Challenges, Opportunities, and Impacts of S-STEM Projects: Insights for Institutional Capacity Building at Minority-serving Institutions

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Introduction

Purpose

It is widely understood that a skilled workforce capable of performance and innovation in the fields of Science, Technology, Engineering, and Mathematics (STEM) is a critical component of the Nation's economic health. The American Competitiveness and Workforce Improvement Act of 1998 established the National Science Foundation program now known as Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM). S-STEM is designed to positively impact the growth, development, sustainability, and diversity of the STEM workforce by providing scholarships to low-income academically talented students with demonstrated financial need pursuing degrees in STEM. Low-income students who may have potential to succeed in STEM and therefore contribute to workforce needs, often need additional supports to be recruited and retained to graduation in the exciting and rewarding, yet academically and emotionally challenging fields of STEM.

During the tenure of the S-STEM program, there is often a focus on the term "academically talented" used in the various solicitations. Academic talent is often equated to high grade point average (GPA) or scores on standardized tests such as the American College Test (ACT) or Scholastic Aptitude Test (SAT). Because low-income students frequently have less access to academic enrichment, test preparation, advanced placement, and other opportunities than their more affluent peers, their scores on these common measures may be lower even though many have the aptitude to become scientists and engineers. Consequently, the opportunity may be missed to affect the very students S-STEM was intended to serve. Within the phrasing of the S-STEM solicitation, the term "academic potential" is used almost interchangeably with academic talent to describe scholar requirements. This opens up potential S-STEM projects to consider additional favorable traits which may indicate a student's probability to succeed in pursuing and obtaining a STEM degree, especially if the project offers proven curricular and co-curricular activities and supplemental support to help student achievement. It also allows the opportunity to recognize that, with the proper financial and academic supports, individual students can potentially conquer educational and other obstacles that can constrain persons from low-income households and communities. Empowering those from diverse socioeconomic backgrounds to engage and master the STEM fields will thereby aid the progress of the national technical workforce.

S-STEM Background

The National Science Foundation’s (NSF’s) Scholarships in Science, Technology, Engineering and Mathematics (S-STEM) program provides funding for projects that support financially needy students in their pursuit of STEM degrees. Funding for the program comes from H1B Visa fees that companies pay when hiring foreign workers in STEM and other highly specialized
disciplines. The scholarships and other supports are provided through S-STEM with the overarching aim to increase the number of U.S. citizens and permanent residents entering the STEM workforce or graduate school upon completion of their degree programs. Recognizing that funding is not the only barrier that students with financial need face, the program also sponsors support activities that have proven to be effective means to improve outcomes related to student success.¹

The predecessor to S-STEM was the NSF Computer Science, Engineering, and Mathematics Scholarships (CSEMS) program. Over the years, there have been several iterations of CSEMS, followed by S-STEM. Two S-STEM projects are discussed in this paper. The first, Scholarships Creating Opportunities for Retention in Engineering (SCORE) at Southern University Baton Rouge (SUBR) was funded from 2007 through 2012. The second, Focus On Retention in Cohorts of Engineering Students (FORCES) at the University of Texas at Arlington (UT Arlington) was funded from 2009 through 2015. The S-STEM program was re-envisioned for the 2016 fiscal year to solicit projects that will yield more evidence and more widespread use of strategies that prove successful in the attainment of the program's goals. Specifically, there are now two strands: Strand I, S-STEM Institutional Capacity Building and Strand II, S-STEM Design and Development. As indicated by the title, Strand I awards are intended for institutions who have little or no experience with S-STEM or other NSF education funding opportunities. Strand II "seeks to leverage S-STEM funds with institutional efforts and infrastructure to increase and understand recruitment, retention, student success, and degree attainment in STEM..."² In this paper, we summarize some of the key features of the FY2016 revision of S-STEM, drawing distinctions between the current announcements and previous announcements under which our projects were funded. We then share insights that we believe will be helpful to investigators considering Strand I submissions, as those are closest in scope (but not equivalent) to our projects.

**Scope**

A number of factors are significant to individual schools and the populations they serve. For this reason, proposers to the S-STEM program must provide the rationale for their projects in terms of institutional context, student demographics, and existing services and program elements. Among minority serving institutions (MSIs), Historically Black Colleges and Universities (HBCUs) and Hispanic Serving Institutions (HSIs) have some of but not all of the same issues and therefore best practices. S-STEM wants to study what works best, where, and with whom.

This paper provides examples of approaches to seize the opportunity leading to successful methods which had a positive impact on students and project success. Not all approaches have been successful and therefore embody the challenges faced by programs, particularly in the settings of these MSIs. We take this chance to offer suggestions based on lessons learned from the missteps. Offer support for the new rules for S-STEM and how they can help projects to have better impacts on local students as well as the broader MSI community.
Institutional Context

The two S-STEM projects discussed herein were housed at two different minority-serving institutions. SUBR is an HBCU with 91.8% African American and 65.6% female enrollment (based on Fall 2014 data). Over 55% of Louisiana’s African American engineering graduates earn their degrees at SUBR. This is even higher than the national statistics, which indicate that HBCUs and HSIs award 33% of all undergraduate science and engineering (S&E) degrees awarded to African Americans and Hispanics. The university ranked 11th nationwide in 2003-04 for the number of degrees awarded to African Americans in engineering. Although African Americans represent about 13% of the US population, the group represents only about 3% of the engineering workforce.

UT Arlington has provided higher education to a diverse population for many years and was designated as an HSI by the Hispanic Association of Colleges and Universities (HACU) in 2014, after FORCES began. Based on 2006-07 data (just before the FORCES proposal was written), UT Arlington had an enrollment of approximately 19,205 undergraduate students of whom 53.2% were female, 14% were Hispanic, 12% were African American and less than 1% were Native American. The College of Engineering’s undergraduate enrollment in 2006-07 was 1,884 students, nearly 10% of the university’s. There were 410 students at the university who were registered with the Office for Students with Disabilities. Of those, forty-four (44), or nearly 11%, were engineering majors. National data at that time reflected enrollment of students from underrepresented groups in undergraduate engineering programs as 17.5% female, 5.5% African American, 9.3% Hispanic and 0.6% Native American. Enrollment of Hispanics and African American in engineering at UT Arlington exceeded the national figures while that of females and Native Americans lagged slightly behind the national figures. The exact figures are provided later in this paper.

Key S-STEM Program Elements

S-STEM Program Goals

The FY2016 S-STEM solicitation seeks projects that will yield more evidence and more widespread use of strategies that prove successful in the attainment of the program’s goals, which are to:

- increase the recruitment, retention, student success, and graduation (including student transfer) of low-income academically talented students with demonstrated financial need who are pursuing associate, baccalaureate, [or] graduate degrees in STEM and enter the STEM workforce or graduate study;
- implement and study models, effective practices, and/or strategies that contribute to understanding of factors of supportive curricular and co-curricular activities that affect recruitment, retention, student success, academic/career pathways, and/or degree attainment (including student transfer) in STEM of low-income academically talented students with demonstrated financial need; and
• contribute to the implementation and sustainability of effective curricular and co-curricular activities (e.g. curriculum, professional, and workforce development activities) for low-income academically talented students with demonstrated financial need, pursuing undergraduate or graduate STEM education.\(^8\)

Prior to FY2016, the S-STEM program goals were essentially the elements described in the first and third goals of the revised solicitation, namely:

• improved educational opportunities for students;
• increased retention of students to degree achievement;
• improved student support programs at institutions of higher education; and
• increased numbers of well-educated and skilled employees in technical areas of national need.\(^9\)

The program has always focused support on low-income students who are academically talented or demonstrate the potential to successfully complete STEM degrees and ultimately enter the STEM workforce. The main programmatic changes are in the structure of program strands, which are described in the introduction.

**Low-Income and Demonstrated Financial Need**

Prior to FY2016, S-STEM projects did not necessarily distinguish between low-income students and students with demonstrated financial need. For undergraduate students, demonstrated financial need is based on the awardee institution’s cost of attendance and the scholarship applicant’s estimated family contribution, which is determined by the Free Application for Federal Student Aid (FAFSA).\(^{10}\) All recipients of S-STEM scholarships must meet the program’s need-based requirement; therefore, it is imperative that project management teams work closely with the institution’s financial aid personnel, as students’ financial needs change and must be re-evaluated from year to year. It is equally important to obtain data from the financial aid staff members to help rationalize the number and amount of scholarship awards based on historical data for students like those who will be supported by the project.

**Academic Ability or Potential**

S-STEM awards have always been both need-based and merit-based. One unique aspect of the program is the broad definition of merit-based and the flexibility institutions are given in making the awards. In addition to the citizenship, enrollment, and financial need requirements, the S-STEM eligibility criteria state students must “demonstrate academic ability or potential.”\(^11\) While some projects tend to focus on this criterion in a way that limits selection to students who have high grade point averages and standardized test scores, others use it in a way to bolster the success of students who may not necessarily be top performers, but still have the potential to complete STEM degrees and even excel in STEM studies or in the STEM workforce. Both
projects featured in this article required less than a 3.0 grade point average for students to retain the scholarships each year, and both were successful in attaining improved student outcomes.

Studies have consistently shown disparities in exposure, access, and degree pursuits and completion between low-income students and their more affluent counterparts. These disparities are attributable to a wide range of factors. It is therefore important that projects funded by S-STEM do not further disadvantage the very students the program is intended to support. Care should also be taken not to equate low-income with race or ethnicity; low-income students come from all racial and ethnic backgrounds. Additionally, S-STEM project teams should implement strategies specific to the needs of the students they intend to support at their institution.

_Evaluation and Research_

Prior to FY2016, S-STEM projects were limited in their ability to contribute to the STEM education knowledge base. This was largely due to very stringent budget requirements. The budgets were limited to $600,000 plus indirect costs. A maximum of 15 percent of the total scholarship amount - not award amount - could be allotted for administrative and student support costs. In the most recent years (FY2012 through FY2015), only 5 percent of the scholarship amount could be allotted to project administration (salaries, fringe benefits, evaluation, dissemination, etc.); the remaining 10 percent could be allocated to student support (mentoring, tutoring, student travel, activities, etc.). Assuming a principal investigator (PI) would choose to maximize the administrative and student support allocations, the budget would break down as shown in Table 1. For awards prior to FY2016, a maximum of $90,000 was available for all student support and administrative costs, which made robust project evaluation and dissemination very challenging.

<table>
<thead>
<tr>
<th>Budget Parameter</th>
<th>FY2012 - FY2015</th>
<th>FY2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Award Amount</td>
<td>$600,000</td>
<td><strong>$650,000</strong></td>
</tr>
<tr>
<td>Maximum Scholarship Amount</td>
<td>$510,000</td>
<td>$390,000</td>
</tr>
<tr>
<td>Maximum Student Support and Administrative Costs</td>
<td>$90,000</td>
<td><strong>$260,000</strong></td>
</tr>
</tbody>
</table>

*Excludes indirect costs; total award amounts may exceed $600,000  **Includes indirect costs

Beginning in FY2016, all S-STEM projects are required to apply evidence-based practices to improve student recruitment, retention, graduation (and/or transfer) and pathways to the STEM workforce or graduate studies. They must also contribute to the knowledge base on STEM education. To help with this, the solicitation now specifies the team members who must be included to ensure successful project implementation. Among them is a researcher with expertise in educational, social/behavioral, or related areas who can help shape the program in a way that frames the study in the context of existing literature while extending the implications. Additionally, all projects must identify an evaluator who is not a part of the project team to collect and analyze project data.
Challenges, Opportunities, and Impacts

The following sections describe the implementation of several key components of both SCORE and FORCES. The intent is to provide readers with insight to some of the challenges encountered, opportunities discovered, and impacts realized through the projects. The impacts should be interpreted as observations rather than in a cause-and-effect manner; the program elements were not studied in that manner.

Recruitment and Selection

Because the funding was received late in our normal recruitment cycle, FORCES’ first-year outreach efforts to prospective applicants were somewhat limited compared to subsequent years. Upon receipt of the award notice, we made application and recruitment materials available on the Scholarships page of the College of Engineering’s website and sent public service announcements to local radio stations. We also emailed all students who applied to UT Arlington and expressed an interest in engineering advertising the scholarship opportunity. Initially, we received very few applications. We modified the subject line of the targeted emails to read “grant” instead of “scholarship” and the number of applications increased substantially. We did not collect any data or build this into our assessment; however, we speculate this was because our project targeted students who had characteristics that were not entirely typical of those sought by managers of other scholarship programs. There was no minimum grade point average required for initial selection; as long as students met basic requirements (described below), they had a chance of being selected for an award. In years two and three of the award, the engineering recruiter distributed flyers to students he met during visits to individual schools and college fairs. Emphasis was placed on local school districts with large minority enrollments.

In order to qualify for the scholarship, students were required to (1) be citizens of the United States, nationals of the United States (as defined in section 101(a) of the Immigration and Nationality Act), aliens admitted as refugees under section 207 of the Immigration and Nationality Act, or aliens lawfully admitted to the United States for permanent residence; (2) be new freshman undergraduate students accepted as full time majors in engineering at UT Arlington; (3) meet College of Engineering entry requirements for SAT or ACT score; (4) be ready for Pre-Calculus I or higher; and (5) demonstrate financial need, defined for undergraduate students by the US Department of Education rules for needs-based Federal financial aid.

FORCES sought to improve educational opportunities for engineering students who demonstrated financial need, with an emphasis on those from underrepresented groups. Table 2 summarizes the demographic data for the scholars by cohort. Roughly 30% (14/47) of the scholars were female, and about 47% (22/47) were underrepresented minorities. By comparison, the baseline data used in the proposal showed the undergraduate engineering population was comprised of 14% females and 23% underrepresented minorities.
Table 2. FORCES Demographics

<table>
<thead>
<tr>
<th>Cohort</th>
<th>Total No. Students</th>
<th>No. Females</th>
<th>No. Underrepresented Minorities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Fall 2009)</td>
<td>18</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>2 (Fall 2010)</td>
<td>10</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>3 (Fall 2011)</td>
<td>19</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

The average annual award amounts varied from $4,092 for Cohort 1 to $5,736 for Cohort 3; however, some students did receive the maximum $10,000 per year award allowed by NSF because of their level of financial need. The project budget was developed to allow for incremental changes in cost of attendance, and with flexibility to address individual students’ levels of financial need rather than simply awarding a consistent amount to each student.

At SUBR students were targeted primarily through the college’s recruitment efforts. Project staff also worked with the directors of the college’s summer programs – Engineering Summer Institute and the Summer Transportation Institute – to distribute applications to past participants who are in their senior years in high school. Additionally, application materials were made available online via the College of Engineering’s website (www.subr.edu/index.cfm/subhome/5). Recruiting entering freshmen was a persistent challenge for S-STEM projects at SUBR. In subsequent years, the College of Engineering recruitment activities, which followed the schedule of University Admissions, began to struggle. It was determined that those efforts did not garner the number and type of applicants needed for the College of Engineering. By Fall 2010 the College of Engineering recruiters began to focus more on high schools both inside and outside of the local area with pre-engineering and technology programs. The College also began working with other campus units and programs, including the Honors College, the Office of Sponsored Programs, and the Louis Stokes Louisiana Alliance for Minority Participation (LS-LAMP) to help promote the project and find applicants from their candidate pools. While these efforts increased the number of applicants, the project was never able to fill all the available slots.

Similar to the project at UT Arlington and in accordance with the solicitation in effect, in order to qualify for the scholarship, SCORE students were required to: (1) be citizens of the United States, nationals of the United States (as defined in section 101(a) of the Immigration and Nationality Act), aliens admitted as refugees under section 207 of the Immigration and Nationality Act, or aliens lawfully admitted to the United States for permanent residence, (2) be undergraduate students enrolled (or applying to enroll) full time in civil, electrical or mechanical engineering at SUBR (enrollment must be full-time for each semester), (3) have a minimum 2.8 cumulative grade point average, (4) meet university and College of Engineering entry requirements; and (5) demonstrate financial need, defined for undergraduate students by the US Department of Education rules for need-based Federal financial aid. The last cohort of scholars was additionally required to have a minimum cumulative ACT score of 21 (or equivalent).
Retention, Student Success and Graduation

At the time of these projects’ inception, according to Science and Engineering (S&E) Indicators 2004, “… women and underrepresented minorities leave S&E programs at higher rates than men and white students, resulting in lower degree completion rates…” The document further states that “… the gap in educational attainment between these groups and whites remains wide, especially in S&E fields…” noting that in 2000 underrepresented minorities earned college degrees at less than half the rate of whites, with the gap being wider in S&E fields. The American Society for Engineering Education (ASEE) reported that in 2003-04, only 5.1% of B.S. degrees in engineering nationwide were awarded to African Americans (67.1% were awarded to whites). The S&E 2016 report states,

The gap in educational attainment at the bachelor’s level between young minorities and whites continues to be wide, despite considerable progress for underrepresented minority groups over the past two decades. From 1980 to 2014, the percentage of the population ages 25–29 with bachelor’s or higher degrees changed from 12% to 22% for blacks, 8% to 15% for Hispanics, and 25% to 41% for whites [as reported by the National Center for Education Statistics, 2015]. Continuing differences in completion of S&E bachelor’s degrees reflect lower rates of high school completion, college enrollment, and college persistence and attainment by blacks, Hispanics, and American Indians and Alaska Natives.

SCORE at SUBR

Retention and Graduation. Table 3 presents the four-year baseline first-time full-time freshman class retention rate trend at SUBR at the time of the project. The data show that on average, the college lost 32.3% of its freshman class each year, (a retention rate of 67.7%) either because of students leaving the university or changing their majors. Closely related to retention is the graduation rate, as it is our goal to retain students through graduation. The data presented in Table 4 reflect the baseline graduation rates of first time full time freshman student cohorts who began matriculation six years prior to graduation. The college average was 23.4%, but when viewed by department, ranged from 8.9% to as high as 32.6%.

Table 3. Full Time Freshman Retention Rates in the College of Engineering

<table>
<thead>
<tr>
<th>Departments</th>
<th>2000-01</th>
<th>2001-02</th>
<th>2002-03</th>
<th>2003-04</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil and Environmental</td>
<td>52.4%</td>
<td>93.3%</td>
<td>70.0%</td>
<td>55.3%</td>
<td>67.8%</td>
</tr>
<tr>
<td>Electrical</td>
<td>64.8%</td>
<td>69.9%</td>
<td>63.6%</td>
<td>55.8%</td>
<td>63.5%</td>
</tr>
<tr>
<td>Mechanical</td>
<td>65.7%</td>
<td>63.6%</td>
<td>85.3%</td>
<td>72.1%</td>
<td>71.7%</td>
</tr>
<tr>
<td>Yearly College Averages</td>
<td>61.0%</td>
<td>75.6%</td>
<td>73.0%</td>
<td>61.1%</td>
<td>67.7%</td>
</tr>
</tbody>
</table>

Table 4. Freshman Class Graduation Rates in the College of Engineering

<table>
<thead>
<tr>
<th>Departments</th>
<th>2000-01</th>
<th>2001-02</th>
<th>2002-03</th>
<th>2003-04</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil Engineering</td>
<td>32.6%</td>
<td>8.9%</td>
<td>19.6%</td>
<td>30.8%</td>
<td>23.0%</td>
</tr>
<tr>
<td>Electrical</td>
<td>26.0%</td>
<td>19.9%</td>
<td>13.1%</td>
<td>31.2%</td>
<td>22.6%</td>
</tr>
<tr>
<td>Mechanical</td>
<td>23.5%</td>
<td>29.3%</td>
<td>27.6%</td>
<td>18.1%</td>
<td>24.6%</td>
</tr>
<tr>
<td>Yearly College Averages</td>
<td>27.4%</td>
<td>19.4%</td>
<td>20.1%</td>
<td>26.7%</td>
<td>23.4%</td>
</tr>
</tbody>
</table>
A survey was conducted in the College of Engineering to ascertain the trends in current students’ success rates in core courses, workloads and grade point averages. The survey was conducted using a small sample of freshmen and juniors. The survey also showed that on average, students have to take the core science and engineering courses more than one time before earning a grade of C or better. The details are provided in Table 5.

### Table 5. Student Success Rates in Core Science and Engineering Courses

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Average Number of Attempts before Earning a C or Better</th>
<th>Fraction of Students Earning a C or Better on First Attempt (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculus I</td>
<td>1.3</td>
<td>71.4</td>
</tr>
<tr>
<td>Calculus II</td>
<td>1.1</td>
<td>89.5</td>
</tr>
<tr>
<td>Physics I</td>
<td>1.4</td>
<td>65.0</td>
</tr>
<tr>
<td>Physics II</td>
<td>1.1</td>
<td>87.5</td>
</tr>
<tr>
<td>Electrical Network Theory</td>
<td>1.9</td>
<td>37.5</td>
</tr>
<tr>
<td>Statics</td>
<td>2.0</td>
<td>43.7</td>
</tr>
<tr>
<td>Dynamics</td>
<td>1.2</td>
<td>80.0</td>
</tr>
</tbody>
</table>

The students surveyed had taken Electrical Network Theory and Statics an average of 1.9 and 2.0 times, respectively before earning a C or better. Accordingly, the data reflect a very low first-time pass rate for these courses (37.5% and 43.7%, respectively). The survey also showed that relatively few students pass Calculus I and Physics I on the first attempt (71.4% and 65.0%, respectively). It was theorized that improving student learning and performance in core courses would improve student learning and performance in subsequent engineering courses, and would result in improved retention. The courses targeted were Calculus I, Physics I, Statics and Electrical Network Theory. At the time of the project, Electrical Network Theory was required for all engineering majors. During the course of the project, this requirement was eliminated for mechanical engineering majors. Therefore herein the data for SUBR will focus on the remaining three courses.

**Gatekeeper Course Readiness and Performance.** To support the students’ ability to succeed in core courses, they were required to participate in enrichment activities designed to strengthen mathematics and problem solving skills. Improving performance in these courses will have the direct benefit of improving student retention. If students are successful in the program, they are less likely to drop out.

A major enhancement component of SCORE was the Summer Enrichment in Mathematics and Problem Solving Program. The Summer Enrichment Program was developed to engage and immerse scholars in challenging and fun activities designed to further develop their interest in engineering and cultivate the mathematics and problem-solving capabilities. During the first summer of enrollment, entering freshmen scholars were required to participate in the eight-week summer program which provided applications-based hands-on activities. The once-weekly sessions were led by a graduate assistant. The weekly seminars/workshops provided the scholars with an introduction to engineering through interactive projects. They were also prepared in applying mathematics skills to engineering problems. Also scholars were allowed to take classes, one of which had to be a math course. As determined by their ACT scores, most of the scholars
were required to take Pre-Calculus I. Providing funding for the entering freshmen to take summer courses allowed them to progress faster toward being eligible to take the first Calculus course required in the Engineering curricula.

Additional academic enrichment was available through peer tutoring provided by the Center for Student Success (CSS) which offers peer tutoring free of charge to all students in many subject areas including calculus, physics and sophomore engineering courses. Peer tutors are selected by CSS from student applicants who have demonstrated high achievement overall and in the targeted classes. CSS tutors are available at scheduled times at a central campus location. Also, students in the engineering professional societies intermittently offer informal tutorial help in math, science, and engineering courses. Tutoring provided reinforcement of classroom learning to ensure students performed their best academically.

Additional Enrichment Activities. Additional enrichment activities included academic and professional development and mentoring. Scholars were required to attend a minimum of three academic and professional development seminars each semester. There were several opportunities available through CSS which offers seminars covering topics such as effective study habits, test taking skills and reading techniques. SCORE scholars were encouraged to attend weekly seminars arranged by the LS-LAMP program on various subjects including research presentations and graduate school preparedness. There were also opportunities available through the SUBR Chancellor’s Speaker Series to hear motivational talks. Mandatory mentoring was coordinated by project investigators in each engineering department who ensured that each participant was paired with a faculty mentor. Scholars met with mentors a minimum of twice per semester. The mentors were responsible for providing academic and professional counseling for students and monitoring of students’ academic progress. Scholars were required to meet with mentors for academic advisement where the mentors would review the students’ academic progress and ensure they were properly following the prescribed curriculum. Faculty mentors in each department worked with the students to help them apply for and be placed in relevant research or employment internships during each summer after their initial year of funding. While all scholars were required to participate in mentoring and academic enhancement or professional development activities, participation in other activities such as student chapter organizations was optional, but strongly encouraged.

Retention and Success in Gatekeeper Courses. Table 6 summarizes the first-time success rates in the targeted core courses compared to the baseline data. Of the 17 original Cohort I participants, 13 (76.5%) passed Calculus I with a C or better on the first attempt. A total of eight (61.5%) passed Physics I with a C or better on the first attempt (note the percentage is based on the 13 remaining Scholars who actually took Physics I); five had to take Physics I twice before passing. A total of 10 (76.9%) Cohort I Scholars passed Statics with a C or better on the first attempt. Two students did not enroll in Statics (or Statics/Dynamics for electrical engineering majors) with the cohort; one changed his/her major before taking the course. One student earned a C or better on his/her second attempt. For Cohort II, only one student had to take Calculus I more than once to pass with C or better; this was the one who left the university to pursue religious studies. Six students passed Physics I with a C or better the first attempt; two had to take Physics I twice before passing. Three passed Statics with a C or better the first time (again,
note the Physics I and Statics percentages were calculated using the students who remained in the program long enough to take these courses).

Table 6. S-STEM Scholar Success Rates in Core Science and Engineering Courses

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Average Number of Attempts before Earning a C or Better</th>
<th>Fraction of Students Earning a C or Better on First Attempt (%)</th>
<th>Fraction of S-STEM Scholars Earning a C or Better on First Attempt</th>
<th>Cohort 1 (%)</th>
<th>Cohort 2 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculus I</td>
<td>1.3</td>
<td>71.4</td>
<td>76.5 (n=17)</td>
<td>91.7 (n=12)</td>
<td></td>
</tr>
<tr>
<td>Physics I</td>
<td>1.4</td>
<td>65.0</td>
<td>61.5 (n=13)</td>
<td>75.0 (n=8)</td>
<td></td>
</tr>
<tr>
<td>Statics</td>
<td>2.0</td>
<td>43.7</td>
<td>76.9 (n=13)</td>
<td></td>
<td>37.5 (n=8)</td>
</tr>
</tbody>
</table>

Due to staffing limitations, there was no summer training for Cohort II. Cohort II also had additional selection criteria of minimum 21 ACT (or equivalent). Of the 12 students in Cohort II, one left SUBR before entering the second semester. We were unable to contact the student after they left the university. One left the institution after completing two semesters to pursue religious studies. One left Engineering after completing two semesters and changed their major to Architecture. One was removed from the scholarship after the first semester due to extremely low performance. The remaining eight of 12 retained S-STEM funding the entire 2-yr period. Only one student had to take Calculus more than once to pass with C or better. This was the one who left the university to pursue religious studies. Six students passed Physics I with a C or better the first try. Two had to take Physics I twice before passing. Three passed Statics with a C or better the first time.

A total of 11 of the 12 Cohort I scholars who remained in engineering continued and graduated. Of the eight Cohort II scholars that retained funding, six have graduated and two are still matriculating in engineering and are expected to graduate this year. The one student who lost S-STEM funding after the first semester persisted in engineering and will graduate this year.

**FORCES at UT Arlington**

**Retention and Graduation.** In” Fall 2006, the College of Engineering at UT Arlington surveyed approximately 150 students who started their freshman year (Fall 2005) as engineering majors but who were not enrolled as engineering majors at the beginning of their sophomore year (Fall 2006). Of the many issues that students mentioned, two emerged as primary for students who left engineering. The first issue for about 20% of the students surveyed was the decision that they did not want to major in engineering. From similar surveys in other years, some of the reasons for changing majors included lack of preparation in math and physics and a distrust about the engineering job market. The second primary issue was that nearly 30% of the non-retain students had been put on academic probation due to low grades.

FORCES activities were designed to improve retention by bolstering academic performance beginning with improved calculus readiness before the first semester. This involved two key components - community building through cohorts and improved calculus readiness and
performance. The strategies and some of the impacts of those strategies are presented in the sections that follow. Additional details can be found in the article “Mathematics Performance and First Year Retention of Students in Engineering Learning Communities.”

**Improved Calculus Readiness and Performance.** FORCES scholars that were not ready to enter Calculus I enrolled in Consolidated Pre-calculus, referred to as Jump Start Math (JSM) during the summer prior to their first Fall semester. JSM combined the elements of algebra, trigonometry and pre-calculus to prepare students to successfully enroll in and complete Calculus I. Students also participated in tutor-led study groups as a mandatory component of the project. The implementation of both JSM and study groups evolved as formative assessments provided feedback that led to program improvements.

**Cohort Community Building.** Studies indicate that students who are connected to their peers socially as well as academically are generally retained at higher rates than those who are not; learning communities help students develop these connections. For this reason, we developed Freshman Interest Groups (FIGs) for each entering FORCES cohort, building upon the university’s existing FIG structure and resources. One of the FIG requirements was that students take a prescribed set of courses as a cohort. The required courses for the FORCES FIG were:

- UNIV 1131 – College Adjustment
- MATH 1426 – Calculus I
- XE 1104 – Introduction to Engineering (all FORCES scholars took the same section regardless of major)
- XE 1105 – Introduction to “X” Engineering (cohorts within different engineering majors)

FORCES scholars’ performance was compared to their peers who entered during the same semester. Two groups were chosen for comparison: (1) students enrolled in other engineering FIGs and (2) remaining first-time freshmen in the College of Engineering who were not enrolled in FIGs. FORCES scholars consistently enrolled in Calculus I or higher at a higher rate than their peers (as expected because it was a scholarship requirement), and they consistently completed Calculus I with a grade of C or better during their first fall semester of enrollment. Table 7 shows these results for Cohort 3 students who entered in Fall 2011.

<table>
<thead>
<tr>
<th>Group</th>
<th>Total Number of Students</th>
<th>Enrolled in Calculus I or Higher (%)</th>
<th>Enrolled in Calculus I (%)</th>
<th>Completed Calculus I with a C or Better (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORCES</td>
<td>19</td>
<td>100</td>
<td>100</td>
<td>63</td>
</tr>
<tr>
<td>COE</td>
<td>311</td>
<td>46</td>
<td>39</td>
<td>27</td>
</tr>
<tr>
<td>Other FIGs</td>
<td>85</td>
<td>61</td>
<td>55</td>
<td>33</td>
</tr>
</tbody>
</table>

Table 7. Comparison of Calculus Enrollment and Performance for Fall 2011

Figure 1 shows the average retention rates from the baseline year for all three FORCES cohorts and the comparison groups. An average of 52% of FORCES scholars entering in Fall 2009, Fall 2010, and Fall 2011 were retained through their first year, 59% were retained through their second
year, and so on. Note that Year 4 only contains two data points for each group, representing the cohorts that entered in Fall 2009 and Fall 2010 only, as fourth year data for the Fall 2011 cohorts had not yet been collected and analyzed at the time of this writing. By comparison, peers in the College of Engineering had first and second year retention rates of 50% and 38%, respectively, on average. Peers in other FIGs performed comparably to the FORCES cohorts. Overall, students in learning communities were retained at higher rates than those who were not in learning communities. We note, however, that the results varied for each separate cohort, as did the level of significance of the results. The FORCES retention rate was never significantly different from the other engineering FIG students.

![Figure 1. Average Retention Rates from Year of Entry](image)

Figure 2 shows the graduation rates of the three cohorts from 2009-2011 for COE, FORCES and other engineering FIGs. While the graduation rates for the 2009 and 2011 cohorts appeared insignificant, the 2010 cohort showed a significantly \( (\alpha = 0.1) \) greater graduation rate for FORCES students compared to the overall COE.

**STEM Workforce and Graduate Studies Preparation**

Internship and research opportunities are invaluable in providing students with the experience and exposure they need to achieve success in their studies as well as in their post-graduation endeavors. Companies want to hire new graduates who have had experience as interns, and graduate schools want to recruit high academic achievers who have research capabilities. Both projects had objectives to prepare scholars for the engineering workforce and/or advanced studies. Students were strongly encouraged to participate in either internship or research opportunities. These efforts were coordinated by faculty members in conjunction with career services personnel and research programs with whom the colleges had established relationships. Opportunities included professional development and/or research seminars each semester that focused on topics such as résumé writing, interviewing skills and etiquette, transitioning from undergraduate studies to the
workforce, etc. During some seminars, S-STEM scholars presented their internship and research experiences to their peers. Students were also encouraged to participate in Career Fairs which draw local and national industries and Graduate School Fairs where representatives from several graduate programs come to recruit students into research internships and degree programs.

An interesting challenge surfaced during project implementation that resulted in a “catch-22” for some of the scholars. The more ambitious students regularly pursued research and internship opportunities. Some, as they excelled academically, received merit-based scholarships from other sources. This resulted in reduced financial need, and in some cases, rendered the students financially ineligible for the scholarships.

Summary

S-STEM provides funding to support low-income students intending to pursue degrees in STEM disciplines with an ultimate aim of improving the Nation’s workforce. The Strand I S-STEM proposals are provided to help institutions new to the program to establish the student support structures and organizational culture proven to help students with financial need to excel beyond their economic circumstances. The structures needed should center around needs of the students in their institutional contexts. In addition to knowledge and use of institutional data such as demographic, retention, and graduation, it is important to gauge the specific climate of the programs and the student situation. Various data sources and assessments are useful to determine the nature of local problem(s) related to the S-STEM program goals and to determine the best use of existing resources as well as to adopt and/or adapt services to aid the project teams in achieving their goals.

Since the time of the projects discussed in this paper, S-STEM has added a focus on “knowledge generation.” New projects should seek to couch locally identified problems and needs in the
larger context of educational research to help the broader STEM education community determine what interventions work best with scholars in their environments.

The challenges faced by S-STEM investigators can potentially lead to breakthrough ideas for solutions that may turn into opportunities to impact students on individual campuses and at STEM departments nationwide.

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