Board 350: NSF S-STEM Academy of Engineering Success: Reflections on a Seven-Year Journey

Dr. Robin A.M. Hensel, West Virginia University

Robin A. M. Hensel, Ed.D., is a Teaching Professor in the Benjamin M. Statler College of Engineering and Mineral Resources at West Virginia University and an ASEE Fellow member. Throughout her career, she has supported engineering teams as a mathematician and provided complete life-cycle management of Information Systems as a Computer Systems Analyst for the U.S. Department of Energy; taught mathematics, statistics, computer science, and fundamental engineering courses and served in several administrative roles within higher education; secured over $5.5M funding and support for STEM education research; and led several program development efforts, including: a childcare facility at a federal research laboratory, STEM K-12 teacher training programs, a Molecular Biology/Biotechnology master's degree program at a small internationally-focused teaching institution, as well as a first-year engineering program and a B.S. Engineering Technology degree program at an R1 research institution. She has been recognized for her teaching, advising, and service, and as an Exemplary Faculty Member for Excellence in Diversity, Equity, and Inclusion.

Dr. David A. Wyrick PE, CPEM, West Virginia University

Professor specializing in engineering management. Former dean, academic associate dean, department chair, and engineer in energy, manufacturing, and computing industries.

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Abstract

Much has changed in the seven years since 2016 – in society, in education, and in our NSF S-STEM Program. The goal, however, of the West Virginia University (WVU) Academy of Engineering Success (AcES), which received NSF S-STEM funding beginning in 2016, has remained constant: to increase the number of graduating engineers and contribute to the diversification of the engineering workforce [1], [2]. AcES has endeavored to attract, support and retain through graduation talented, but underprepared (non-calculus-ready) first-time, full-time engineering and computing undergraduate students from underrepresented populations by implementing established, research-based student success and retention strategies. During the seven (7) years of NSF funding, this program has served 71 students and supported 28 students with renewable S-STEM scholarships.

Past research used surveys and individual and focus group interviews to measure AcES scholars' feelings of institutional inclusion, engineering self-efficacy and identity, and assessment of their own development of academic and professional success skills [1], [2]. Results supported the Kruger-Dunning Effect, "a cognitive bias in which unskilled people do not recognize their incompetence in specific areas and often overestimate their abilities" [3], [4], [5]. Specifically, students who did not retain to the second year tended to enter college with unrealistic expectations regarding: (1) the time and effort required to succeed in a challenging major and (2) their ability to succeed with little effort. Students tended to underestimate the challenges and overestimate their ability to meet the challenges. [2], [3], [5].

Instead of focusing on those who left the program, this work focuses on AcES scholars who have completed or nearly completed an engineering or computing degree even through the additional complications and challenges presented by the COVID-19 pandemic. From these successful graduates, we hope to learn what elements of the AcES program were the most impactful and supportive to their journey. The lessons learned are shared to inform other, future engineering education programs.

1.0 PROGRAM DESCRIPTION

Three elements comprise the AcES first-year experience: (1) a structured week-long summer bridge experience, (2) a fall semester two credit-hour professional development course, and (3) a spring term three credit hour, general education *Engineering in History* course. The second semester *Engineering in History* course, taught by an AcES faculty member, was included to provide continued cohort development and mentoring opportunities for AcES students while they complete an engineering-related course that meets a university general education requirement. The AcES program director served as the faculty academic advisor for all AcES participants until they moved into their engineering discipline major and were assigned a faculty

advisor within their major department. All first-year students receive significant academic and student success support through the College's Engineering Learning Center and participate in student success, career exploration and professional development experiences through the Fundamentals of Engineering Program (FEP). After the first year, AcES scholars had opportunities to interact with program leaders, attend annual AcES reunions, and volunteer to help with the summer program for each new year's cohort.

Summer Bridge Experience

The one-week summer bridge program was held the week directly before the fall move-in day and contained a variety of experiential learning and cohort-building experiences, including: a hands-on engineering design challenge, field trips, math and chemistry review and practice sessions, student success seminars, and social activities. Faculty, staff, peer, and industry mentors led and participated in the activities.

While specific schedule and activities necessarily changed from year to year, the overall bridge program provided each AcES student with an excellent transition-to-college experience and prepared them well for their first semester. In some years, since the AcES students were familiar with the main engineering building locations, they served as leaders to help groups of incoming first-year students find their correct room during "Academic Day" preceding the first day of classes. The NSF S-STEM funding was valuable in providing support for students who would otherwise not have been able to leave their summer jobs a week early and participate in the Summer Bridge Experience. Currently, the AcES summer bridge component is institutionalized and supported by the college and industry partners.

Fall Professional Development Course

The fall professional development course, comprised of faculty and guest speaker lectures, design projects, and research laboratory visits, is open only to AcES participants. The course instructor teaches goal setting, learning styles, teamwork, engineering principles, and professional communication, and introduces potential career paths. Guest speakers cover topics such as: emotional maturity, resume design, career planning, professionalism, and undergraduate research opportunities. The class also visits campus research labs to learn about undergraduate research opportunities and emerging research in engineering and computing fields, and, usually, tours an industrial facility, such as a pharmaceutical plant or a wind turbine site. Students also begin to develop teamwork, engineering design, and professional communication skills through participation in engineering design projects.

Spring Engineering in History Course

All AcES cohorts before 2020 joined one section of the general education course, *Engineering in History*, which was taught by an AcES faculty mentor or project director. *Engineering in History* explores how engineering advancements have shaped society throughout history. While this programmatic element was successful in increasing interest and appreciation for engineering's value and role in societal development and in facilitating additional cohort development and faculty mentorship, changes in scheduling related to COVID, staffing, and

academic advising structure made it necessary to change this requirement to a recommendation. While AcES scholars are encouraged to select the *Engineering in History* general elective, currently, no section is dedicated to the AcES scholar cohort.

End of Year Celebration

To facilitate continuous networking among all stakeholders, an end-of-the-year social event is planned for all current and former AcES participants, including graduate and undergraduate student assistants, staff. This event provides an opportunity for upper-level students to continue engaging in the program and to share their experiences with younger students.

2.0 PARTICIPANTS

A total of 28 S-STEM scholars participated in the AcES program in five admission cohorts (2016 – 2020) as shown in Figure 1 below. The 2020 cohort consisted of second year students who participated in the 2019 first-year program elements without scholarship support and were awarded scholarship support beginning in summer or fall 2020. Due to the COVID-19 pandemic restrictions, no new first-year students were recruited into the AcES program for 2020.

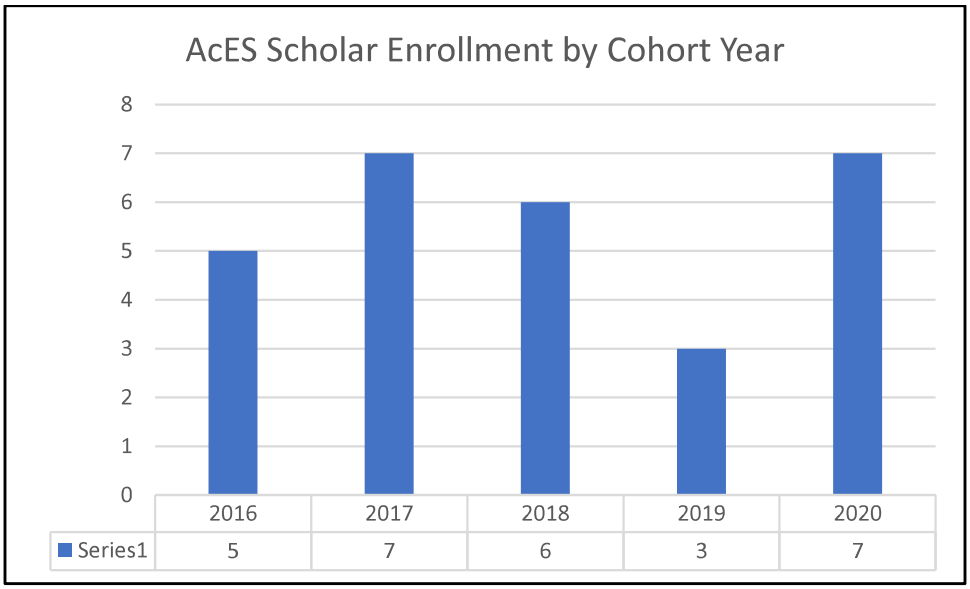

Figure 1. Graph of AcES S-STEM scholar enrollment, by cohort year (2016 - 2020)

Gender Distribution

Of these 28 students, eight (29%) were female and twenty (71%) were male. The 2019 cohort was very small, only three male students (and no female students), but four of the seven (57%) or the 2020 cohort was female. Gender data was taken from university records. While students were given an "other" option, all students in these cohorts selected either male or female, so no other gender options are included here. The specific cohort gender distribution is shown in Figure 2 below.

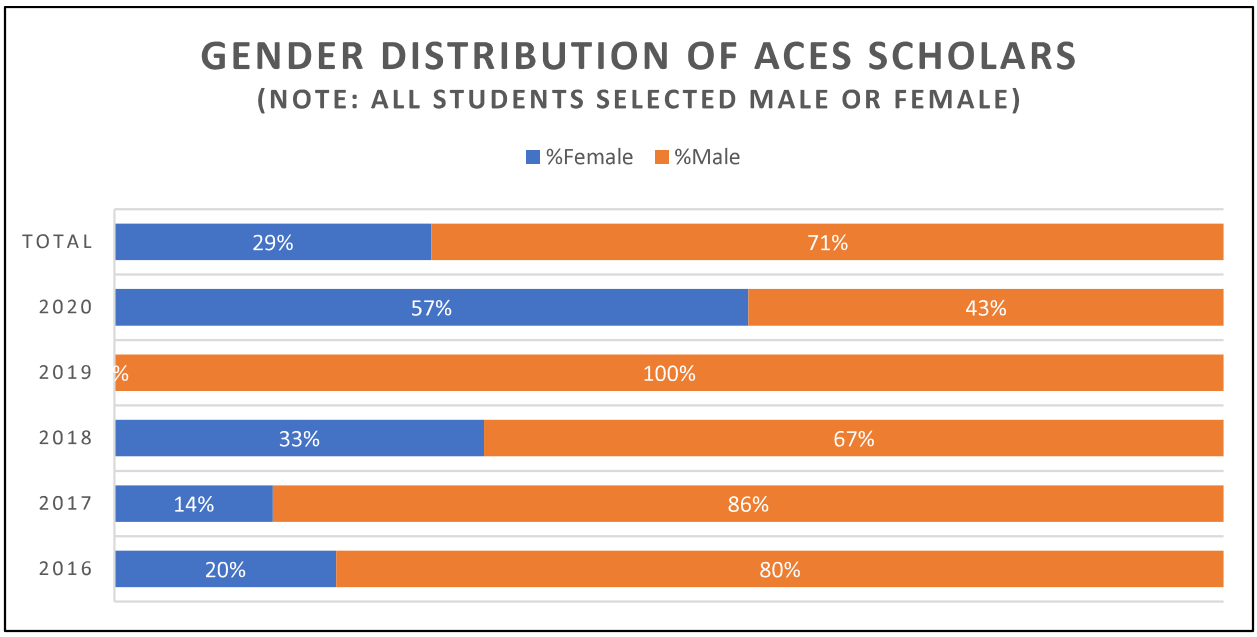

Figure 2. Graph of the gender distribution of the AcES S-STEM scholar cohorts (2016 - 2020).

While there was significant variation in the percent of female students between cohorts, the overall 29% female is higher than the engineering college's overall female admission percent during those years.

Race/Ethnicity Distribution

Of the 28 AcES S-STEM Scholars, seven (25%) were from ethnic or racial minority populations. Specifically, these students indicated their ethnicity as Hispanic or Latino or their race as Black or African American or more than one race, with one race being either Black or African American. The specific race and ethnicity (minority vs. majority) information is presented in Figure 3 below.

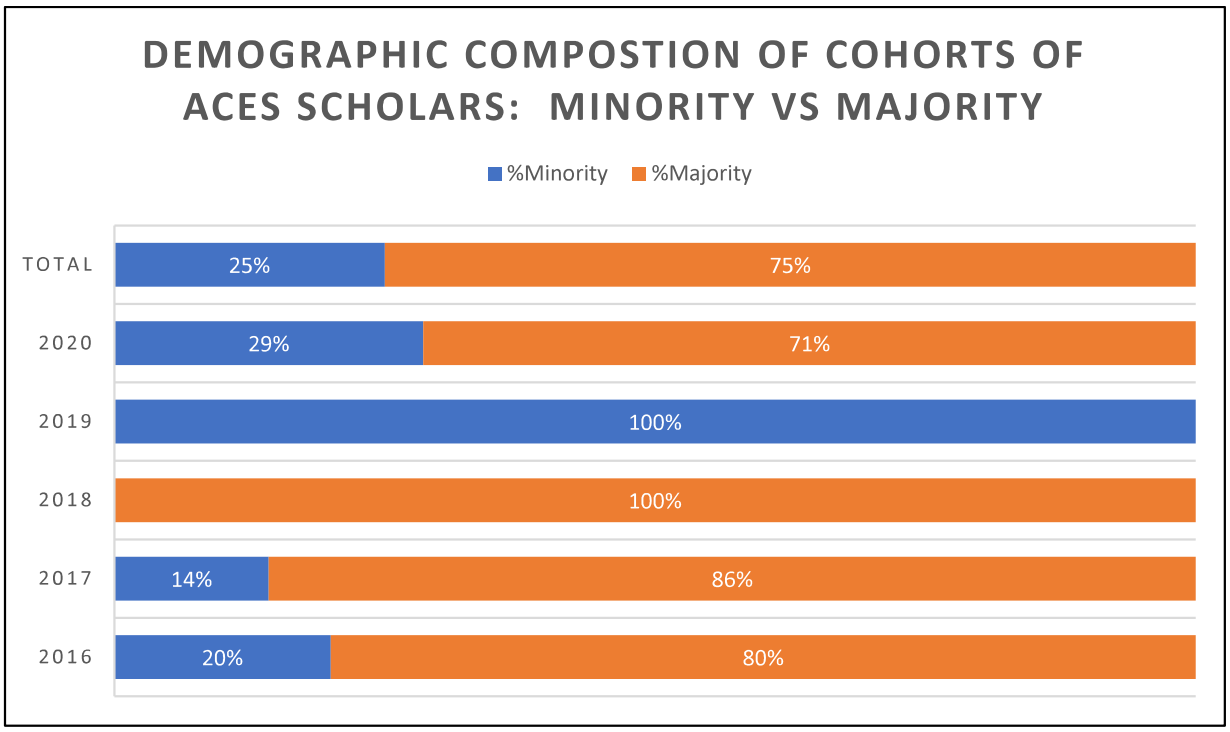

Figure 3. Graph of the race and ethnicity composition of the AcES S-STEM scholar cohorts (2016 - 2020).

The overall 25% racial or ethnic minority population of the AcES S-STEM scholars is higher than the racial or ethnic minority population of the engineering college during these cohort years. The following anomalies are noted: (1) the 2018 cohort of 6 scholars include 2 females and no students from an ethnic or racial minority; and (2) the 2019 cohort only had 3 scholars, all were male and were from racial or ethnic minority populations.

3.0 RESULTS

The NSF S-STEM funded AcES program research has resulted in eight conference papers and two invited presentations which focused on first-to-second year retention of AcES S-STEM Scholars, the AcES S-STEM Scholars' self-assessment of academic and professional success skills, and their feelings of institutional inclusion, engineering self-efficacy and identity [1], [2]. These results focused on attrition between the first and second years of college and indicated support for the Kruger-Dunning Effect, "a cognitive bias in which unskilled people do not recognize their incompetence in specific areas and often overestimate their abilities" [3], [4], [5]. Specifically, AcES scholars not retaining to the second year tended to enter college with unrealistic expectations: underestimating the time and effort required to succeed in their major and overestimating their ability to succeed with little effort [2], [3], [5].

This study focuses on AcES S-STEM Scholars' persistence to graduation. Presented in Figures 4 – 6, below, are the persistence results for all AcES S-STEM scholars and for the sub-categories of female AcES S-STEM scholars and minority AcES S-STEM scholars. Figure 4 below presents the educational outcomes of the AcES scholars, in total and by cohort (2016 – 2020). On that graph, "Grad ENGR" refers to the AcES S-STEM scholars who graduated or will

graduate (within a year) with an engineering or computing degree from the WVU Statler College of Engineering and Mineral Resources; "Grad Non-STEM" refers to the AcES S-STEM scholars who graduated will graduate (within a year) from WVU with a non-STEM degree, and "Left WVU" refers to those students who started in the WVU AcES program as S-STEM scholars, but left WVU sometime after their first year. The "Left WVU" AcES scholars did not graduate with any WVU degree.

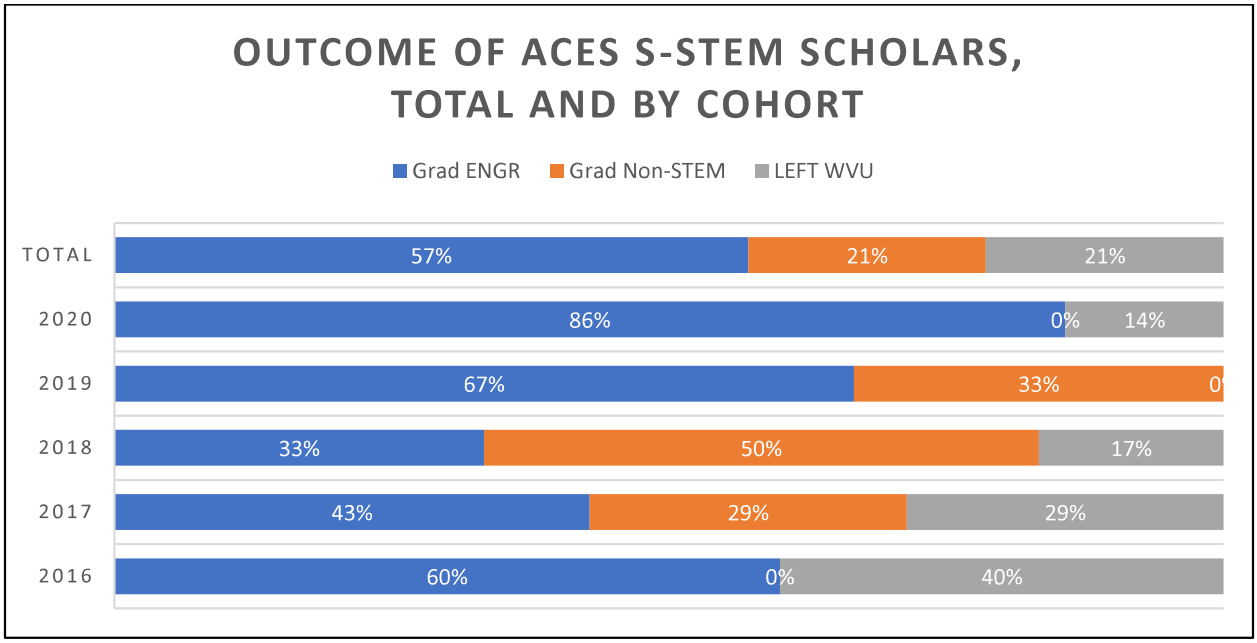

Figure 4. Graph of educational outcome of the AcES S-STEM scholars, by cohort (2016 - 2020).

Of the 28 AcES S-STEM scholars (2016 – 2020), 16 (57%) have earned B.S. degrees in a STEM field, and specifically in an engineering or computing field. Another six students (21%) earned degrees at WVU, but not in STEM fields. Two students earned degrees in Business, two students earned Criminology degrees, one student earned a degree in Interactive Design for Media and one student earned a degree in Management Information Systems. Each of these six students who started as AcES S-STEM scholars, but left the engineering college to pursue different degrees, ended up selecting degrees with elements of problem solving, design, and analytical thinking skills – all skills developed in early engineering courses and in the AcES program first-year experience.

Six of the 28 AcES S-STEM scholars (21%) did not complete a degree at this institution. Four scholars lost their scholarship because of low academic performance (GPA dropped below the scholarship renewal criteria) and left the university. Two students in good academic standing left the university. Of these scholars, two (one in good standing and one with a GPA issue) left the university following the spring 2020 term, partially due to frustrations of learning online through the early COVID-19 pandemic.

Overall, 79% degree completion and 57% STEM-degree completion rates are higher than the university overall degree completion rates.

Figure 5 below presents the educational outcomes of the eight female AcES S-STEM scholars, in total and by cohort (2016 – 2020). On that graph, "F_Grad STEM" refers to the female AcES S-STEM scholars who graduated or will graduate (within a year) with an engineering or computing degree from the WVU Statler College of Engineering and Mineral Resources; "F_Grad Non-STEM" refers to the female AcES S-STEM scholars who graduated or will graduate from WVU with a non-STEM degree; and "F_Left WVU" refers to those female students who started in the WVU AcES program as an S-STEM scholar, but left WVU sometime after their first year. The "Left WVU" students did not graduate with any WVU degree.

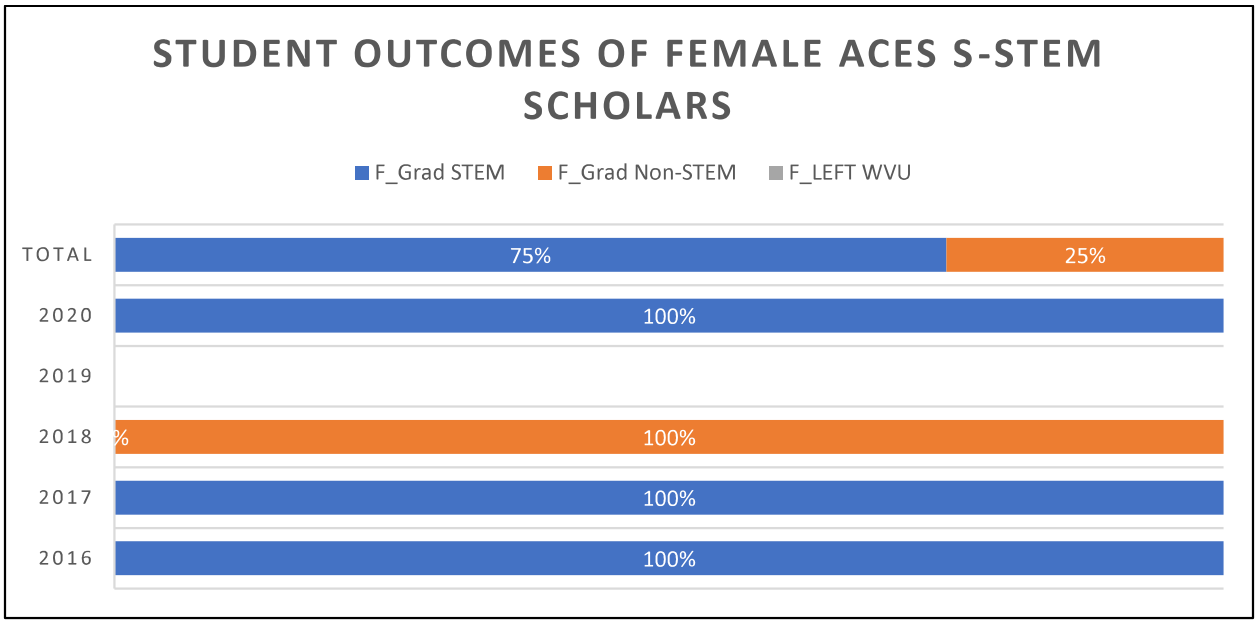

Figure 5. Graph of educational outcome of female AcES S-STEM scholars, by cohort (2016 - 2020).

Of the 28 AcES scholars (all cohorts), eight (29%) were female. The 2019 AcES S-STEM Scholar cohort comprised only 3 students, all male. The 2020 AcES S-STEM Scholar cohort contained the most female students; four of the seven scholars (57%) were female. The 2018 AcES S-STEM scholar cohort contained two female students (of 6 total scholars) and 2016 and 2017 cohorts contained only one female scholar each. Overall, two of the female AcES S-STEM scholars, both members of the 2018 cohort (the only female members of that cohort) completed non-STEM degrees. All six of the remaining female AcES S-STEM scholars completed (or will complete) engineering or computing degrees in the Statler College. No female AcES S-STEM scholar left WVU without completing a degree.

Figure 6 below presents the educational outcomes of the seven AcES S-STEM scholars from minority populations, in total and by cohort (2016 – 2020). On that graph, "M_Grad STEM" refers to the AcES S-STEM scholars from minority populations who graduated or will graduate (within a year) with an engineering or computing degree from the WVU Statler College of Engineering and Mineral Resources; "M_Grad Non-STEM" refers to the AcES S-STEM scholars from minority populations who will graduate from WVU with a non-STEM degree; and "M_Left WVU" refers to those students from minority populations who started in the WVU

AcES program as an S-STEM scholar, but left WVU sometime after their first year. The "Left WVU" students did not graduate with any WVU degree.

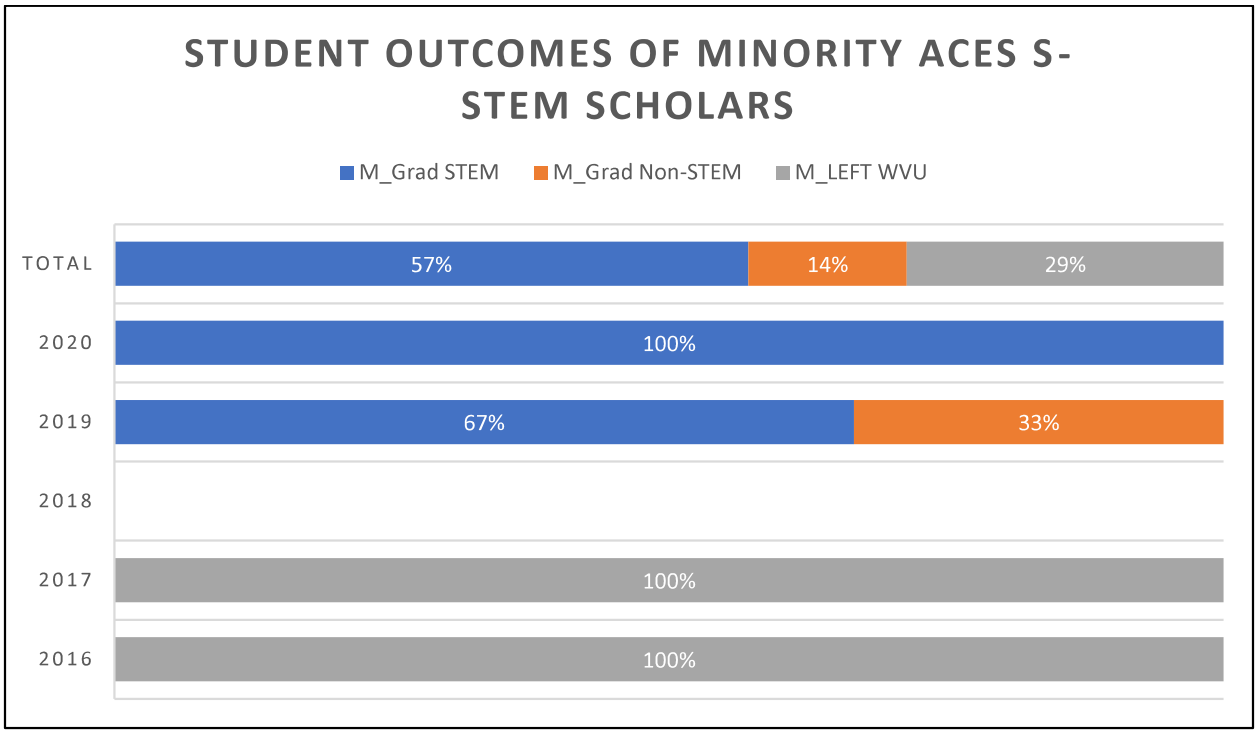

Figure 6. Graph of educational outcome of AcES S-STEM scholars from minority populations, by cohort (2016 - 2020).

Before 2019, only two AcES S-STEM scholars were from a racial or ethnic minority group, one in the 2016 cohort and one in the 2017 cohort. Both students left the institution before completing a degree. All five AcES S-STEM scholars from minority populations in the 2019 and 2020 cohorts are completing degrees at WVU. Four of these scholars are completing degrees in an engineering or computing field and one student will complete a Management Information Systems degree in the business college.

Overall, five of the seven AcES S-STEM scholars from minority populations (71%) are completing degrees at WVU, with four of them (57%) completing undergraduate STEM degrees in engineering or computing fields.

4.0 LESSONS LEARNED

Feedback from students who have completed or nearly completed their engineering degree and have persisted through the challenges of an engineering or computing education, even with the additional complications and challenges of COVID, reinforce the program objectives. Many students appreciate the cohort-building activities of the summer bridge and fall professional development course. Having the informal support of a faculty member and graduate students throughout the challenging first year helped students navigate through the unique challenges they faced at the university. Even when their academic advisor changed as they progressed to their engineering major departments, many students remained in contact with the AcES faculty and graduate student mentors throughout their college experience.

4.1 What Went Well/What to Keep

Early cohort-building experiences such as the team project and social events are valuable in helping students bond with their peers and with the program faculty and graduate assistants. Career exploration activities, such as the visits to on-campus faculty research laboratories, attending panels of engineers, and visiting engineering-related industrial sites provide motivation to work hard to prepare for an engineering or computing career and prepares the student for what to expect when they begin their career.

4.2 Suggestions for Improvement

If we were creating a new S-STEM program, we would consider making the following improvements: Improve recruitment activities, engage the upper-level students more fully into the program, improve near-peer mentoring, and increase the number of celebrations!

Recruitment

Recruitment has continued to be a challenge throughout this S-STEM project. We have attempted various methods, including sending out program literature to eligible students, calling students, announcing AcES at "High School Visitation Days" and reminding students of it at "New Student Orientation" in June of each year. Graduating high school students seem reluctant to commit to coming to college a week early and enrolling in a student success program. Many students believe they do not need any help as they start college. Low-income students, especially, believe they cannot miss the week of summer job income to join a 1-week summer bridge program. We have found that calling potentially eligible students and explaining the value of the program is helpful in getting students to register.

Upper-level Student Engagement and Near-Peer Mentoring

As students mature and move through their majors, they experience different challenges. While the type of support needed may change, many of these students would benefit from additional support, including opportunities to: maintain friendships and interact with their original cohort, assistance and guidance in finding professional and industry (internships, co-ops, shadowing, and job) experiences, and opportunities to "give back" to the program that helped them start.

One suggestion is to incentivize opportunities for upper-level students to interact more frequently with each incoming cohort. Opportunities may include: offering paid positions to AcES alumni to work with new cohorts of incoming first-year students during the one-week summer bridge and in the fall professional development course; establishing a near-peer mentorship program in which upper-level AcES scholars are paired with new AcES students; and encouraging senior students to participate in a "what I wish I knew when I started" panel discussion for a first-year student audience.

Other suggestions include hosting reunion events, industry speakers, and career-related discussions for upper-level students. Working closely with the Corporate and Career Services office, many events could be planned to meet the needs of the upper-level AcES students.

There are many ways to engage upper-level scholars. How it is accomplished is not as important as that it happens. Both the upper-level and entering scholars benefit through the near-peer interactions. First-year students benefit by hearing advice from the upper-level students and the upper-level student develop their confidence and engineering self-efficacy.

Celebration!

Celebration of all milestones is motivating! Students need to recognize accomplishments and encourage one another. Unfortunately, our budget model did not include funds to provide food for events and since food is an important part of student gatherings, our celebrations were limited to once a year (using funding from other sources) and didn't exist during COVID. Celebrations can be in-person gatherings or simply announcements of achievements on campus and through social media. Future programs should plan for these celebration experiences: celebrate the incoming S-STEM Awardees, celebrate those who move from the first-year experience to their engineering (or STEM) major, celebrate and recognize those who find internships, co-op, job-shadowing experiences or participate in study abroad experiences, and celebrate those who graduate and enter the workforce or pursue graduate school! Celebrating each milestone not only affirms those who have achieved that goal, but encourages and motivates those who are still working toward similar goals.

3.0 CONCLUSION

During the seven years of NSF funding, this program has served 71 students and supported 28 students with renewable S-STEM scholarships. While not all supported students graduated (or will graduate) with STEM degrees, many did. The many curricular and student support components of this program helped many more than the 71 AcES and 28 NSF S-STEM supported students and has truly contributed to adding more qualified and diverse engineers to the engineering workforce.

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