

2014

Improving outcomes for underrepresented women in science: The Achieving Excellence in Mathematics, Engineering, and Science (AEMES) programs at Smith College

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Recommended Citation

Katz, Laura A.; Aloisio, Kathryn M.; Flores, Yadira; Horton, Nicholas J.; Joseph, Valerie; Lipp, Katie; Ly, Minh; Pruss, Sara; Queeny, Kate; Rowen, Cate; and DiBartolo, Patricia Marten, "Improving outcomes for underrepresented women in science: The Achieving Excellence in Mathematics, Engineering, and Science (AEMES) programs at Smith College" (2014). Conference Proceeding, Smith College, Northampton, MA. https://scholarworks.smith.edu/institutional_research/1

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ABSTRACT

Created to support diverse students interested in the sciences, Smith College's Achieving Excellence in Mathematics, Engineering, and Science (AEMES) programs have improved life science academic outcomes for women of color. Elements of Smith's AEMES programs include leadership development, peer mentoring, and faculty-mentored research opportunities, all sharing the goals of building community, increasing academic engagement, and encouraging persistence for underrepresented students. Since launching AEMES, our students of color in the life sciences have shown significant gains in positive outcomes (introductory biology and chemistry course GPA; retention in life sciences majors), dissolving a previously observed gap in gateway course performance relative to majority students. We discuss potential explanations for these outcomes as well as our ongoing work to evaluate and foster programming efforts aimed at achieving further inclusive excellence in the sciences, especially given the lack of change in advanced life sciences research participation for students of color over time. With greater investments in programs that encourage access in undergraduate programs across the United States, such as Smith's AEMES program, the next generation of scientists will become increasingly diverse, broadening the approaches and perspectives of our STEM talent and workforce.

THE AEMES PROGRAMS

Smith College, the largest women's liberal arts college in the United States, educates a diverse student body and has a core commitment to educational access in order to fulfill its mission to "educate women of promise for lives of distinction." In 2006, a Smith delegation attended the meeting, "Symposia on Diversity in the Sciences," sponsored by the Howard Hughes Medical Institute (HHMI), where participating institutions were charged with analyzing key academic outcomes for its students of color in STEM. Despite Smith's strong rate of life sciences baccalaureate degree production (avg. 10.26%, 2004-13) relative to national rates for women (6.06%; U.S. Department of Education, 2004-13), our 2006 analyses revealed a concerning result: historically underrepresented students, both students of color and first generation college students, were taking life science gateway courses in high numbers at Smith but underperforming in them (see Table 1).

Through the generous support of HHMI and other benefactors, the AEMES (Achieving Excellence in Mathematics, Engineering, and Science) programs were launched in 2007 with the purpose of trying to address some of the barriers that students of color might face in STEM including: inaccessible gateway courses that unintentionally favor students from privileged backgrounds (Bianchini, 2013); lack of preparation for students from underserved schools in areas like skillfully accessing both faculty and resources on campus (Butts et al., 2012; Hurtado & Carter, 1997); and a lack of a sense of community and insufficient numbers of role models (Bianchini, 2013; Hurtado & Carter, 1997). With these in mind, two interrelated AEMES initiatives were developed to build community and increase academic engagement in order to help diverse students succeed in STEM early in their time at Smith College.

The AEMES Scholars program is our flagship initiative. Every year since 2007, 20 AEMES scholars are chosen from among the strongest of Smith's admitted students who have a STEM interest and are students of color, first generation students, or both. AEMES scholars receive a rich array of resources during their first two years to support their development as leaders within the broader community of STEM students, including a stipend for their work with a faculty member on research. Faculty research mentors meet weekly with their AEMES scholar and typically serve as the student's academic advisor. AEMES scholars also take a course on applied learning strategies in their fall semester, participate in peer mentoring (described below), and attend a variety of community building events.

Also in 2007, we reinvigorated a Peer Mentoring Program that matches incoming students with returning student mentors. In the fall semester, invitations are sent to first generation students and students of color in gateway courses; in the spring, we reach out again and make specific invitations to every student who struggled in a fall semester gateway course. Mentors receive training in the fall and are expected to contact their mentees weekly and meet once a month in person. Mentors and mentees participate in a range of networking activities throughout the year, and mentors complete surveys monthly, which allows us to track relationships and intervene when needed.

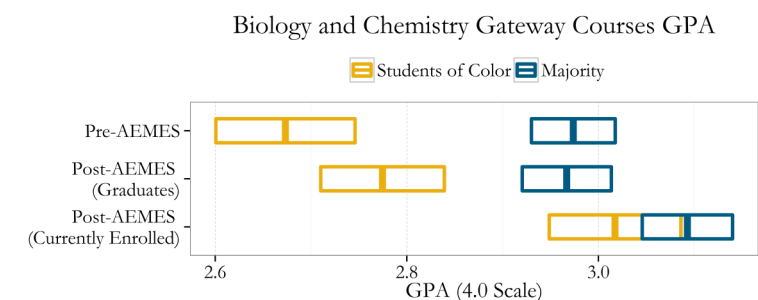
Our aims in launching these programs included: 1)-supporting the students in the AEMES programs; 2)-transforming the Smith College culture surrounding issues of access in STEM fields; and 3)-developing a model which might be replicated elsewhere. At this point, Smith has expanded AEMES programming (see Discussion) and invested in community building events (e.g. workshops) and faculty development (e.g. outside speakers) centered around issues of access and diversity in STEM.

OUTCOMES

In order to capture the full trajectory of students' academic pathways, we focus our analyses on alumnae over time, comparing Smith students graduating before and after the AEMES launch (the only exception is gateway course GPA, where we compare our alumnae to currently enrolled students because they ordinarily take these courses early in their time at Smith). For each analysis, we collapsed students of color in the sciences overall to compare to our majority students, due to a lack of statistically significant results for any outcomes between AEMES Scholars and students of color who were not AEMES Scholars. In order to disentangle academic preparedness in high school from outcomes in college, all analyses only include students with admissions ratings of 3 through 6, representing the middle range of Smith's admission pool (range from 1 to 10; based on a student's preparedness determined by high school GPA, rigor of courses, and participation in leadership opportunities and extracurricular activities).

Narrowing performance in gateway biology and chemistry courses. Prior to AEMES' launch, our students of color had GPAs in introductory life science (biology and chemistry) gateway courses that were significantly lower than their majority peers. That gap has narrowed steadily, with the cohort of currently enrolled students of color and majority students (taking classes from Fall '11 to Spring '14) no longer evidencing a gap in GPA in gateway courses (see Figure and Table 1).

Figure and Table 1. GPA performance in gateway biology and chemistry courses.



Note: Figure 1 displays means and 95% confidence intervals.

	Years	Students of Color	Majority	GPA gap
Pre-AEMES	F03-S07	2.67 ^{a,c} (N=509)	2.97 ^{a,c} (N=963)	0.30
Post-AEMES (Alumnae)	F07-S11	2.78 ^{b,d} (N=645)	2.97 ^{b,f} (N=1,149)	0.19
Post-AEMES (Enrolled)	F11-S14	3.02 ^{c,d} (N=466)	3.09 ^{c,f} (N=800)	0.07

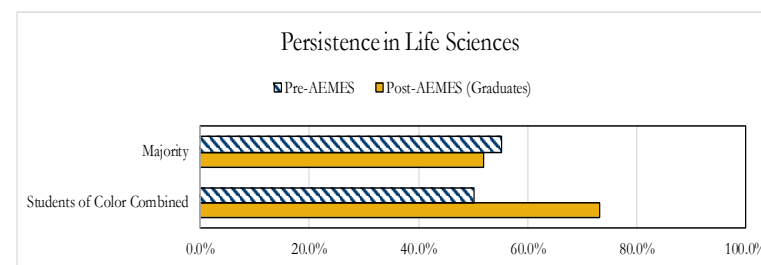
Note. On a 4.0 scale. ^{a,b}Mean difference between students of color and majority is statistically significant for F03-S07 and F07-S11 (*t*-test; $p < 0.0001$) but not for F11-S14 (*t*-test; $p = 0.07$). ^{c,d,e,f}Within categories, the mean GPA for F11-S14 is significantly larger than the other years (*t*-test; $p < 0.0001$).

Improving persistence rates in life sciences majors. Students of color who entered Smith interested in the life sciences (i.e. biology, biochemistry, chemistry, and neuroscience) persisted in those majors at significantly higher rates than before the program (50.0 to 73.2%), a rate that now exceeds their majority peers (51.9%; see Figure and Table 2).

Figure and Table 2. Persistence in life science majors for graduates.

	Students of Color	Majority
Pre-AEMES Alumnae	50.0% ^a (N=32)	55.1% (N=89)
Post-AEMES Alumnae	73.2% ^{a,b} (N=41)	51.9% ^b (N=77)

Notes: Persistence is defined as student stated interest in the life sciences at the time of admissions matching a declared life sciences major. Pre-AEMES covers first-time first-year students entering 2003-2006 while Post-AEMES covers students entering 2007-2010. ^aStatistically significant difference (*t*-test; $p = 0.04$). ^bStatistically significant difference (*t*-test; $p = 0.03$).



Maintaining participation in independent scientific research. No differences in honors and independent research participation of life sciences majors in their junior or senior years were observed comparing students of color with their majority peers. No significant changes in participation were observed in either group over time.

	Students of Color	Majority
Pre-AEMES Alumnae	54.1% (N=61)	51.2% (N=127)
Post-AEMES Alumnae	56.3% (N=64)	61.2% (N=103)

DISCUSSION

Smith College has a strong commitment to educating diverse women in the sciences. We designed the AEMES programs to ensure access for all students interested in STEM, with a particular focus on the early years of college. Since AEMES' launch, the gap in gateway course performance has closed, with current students showing no significant gap relative to majority students. Students of color at Smith now have significantly higher levels of persistence in the life sciences compared to when AEMES began, exhibiting rates exceeding national averages (HERI, 2010) as well as Smith majority student persistence.

Interestingly, all students of color have improved GPAs and increased persistence in life science majors and participants in our flagship AEMES Scholars program did not significantly outperform students of color who were not Scholars. We have two hypotheses about why this might be. First, one explicit goal of the AEMES Scholars program was to build a set of community leaders who would serve as role models and ambassadors to the broader community. Also, part of our AEMES programming, peer mentoring, is open not just to AEMES Scholars but to all students of color and first-generation students in the sciences. The purpose of peer mentoring is to foster a sense of belongingness while providing peer counsel about strategies for success. Thus, the goals of the AEMES programming are consistent with the principles of fostering persistence in STEM students (cf. Maton et al., 2012; Graham et al., 2013) and may account for the positive results for students of color overall, given the program's broad reach. We are currently working to understand the effectiveness of each program component to test this hypothesis.

Another possible reason for the positive impact of AEMES on our students of color in general is related to broad institutional shifts that led to and have been informed by our AEMES programs. The social transformation theory of change asserts that institutional change is both a process as well as an outcome of pro-

grams that support diversity in higher education (Maton et al., 2008, 2012). A number of contextual developments at Smith may have supported and expanded the impact of the AEMES programs, including articulation of access as central to the mission of the college and our science division as well as sustained efforts of a team of faculty and staff to understand and address barriers to access in the sciences. Our faculty has also intensified its focus on student-centered and active pedagogies, approaches that show demonstrable effects on class performance and rates of persistence (Freeman et al., 2014), working disproportionately well for the students we target with AEMES (Eddy & Hogan, 2014). This shift is consonant with the value we place on inclusive excellence and is simultaneously championed by AEMES and related faculty development efforts.

In contrast to GPA and persistence gains for students of color, student participation in research as juniors and seniors through independent research in the life sciences has shown no significant increase since AEMES began, although baseline levels were already relatively high and equally accessible to all students. Smith is exploring ways in which to integrate research opportunities throughout our curriculum using course-based research experiences to encourage and make space for even greater numbers of students. Additional barriers to advanced research participation are also being addressed with the more recent launch (2010-2011) of two additional programs under the AEMES umbrella. The Early Research program pairs first and second year students with faculty as volunteer research assistants, thereby supporting non-AEMES Scholars early in their academic career and the McKinley Honors Fellowship Program enables a small number of eligible juniors and seniors to complete their work-study requirement within the lab where they are pursuing research.

Our initial efforts devoted to access in the life sciences for women at Smith have shown promise. We believe that the insights from our programs will be applicable to other institutions, both big and small. Perhaps most encouraging is that investments in undergraduate programs that cultivate diverse scientists can help transform outcomes for a broader community of students of color in STEM fields at the same institution. Such investments can contribute to the diversification of STEM fields and allows us to reap the benefits of a broader set of approaches and perspectives (Bianchini, 2013; Hong & Page, 2004).

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The AEMES Programs have been generously supported by the Howard Hughes Medical Institute, the McKinley Fund of Smith College, the William Randolph Hearst Foundations, Exelon Corporation, and the special grant program of The Camille and Henry Dreyfus Foundation.

¹Dr. Horton is now at Amherst College.