16	0.11		
Institution has high school STEM outreach programs	-0.06	0.08		-1.4%	-0.08	0.06			-0.06	0.05		
Institution offers undergraduates research opportunities	-0.09	0.08		-2.1%	-0.03	0.07			-0.06	0.06		
Background Characteristics												
Native American	-0.13	0.15			-0.16	0.09			-0.11	0.07		
Black	0.14	0.63			0.26	0.57			0.18	0.45		
HBCU	0.09	0.59			-0.17	0.55			-0.11	0.43		
Selectivity (100)	-0.09	0.07			-0.01	0.05			0.01	0.06		
Latino	-0.19	0.08	*	-4.6%	-0.1	0.07			-0.13	0.07		
Asian American or Pacific Islander	0.30	0.08	***	6.9%	0.27	0.07	***	6.2%	0.29	0.07	***	6.6%
Other Race	0.33	0.14	*	7.4%	0.44	0.13	***	9.7%	0.42	0.11	***	9.3%
Sex: Female	-0.19	0.05	**	-4.5%	-0.13	0.04	***	-3.1%	-0.09	0.04	*	-2.1%
Selectivity (100)	-0.06	0.03			-0.04	0.03			-0.06	0.02	*	-1.4%
Low Income (Under $25K)	-0.03	0.09			-0.06	0.06			-0.06	0.06		
Low-middle income ($25K to $49,999)	-0.05	0.05			-0.03	0.04			-0.01	0.04		
High Middle Income ($100K-$199,999)	0.03	0.05			0.02	0.04			0.03	0.04		
High Income ($200K+)	-0.08	0.07			-0.06	0.04			-0.06	0.04		
Student Native English Speaker	-0.38	0.06	***	-8.6%	-0.35	0.07	***	-7.9%	-0.32	0.05	***	-7.3%
Father's education	0.02	0.01			0.02	0.01	*	0.5%	0.02	0.01		
Prior Preparation												
Average High School Grade	0.24	0.02	***	5.5%	0.23	0.02	***	5.3%	0.23	0.01	***	5.3%
Avg. STEM faculty score on student-centered pedagogy construct	0.12	0.06	*	2.8%	0.09	0.04	*	2.1%	0.11	0.04	**	2.6%
Selectivity (100)	-0.01	0.02			-0.01	0.02			0.01	0.01		
SAT composite	0.23	0.03	***	5.3%	0.19	0.02	***	4.4%	0.20	0.01	***	4.6%
Years of HS study: Math	0.17	0.03	***	3.9%	0.14	0.03	***	3.2%	0.13	0.02	***	3.0%
Years of HS study: Biological sciences	0.06	0.02	***	1.4%	0.03	0.01	**	0.7%	0.04	0.01	***	0.9%
Pre-College Experiences												
Frequency: Felt Overwhelmed by All I Had to Do	-0.08	0.03	**	-1.9%	-0.09	0.02	***	-2.1%	-0.08	0.02	***	-1.9%
Frequency: Socialized w/Diff Ethnic Group	-0.04	0.03			-0.02	0.03			-0.02	0.02		
Hours per week spent studying/doing homework in HS	0.07	0.02	***	1.6%	0.07	0.01	***	1.6%	0.07	0.01	***	1.6%
Entering Aspirations and Expectations												
Expectation of transferring to another institution	-0.04	0.02			-0.02	0.02			-0.02	0.02		
Academic self-concept construct	0.03	0.01	***	0.7%	0.03	0.01	***	0.7%	0.03	0.01	***	0.7%
Social self-concept construct	-0.03	0.01	***	-0.7%	-0.03	0.01	***	-0.7%	-0.03	0.01	***	-0.7%
Medical Degree Aspiration	0.55	0.08	***	12.4%	0.45	0.06	***	10.2%	0.39	0.06	***	8.9%
Pct. of STEM faculty who grade on a curve	-0.28	0.13	*	-6.8%	-0.26	0.09	***	-6.3%	-0.22	0.09	*	-5.3%
Selectivity (100)	-0.16	0.05	***	-3.8%	-0.12	0.03	***	-2.9%	-0.12	0.03	**	-2.9%
Masters Degree Aspiration	0.05	0.06			0.06	0.04			0.06	0.04		
Ph.D./Ed.D. aspiration	0.25	0.07	***	5.8%	0.25	0.05	***	5.8%	0.26	0.05	***	6.0%
Law Degree Aspiration	-0.98	0.17	***	-24.0%	-0.75	0.13	***	-18.5%	-0.77	0.12	***	-19.0%
Plan to live on campus	-0.11	0.06		-2.6%	-0.12	0.04	***	-2.8%	-0.10	0.04	*	-2.3%
STEM Identity	0.06	0.02	***	1.4%	0.05	0.01	***	1.2%	0.05	0.01	***	1.2%

Intended Major (ref. biological sciences)									
Engineering Major	0.62	0.19 ***	14.0%	0.79	0.11 ***	17.6%	0.79	0.10 ***	17.6%
Physical Sciences Major	0.24	0.07 ***	5.5%	0.19	0.06 ***	4.4%	0.20	0.05 ***	4.6%
Math/Stat Major	0.05	0.14		0.07	0.11		0.08	0.10	
Health technology/nursing major	1.18	0.18 ***	23.6%	0.97	0.12 ***	20.1%	0.90	0.11 ***	18.8%
Pre-med/pharm/dental/vet major	-0.27	0.06 ***	-6.5%	-0.22	0.05 ***	-5.3%	-0.13	0.05 *	-3.1%
Computer Science Major	0.47	0.17 **	10.4%	0.35	0.11 ***	7.9%	0.37	0.09 ***	8.3%

Table 2

HGLM Results of STEM Completion versus No Completion

	Four-Year STEM Completion				Five-Year STEM Completion				Six-Year STEM Completion			
	Coef.	S.E.	Sig.	Delta-P	Coef.	S.E.	Sig.	Delta-P	Coef.	S.E.	Sig.	Delta-P
Institutional Characteristics												
Intercept	-1.44	0.35			-0.33	0.42			-0.13	0.45		
Percentage of pre-med students (10)	0.03	0.04			0.1	0.05	*	2.5%	0.12	0.05	*	2.8%
Control: Private	0.64	0.12	***	15.3%	0.23	0.14			0.24	0.14		
Institutional type: Research (ref. masters comp.)	-0.37	0.12	***	-7.6%	-0.32	0.13	*	-8.0%	-0.30	0.14	*	-7.3%
Institutional type: Liberal arts (ref. masters comp.)	0.08	0.12			-0.1	0.14			-0.06	0.14		
Percentage of undergraduates in STEM (10)	-0.13	0.03	***	-2.8%	-0.01	0.01			-0.05	0.06		
HBCU	0.19	0.22			0.3	0.26			0.24	0.26		
Undergraduate FTE enrollment (log)	0.18	0.07	**	4.1%	0.16	0.09			0.24	0.09	**	5.5%
Percentage of STEM faculty involving undergraduates in research	0.37	0.16	*	8.6%	0.31	0.19			0.38	0.19	*	8.5%
Pct. Of STEM faculty who grade on a curve	0.11	0.11			0.11	0.11			0.15	0.10		
Avg. STEM faculty score on student-centered pedagogy construct	-0.06	0.12			-0.09	0.12			0.03	0.13		
Selectivity (100)	0.46	0.04	***	10.8%	0.48	0.05	***	11.5%	0.36	0.07	***	8.0%
Institution offers undergraduate research opportunities to freshmen	-0.11	0.09			-0.04	0.11			-0.10	0.10		
Institution provides targeted financial aid to STEM students	-0.02	0.13			0.09	0.16			0.05	0.14		
Institution has high school STEM outreach programs	-0.09	0.07			-0.04	0.08			-0.04	0.08		
Institution offers undergraduates research opportunities	-0.09	0.08			-0.09	0.08			-0.02	0.09		
Background Characteristics												
Native American	-0.42	0.06	***	-8.6%	-0.57	0.07	***	-14.1%	-0.50	0.08	***	-12.2%
Black	-0.74	0.18	***	-14.4%	-0.38	0.28			-0.74	0.27	**	-18.1%
HBCU	0.48	0.17	**	11.3%	0.11	0.26			0.42	0.25		
Selectivity (100)	-0.14	0.03	***	-3.0%	-0.11	0.04	**	-2.7%	0.01	0.05		
Latino	-0.25	0.05	***	-5.3%	-0.27	0.06	***	-6.7%	-0.29	0.05	***	-7.0%
Asian American or Pacific Islander	0.14	0.05	**	3.1%	0.11	0.06			0.13	0.05	*	3.0%
Other Race	0.19	0.09	*	4.3%	0.32	0.11	**	7.8%	0.29	0.09	***	6.6%
Sex: Female	0.26	0.03	***	5.7%	0.23	0.03	***	5.7%	0.21	0.03	***	4.9%
Selectivity (100)	0.02	0.02			0.04	0.02	*	1.0%	0.05	0.02	*	1.2%
Low Income (Under $25K)	-0.19	0.03	***	-4.1%	-0.27	0.04	***	-6.7%	-0.28	0.04	***	-6.7%
Low-middle income ($25K to $49,999)	-0.11	0.03	***	-2.4%	-0.11	0.03	***	-2.7%	-0.10	0.03	***	-2.4%
High Middle Income ($100K-$199,999)	0.08	0.03	*	1.8%	0.09	0.03	**	2.2%	0.11	0.03	***	2.6%
High Income ($200K+)	0.01	0.03			0.02	0.04			-0.01	0.04		
Student Native English Speaker?	-0.18	0.05	***	-3.8%	-0.22	0.04	***	-5.4%	-0.25	0.04	***	-5.7%
Father's education	0.05	0.01	***	1.1%	0.06	0.01	***	1.5%	0.07	0.01	***	1.6%
Prior Preparation												
Average High School Grade	0.37	0.01	***	8.6%	0.39	0.01	***	9.4%	0.40	0.01	***	8.9%
Student-centered pedagogy	-0.01	0.04			0.04	0.04			0.04	0.05		
Selectivity (100)	-0.01	0.01			0.01	0.01			-0.01	0.01		
Final SAT Composite score CIRP then CB and imputed	0.20	0.01	***	4.6%	0.14	0.01	***	3.5%	0.13	0.01	***	3.0%
Years of HS study: Math	0.11	0.02	***	2.5%	0.12	0.02	***	3.0%	0.14	0.02	***	3.2%
Years of HS study: Biological sciences	0.04	0.01	***	0.9%	0.01	0.01			0.01	0.01		
Pre-College Experiences												
Felt Overwhelmed by All I Had to Do	-0.04	0.02	*	-0.9%	-0.04	0.02	*	-1.0%	-0.01	0.02		
Socialized w/Diff Ethnic Group	-0.14	0.02	***	-3.0%	-0.15	0.02	***	-3.7%	-0.13	0.02	***	-3.1%
Studying or Homework	0.07	0.01	***	1.6%	0.09	0.01	***	2.2%	0.09	0.01	***	2.1%
Entering Aspirations and Expectations												
Transfer to Another College	-0.08	0.01	***	-1.7%	-0.04	0.01	***	-1.0%	-0.02	0.01		
Academic self-concept construct	0.02	0.00	***	0.4%	0.01	0.00	***	0.2%	0.01	0.00	***	0.2%
Social self-concept construct	-0.01	0.00	***	-0.2%	-0.01	0.00	***	-0.2%	-0.01	0.00	***	-0.2%
Medical Degree Aspiration	0.27	0.04	***	6.1%	0.19	0.05	***	4.7%	0.11	0.03	*	2.6%
Pct. of STEM faculty who grade on a curve	-0.29	0.07	***	-6.1%	-0.04	0.08			0.04	0.08		
Institutional selectivity	0.03	0.03		0.7%	-0.05	0.02	*	-1.2%	-0.05	0.02	*	-1.2%
Masters Degree Aspiration	0.09	0.02	***	2.0%	0.08	0.03	*	2.0%	0.09	0.03	***	2.1%
Ph.D./Ed.D. aspiration	0.02	0.04			-0.06	0.04			-0.04	0.04		
Law Degree Aspiration	-0.43	0.12	***	-8.8%	-0.38	0.13	**	-9.5%	-0.31	0.13	*	-7.5%
Plan to live on campus	0.16	0.03	***	3.5%	0.25	0.03	***	6.2%	0.28	0.04	***	6.7%
STEM Identity	0.01	0.01			-0.01	0.01			-0.01	0.01		

Intended Major									
Engineering Major	-0.35	0.05 ***	-7.5%	-0.05	0.06		0.09	0.05	
Physical Sciences Major	-0.02	0.04		-0.03	0.05		-0.03	0.05	
Math/Stat Major	0.09	0.08		0.01	0.08		-0.03	0.07	
Health technology/nursing major	0.21	0.09 *	4.8%	0.07	0.06		0.01	0.06	
Pre-med/pharm/dental/vet major	-0.36	0.05 ***	-7.6%	-0.43	0.06 ***	-5.7%	-0.23	0.04 ***	-5.5%
Computer Science Major	-0.05	0.07		-0.11	0.07		-0.11	0.07	

Table 3

HGLM Results of URM STEM Completion versus non-STEM Completion and No Completion

	Six-Year STEM vs. Non-STEM				Six-Year STEM vs. No Completion			
	Coef.	S.E.	Sig.	Delta-P	Coef.	S.E.	Sig.	Delta-P
Institutional Characteristics								
Intercept	-0.3	0.99			-0.10	0.07		
Percentage of pre-med students (10)	-0.16	0.06	**	-4.0%	0.93	0.53		
Control: Private	0.17	0.17			0.21	0.20		
Institutional type: Research (ref. masters comp.)	-0.1	0.2			-0.01	0.16		
Institutional type: Liberal arts (ref. masters comp.)	-0.25	0.23			-0.09	0.21		
Percentage of undergraduates in STEM (10)	0.01	0.05			-0.01	0.06		
HBCU	1.1	0.88			0.67	0.47		
Undergraduate FTE enrollment (log)	-0.2	0.11			-0.01	0.11		
Percentage of STEM faculty involving undergraduates in research	0.29	0.33			0.58	0.25	*	14.3%
Pct. Of STEM faculty who grade on a curve	0.28	0.17			0.19	0.15		
Avg. STEM faculty score on student-centered pedagogy construct	-0.1	0.2			0.19	0.18		
Selectivity (100)	-0.02	0.07			0.27	0.09	***	6.6%
Institution offers undergraduate research opportunities to freshmen	-0.09	0.18			-0.22	0.16		
Institution provides targeted financial aid to STEM students	-0.21	0.34			0.21	0.22		
Institution has high school STEM outreach programs	-0.09	0.11			-0.23	0.10	*	-5.3%
Institution offers undergraduates research opportunities	-0.16	0.12			0.06	0.11		
Background Characteristics								
Native American	-0.1	0.12			-0.35	0.10	***	-8.0%
Black	0.9	0.82			-0.25	0.48		
HBCU	-0.73	0.82			0.23	0.45		
Selectivity (100)	0.02	0.07			0.08	0.07		
Sex: Female	-0.21	0.07	**	-5.2%	0.22	0.07	**	5.2%
Selectivity (100)	0.02	0.04			0.02	0.04		
Low Income (Under $25K)	0.18	0.12			-0.10	0.08		
Low-middle income ($25K to $49,999)	0.19	0.11			0.09	0.08		
High Middle Income ($100K-$199,999)	-0.07	0.12			0.09	0.11		
High Income ($200K+)	0.06	0.17			0.08	0.19		
Student Native English Speaker	-0.18	0.11			-0.35	0.1	***	-8.5%
Father's education	0.04	0.02	*	1.0%	0.1	0.02	***	2.4%
Prior Preparation								
Average High School Grade	0.18	0.03	***	4.5%	0.38	0.03	***	9.3%
Avg. STEM faculty score on student-centered pedagogy construct	0.21	0.09	*	5.8%	0.09	0.09		
Selectivity (100)	-0.01	0.02			0.01	0.02		
SAT composite	0.25	0.03	***	6.2%	0.19	0.02	***	4.6%
Years of HS study: Math	-0.04	0.07			0.04	0.04		
Years of HS study: Biological sciences	0.04	0.03			0.01	0.03		
Pre-College Experiences								
Frequency: Felt Overwhelmed by All I Had to Do	-0.13	0.06	*	-4.4%	0.03	0.05		
Frequency: Socialized w/Diff Ethnic Group	0.05	0.08			-0.11	0.08		
Hours per week spent studying/doing homework in HS	0.09	0.03	***	2.2%	0.09	0.02	***	2.2%
Entering Aspirations and Expectations								
Expectation of transferring to another institution	0.03	0.05			-0.01	0.03		
Academic self-concept construct	0.23	0.05	***	5.7%	0.17	0.05	***	4.1%
Social self-concept construct	-0.03	0.01	***	-0.8%	-0.01	0	***	-0.2%
Medical Degree Aspiration	0.47	0.13	***	11.5%	0.06	0.1		
Pct. of STEM faculty who grade on a curve	-0.20	0.23			0.26	0.18		
Selectivity (100)	-0.20	0.06	***	-5.0%	-0.09	0.05		
Masters Degree Aspiration	0.01	0.10			0.08	0.07		
Ph.D./Ed.D. aspiration	0.25	0.15			0.05	0.09		
Law Degree Aspiration	-1.42	0.46	**	-31.7%	-0.67	0.3	*	-14.4%
Plan to live on campus	-0.22	0.10	*	-5.5%	0.39	0.08	***	9.0%
STEM Identity	0.04	0.04			-0.04	0.03		

Intended Major (ref. biological sciences)								
Engineering Major	0.77	0.13	***	18.6%	0.01	0.09		
Physical Sciences Major	0.04	0.17			0.1	0.14		
Math/Stat Major	0.27	0.29			-0.17	0.23		
Health technology/nursing major	0.23	0.20			-0.37	0.11	***	-8.5%
Pre-med/pharm/dental/vet major	-0.14	0.12			-0.18	0.1		
Computer Science Major	0.10	0.18			-0.05	0.17		