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NSF BEATS – Creating an Academic Innovation Ecosystem to Drive Student Success

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NSF BEATS

Creating an Academic Innovation Ecosystem to Drive Student Success

The overriding objective of the National Science Foundation funded Broadening Ecosystem Attributes for Talented Scholars (BEATS) project is to recruit, retain, develop, mentor and graduate low-income, underrepresented engineering and computer science students.

Historically underrepresented engineering students (URES) suffer 60% attrition in their freshmen cohort leading to only 40% earning a B.S. degree in engineering. Three key reasons are poor teaching and advising; the difficulty of the engineering curriculum; and a lack of "belonging" within engineering. Each, in some way, erodes a student's self-efficacy, or confidence in his or her ability to perform [1]. The American Society of Engineering Educators conducted two recent national studies on freshmen engineering cohort retention: *Going the Distance* and reported the following B.S. degree completion outcomes by ethnicity: Asian Americans-66.5%, Caucasian-59.7% / Hispanic/Latino-44.4% , Native American-38.6%, African American-38.3%, and All Females-61%. [2]

The attrition problem is concentrated in the 1st generation, low income, urban and rural high school student populations. As evidenced by their SAT Math achievement scores and high GPA's which prompted their admission, these students are smart. However, they received their STEM education in low performing urban and rural high schools and were raised in highly challenged under-resourced neighborhoods. Research shows that these talented students succumb to the intensity of the 1st and 2nd year university math/science courses. The S-STEM BEATS project builds upon prior NSF S-STEM and STEP projects lessons and practices which proved S-STEM scholars will thrive best when embedded and engaged in an academic innovation ecosystem which allows students to benefit from the support talents and knowledge of the community.

The prime S-STEM BEATS project goals are:

1) To recruit, retain, develop, mentor and graduate low-income, first-generation engineering and computer science students considered underrepresented by NSF. The overriding expected outcome for BEATS Scholars is their persistent mindset to degree completion at rates equal to or higher than the average national percentage achieved by all engineering freshmen and transfer cohorts as reported by ASEE.

2) The current S-STEM BEATS project builds upon prior NSF S-STEM and STEP projects lessons and practices that strongly indicate S-STEM scholars will thrive best when situated and engaged in a broader underrepresented engineering student (URES) peer-supportive multicultural academic community. The program has developed an academic innovation ecosystem in which S-STEM scholars will be embedded in order to benefit from the talents and knowledge of over 300 underrepresented engineering peers. However, the NSF scholars will be the strategic focus of the BEATS' academic and social integration programs that include specialized counseling, mentoring, and professional development but will not exist as a separate S-STEM cohort apart from peers. To that end, a collateral project objective is to further develop a more cohesive multicultural community in which S-STEM low income and "At Risk" scholars can gain a strong sense of belonging, self-efficacy, teamwork and collective sense of academic purpose.

3) Thirdly, the project team seeks to gain further knowledge and understanding of the relationship between the curricular and co-curricular programs and the positive quarter-to-quarter persistence to degree completion percentage achieved so far by low income URES generally, and S-STEM scholars over the past S-STEM and BEATS project.

The Persistence In Engineering (PIE) academic and social integration approach addresses this retention challenge by building successive URES cohorts into a peer-supportive community pursuing academic mastery, engagement in the engineering research and professional activities as counter measure to close these disparities. Foremost among these interventions are the programs to address the three critical transition points that lead to high attrition among URES in both the national context and at the university—(I) Freshmen transitioning from high school, (II) Rising third-year URES entering the engineering 'gateway' courses that often contribute to student attrition, and (III) Incoming community college (CC) students who transfer into engineering and computer science gateway courses and its fast-paced, competitive quarter system. These transitions can and do impede academic and social integration as well as reduce student involvement, vigilance, and self-confidence that undermine a "sense of belonging" and fit in the engineering milieu.

The program has designed curricular and co-curricular interventions targeted at these *critical transition points* in order to close the academic and social gaps that constrain low-income, first generation students, new and continuing URES rising from the math/science prerequisites core into the research oriented engineering gatekeeper courses. Also included are the community transfer students encountering engineering courses in a research university for the first time.

The Critical Transition Program (CTP) creates a 'collective self-efficacy' culture to foster persistence and achievement in engineering. To have robust effectiveness, the summer programs must be reinforced by follow-up first quarter interventions that engage URES in collaborative academic behavior, challenging cognitive and emotional academic activities that foster a persistence mindset in engineering. Hence the CTP is organized into summer and academic year components as follows:

Summer Residential CTP consists of three graded courses detailed below that address the three CTP attrition points and populations described above.

> Freshman Summer Bridge is a two-week, residential summer program for incoming freshmen. Summer Bridge provides advanced preparation and early exposure to Fall Quarter math, chemistry, and computer science curricula. The primary purpose of Summer Bridge is to jump-start the "community building and bonding" process early and create a built-in expectation of academic excellence. These principles of excellence are reinforced by intensive classroom instruction and collaborative learning workshops that promote group study and team problem solving.
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> Bridge Review for Enhancing Engineering Students (BREES) is a rigorous, two-week, residential, summer program (taught by graduate students) that provides an intensive introduction to key topics covered in core, engineering 'gatekeeper' courses. BREES

covers concepts and problems not previously encountered by most students who have just completed the math/science prerequisite courses. By providing early exposure to the rigors of these topics, BREES helps URES gain confidence in their ability to perform. This is particularly crucial for low-income, transfer students who are new to research universities and the engineering culture. BREES actively engages URES in a community of learning around coursework and other project-based, problem solving activities.

Computing Immersion Summer Experience (CISE) is s 3-week coding and computer science project instruction for freshmen and community college transfer students majoring in Computer Science and Electrical Engineering just prior to fall classes. The first week of the program in an intense computer science course where students attend class for 4 – 5 hours per day, During the second and third weeks participating students are integrated into the Bridge and BREES Program where they continue to take the computer science course for 2 hours per day and a second course math or engineering course.

Academic Year CTP: Three programs characterize the academic year intervention PIE system:

E87 Course: Introduction to Engineering Disciplines, for freshmen students, provides a team research component in cutting edge labs under faculty guidance, as well as instruction in engineering problem solving tools such as Matlab usage, learning styles, study skills and time management methods. All freshmen which include some NSF scholars are enrolled in the E87 course.

Academic Excellence Workshops (AEW) meet twice weekly for two-hour sessions solving difficult math/science problem sets designed to achieve mastery in math and science coursework

Structured Study Nights (SSN) sessions are aimed to produce B or better grades in mid-term and final exams for all class levels. SSN facilitators review confusing math, science, engineering and/or computing problems to develop students' understanding of important concepts. SSN was held twice per quarter during the academic year.

Course Selection and Counseling methods ensure a critical mass of students are enrolled in the same math, science, or engineering course sections at the same time frame and with a preferred faculty and TA team.

Clustering System and Academic Counseling Twice a quarter, 'At Risk' URES are counseled as a group and clustered in the same math/science and engineering course sections and hours. Clustering methods support group study and AEW and SSN interventions. The NSF BEATS project has provided the funds to improve these interventions by utilizing PhD students to facilitate the teaching and learning in the AEW and SSN sessions. The AEW are designed around these clusters and students self-arrange group study in the dorms.

24 hour Active Learning Center. The Learning Center is situated below the Dean of the Engineering offices and across from the staff offices. This physical space is both a study space and a meeting space for three student engineering organizations; a dual purpose that has established strong 'sense of belonging' in the School and the university'.

Professional Development Programs

The professional development program is designed to develop students' skills in networking, interviewing, and branding.

Resume Workshop and Critique sessions conducted in early fall quarter. All entering freshman and transfer students participate in a resume workshop lead by industry professional to create their resume. Later, these and continuing students meet on-on-one with industry professionals to fine tune their resume in order to obtain internship and full time positions

Corporate Gamesmanship is an informal introduction to industry representatives aimed at new students. Gamesmanship features workshops for all class levels (e.g. interviewing skills, graduate school, leadership characteristics, etc.) and mock and real interview with feedback.

Scholarship and Recognition Banquet Scholarship in an event in which industry and foundation representatives recognize scholarship recipients for their achievements and also provides an opportunity for students to grow their networking.

Corporate Roundtable (CRT) is the highlight industry and professional development event of the academic year. Fifteen to twenty engineering companies purchase tables to discuss their companies' business and the opportunities for summer internship and full-time engineering careers. Company representatives host tables in which 6-8 students are assigned based on the interest of both the company and the student. The CRT features a networking hour followed by a dinner round and a dessert round. In the first round each student presents a 1-minute pitch on their goals and interest. Industry members then begin a coaching exchange and interaction with the dinner group. In the second round, students move to a second industry table and present a 2-minute review of their resume and skills sets. Industry guides the table interaction around their company's business and coaching on career planning and corporate culture.

Program Results

The CTP and CALC activities shaped an ecosystem of self-efficacy and belief in academic achievement among the freshmen that mirrors the collective peer behavior of upper division students.

The participation of students in the NSF BEATS Program from the programs beginning is listed below. The table below indicates the number of students participating each year with the average GPA of the students participating in the program compared to those not participating in the program.

Year	GPA NSF (# scholars)	GPA Non-NSF (# students)
2017-18	3.221 (39)	3.134 (222)
2018-19	3.249 (42)	3.133 (225)
2019-20	3.406 (40)	3.319 (255)

Table 1: GPA Comparison of NSF to Non-NSF students.[3]

The GPA represents the cumulative GPA of the students after one academic year from Sept to June each year. As the table indicates the GPA of the NSF scholars increased each year. Of the students participating in the NSF BEATs program, 20 have participated in the program from 2017- 2020 and 6 participated in the program from 2018 – 2020. During the 2019-20 academic year, 42 student participated in the program. However, only 40 participated for the full academic year. Of the 2 students who did not participate for the full academic year, one graduated in winter 2020 and the other transferred to a major outside of engineering.

NSF BEATS was independently assessed to determine achievement data. Each year students are assessed and the assessment results are summarized below. For the 2019-210 academic year, within this cohort of 42 students, 57.1% of students are low-income (having ever received Pell Grant monies), 38.1% are first-generation college students, 100% are from underrepresented racial minority groups, and 40.5% are female. 26 cohort members were previously BEATS scholars. Below are the specific objectives on which students were assessed.

Outcome 1: To retain 90% of freshmen S-STEM Scholars to continue to the second year
Outcome 2: To retain a minimum of 90% of S-STEM new transfer students to their 2nd year in the School),
Outcome 3: To ensure that a minimum of 90% of S-STEM Scholars participate in the active learning community
Outcome 4: To ensure a minimum of 60% of S-STEM Scholars earn a "B" or better in the Math, Science and Engineering "gatekeeper" courses.

For the 2019-2020, academic year, 100% of the freshman were retained to their sophomore year and 100% of the new transfers were retained through the first year. The table below indicated the participation rate of student is the professional development and academic activities held throughout the academic year

Professional Development/Mentoring Activities	NSF Students	Non-NSF Students
Summer Programs	90.0	87.2
Resume Critique	31.0	21.1
Corporate Gamesmanship	54.8	36.7
Corporate Round Table	40.5	18.7
At least 1 PD event	64.3	44.6
Structured Study Night (Avg # attended of 4)	1.10	0.67

Table 2: Activity Participation Rates during the 2019-20 academic year[3]

Only 47.6 % of the NSF students attended at least 1 Structured Study Night and 100% of eligible students participated in the Academic Excellence Workshop. One of the reasons for the low turnout two of the six possible SSN were cancelled in March 2020 due to the pandemic. To increase participation in the program will implement the recommendation provided by the independent assessment team, to specify a threshold of participation in professional development and academic support events.

Also assessed were the end of year grades in the engineering gatekeeper courses and the cumulative GPA of the students. Out of 80 final course grades representing 75 students, the cumulative of the NSF scholars was 3.39 (based on 79 courses, 1 course was taken for a letter grade) while that of the non-NSF scholars was 3.2. Gatekeeper courses are the prerequisite courses a student must pass before taking an engineering course. Looking at all 80 courses 82.5% of the grades were B or higher. During the 2019 20 academic year, fifteen NSF students graduated. Of those students, the average GPA was a 3.4 and 93.3% (14/15) of the students graduated with a GPA of 3.0 or higher [3].

For the 2020-21 academic year, to support students during remote learning due to the COVID-19 pandemic, the CEED Program transitioned its summer and academic year programs as well as its professional development program online. To provide additional academic support to transfer students during the BREES Program, tutoring was added during the evening Monday- Thursday for the 2 week duration of the program. Additionally, Structured Study Nights were offered once per week for freshman math and science classes and twice per week for introductory engineering courses for new transfers and continuing students.

The discussed NSF BEATS student outcomes support the need for such critical programs for low income and “At Risk” students. Participants can gain a strong sense of belonging, self-efficacy, teamwork and collective sense of academic purpose. We hope the lessons learned from this effort will inform other schools of engineering on effective retention elements that seem to be closely associated with increased persistence of URES students.

References

[1] R. Marra, K. Rodgers, D. Shen. B. Bogue, "Leaving Engineering – A Multi- Year Single Institution Study", *Journal of Engineering Education,* Vol 101, pp. 6 – 27, Jan. 2012

[2] B. Yoder, Going the Distance: Best Practices and Strategies for Retaining, Engineering, Engineering Technology and Computer Science Students, *American Society of Engineering Education*, 2012

[3] H. Whang Sayson, "2019-20 NSF BEATS Evaluation Report", UCLA Center for Education Assessment Los Angeles CA, USA, Final Report, August 2020