Promoting Research and Entrepreneurship Skills in Freshman Engineering Students: A Strategy to Enhance Participation in Graduate and Enrichment Programs

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Abstract

This paper describes the structure, implementation strategy, and early results of an undergraduate NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) Program aimed at: (a) increasing the number of graduating engineers with research and entrepreneurship experience, (b) preparing students for the future needs of their fields through graduate study, and (c) increasing the low on-time completion rates of current dual degree (BS+MS and BS+MBA) programs. The scholarship program, in addition to a series of tailor-made undergraduate research courses and activity offerings, provides a comprehensive system of regular academic advising, mentoring, and opportunities for professional and social development. Students are guided from the beginning to develop ownership in their education by documenting their participation in a personal e-Portfolio, along with the attainment of the necessary academic, research, and entrepreneurship skills needed to excel in today’s fast changing work environment. This S-STEM program provides stipend support for 32 students for the sophomore to senior years for students selected through a competitive application process.

To build interest in the scholarship program and develop a diverse cohort of students to compete for acceptance into the program, two distinct but interrelated programs were executed during the 2014-2015 school year. The first program integrated the Challenge Based Learning pedagogy into the required freshman course Engineering Foundations to build a learning community of students with exposure to the Engineering Research and the Entrepreneurial Processes. The results of this were successful in both developing interest in the scholarship program, 89 of 222 (40%) students in the course expressed interest in applying, and providing the students with exposure to research and entrepreneurship. The second program involved the recruitment of a cohort of five underrepresented minority freshman engineering students (Freshman Scholars). The Freshman Scholars participate in a year-long preparatory program sustainably structured using existing programs in the university system for academic support, faculty and peer mentoring, monthly socials to interact with university and industrial professionals, and workshops and seminars providing research and entrepreneurship experiential learning opportunities throughout the year. Four of the five students (80%) went on to compete for and gain acceptance into the first cohort of students in the S-STEM scholarship program.

The first cohort of Freshman Scholars was evaluated by survey at the end of their freshman year on the various aspects of the program and strongly agreed overall that the program made them more confident in their abilities (3.80/4.00) and that participation improved their freshman year performance (3.60/4.00). The aspect of the program ranked highest by students (3.82/4.00) was peer mentoring, which was provided through an established university program. Trained peer mentors provided social support as well as resume and research plan development support. Also highly rated programs by the students were community engagement (3.57/4.00), and a variety of research skills workshops and seminars (3.43/4.00). Research skills seminars included: technical writing, public speaking, and poster making, and seminars included engineering ethics, research in an academic setting, and graduate education opportunities and application process. The
freshman year programs implemented showed success in recruiting students for the S-STEM program, and can serve as a model for other undergraduate programs looking to enrich the experiences of their undergraduates by providing a comprehensive, supportive, and career-relevant environment inside and outside of the classroom.

1. Introduction

Engineering education is constantly evolving and changing to meet the current and projected needs of the engineering profession. In 2010 the National Society of Professional Engineers (NSPE) released a position statement proposing additional undergraduate engineering outcomes: Leadership, Risk and Uncertainty, Project Management, Public Policy, Business Concepts, and Sustainability. These new outcomes reiterate a number of identical skills proposed at The Summit on the Future of Civil Engineering and subsequently published by the American Society of Civil Engineers (ASCE) in 2007. The outcomes and skills go hand in hand with the vision for the future of professional licensure and the associated educational requirements. Led again by the ASCE, ongoing public debate resulted in the issuance of Policy Statement 465 on October 5, 2014 supporting the concept that an MS or its equivalent is required to practice civil engineering at the professional level. This position has since been publicly supported by the National Council of Examiners in Engineering and Surveying (NCEES) and the National Society of Professional Engineers (NSPE).

Competing in a global economy greatly depends on the technical expertise of a nation’s workforce. In the U.S., interest in STEM careers is steadily decreasing. The 2005 report "Rising Above the Gathering Storm" and follow-up in 2010 clearly explains this degeneration. LabVIEW creator Jeff Kodosky emphasized similar sentiments in one of his 2009 address: "The only people that create wealth are engineers and scientists. We are in a (engineering) crisis situation, and we have been in it for a long time". The situation is no different for Ohio. The Third Frontier Project, the Deloitte Study, and the Science and Mathematics Education Policy Advisory Council of Ohio identified the specific areas of need for a technologically advanced engineering workforce.

In addition to the recognized needs of the engineering profession, diversity in race and gender are also both in need of improvement. Even though women made up 56% of the UG college population in 2013, that year only 19.9% of undergraduate engineering degrees were awarded to women. The share of African-American and Hispanic students has remained low and virtually unchanged for the past decade. Despite comprising 28.6% of the U.S. population, in 2013 these two groups 4.7% and 7.6%, respectively, have earned MS degrees, and 4.1% and 4.7%, respectively, have earned doctoral degrees.

Recognizing that the engineering profession expects a diverse, highly educated body of practitioners possessing skills well beyond simple math and science expertise, the University of Cincinnati Department of Biomedical, Chemical, and Environmental Engineering has begun implementation of the comprehensive, multi-faceted S-STEM Scholarship Program aimed at addressing these industry needs and generating engineering graduates who will be among the first to be sought by universities, industry, and investors.
2. Structure of the S-STEM Program

2.1. Overview of Programs

The S-STEM Scholarship Program consists of two main components: the Freshman S-STEM Scholars Program (FSSP) and the S-STEM Scholars Program (referred to simply as S-STEM). The programs run concurrently, and the implementation timeline for the two programs can be seen in Figure 1. Both the FSSP and S-STEM programs have similar program requirements; however, the FSSP program is for freshman underrepresented minority (URM) students only. The FSSP acts as a feeder program to increase diversity in the larger cohort of S-STEM students, who are recruited near the end of the spring semester of the freshman year for participation during sophomore through senior years. Specifics of the FSSP and S-STEM programs are detailed in Sections 2.2 and 2.3, respectively. Apart from the formal FSSP and S-STEM programs, an additional recruiting tool was implemented through the required freshman Engineering Foundations course. This was implemented in years one and two, and is explained in further detail in Section 2.4.

<table>
<thead>
<tr>
<th>Year</th>
<th>Implementation</th>
<th>FSSP Cohort</th>
<th>S-STEM Cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Engineering Foundations</td>
<td>1 (5 Students)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Engineering Foundations</td>
<td>2 (4 Students)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>1 (16 Students)</td>
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<tr>
<td>4</td>
<td></td>
<td></td>
<td>2 (16 Students)</td>
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<tr>
<td>5</td>
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<tr>
<td>6</td>
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Figure 1: Implementation Timeline for the FSSP and S-STEM Programs

2.2. Freshman SSTEM Scholars Program (FSSP) Structure

**Goals of FSSP**

The main goals of the program are: enhanced retention of URM students, the development of strong URM candidates for admission into the S-STEM program, and to build interest in students for the pursuit of graduate study. **Enhanced retention of URM students** is critical as 2014 data from the National Center for Education statistics describes African American and Hispanic students as 23.6% and 12.7% less likely, respectively, to finish college after 5 years as compared to their white peers. Retention is encouraged particularly through the mentoring and academic reporting systems implemented in this project. The FSSP program is also operationally very
similar to the S-STEM program, meaning that successful FSSP students will be well prepared to compete for **admission into the S-STEM program**. The students who transition will be well versed in the program structure and will be able to hit the ground running, and at the same time their past experiences will increase their likelihood of remaining in the S-STEM program for its full 4 year course. Diversity in the S-STEM program will also be enhanced as the FSSP program is URM specific but the wider S-STEM program is open to all US citizen students. **Building interest in graduate school programs** is crucial for both minority students and U.S. citizen and permanent resident students. Data presented in the previously mentioned study\(^\text{13}\) paint a grim picture for the current state of URM students graduating with advanced degrees, and goes on to show that in 2014 over 55% of doctoral degrees in the U.S. were awarded to foreign nationals. The FSSP acts to counter these trends by exposing the participants to extracurricular activities relating to research and connecting them directly with both peers and faculty who can provide information and potentially even facilitate and support a future laboratory or research experience.

**Recruitment**

Students selected to participate in the FSSP program were required to be incoming URM freshman who were accepted directly into a program in the Department of Biomedical, Chemical, and Environmental Engineering or were accepted into the Freshman Engineering Program, a program which prepares students for admission into their desired program by the sophomore year. Students were recruited using the two methods described in Figure 2: direct solicitation and solicitation through the existing **Summer Scholars Bridge Program (SSBP)**, a summer college preparatory program aimed at incoming freshmen URM students.

**Program Components**

The FSSP program consists of four main program components, which are shown in Figure 2: cohort building, career driven education, networking, and a pathway to graduate school. In addition to these program components, the students were also provided with a stipend each semester they completed all of the program requirements. Detailed descriptions of the main program components are provided below.

**Cohort Building:** Cohort building involves the development of academic and professional relationships between three groups: students and students, students and faculty, and students and professionals. The program has been crafted to promote the development of all three. **Student to student** relationships are indirectly developed through group participation in the FSSP program; however, in addition to this, the students all participate in the Emerging Ethnic Engineers (E\(^3\)) program and SSBP at the university, and the social and academic support programs that provide numerous cooperative learning opportunities throughout the freshman academic year. The E\(^3\) program, most notably, organizes the SSBP, which is a 7–week residential summer program recommended to all incoming freshmen, and in particular to URM students. The objective of SSBP includes creating a “learning community” of students and to help them develop the academic and social skills necessary for achieving academic excellence by preparing students for their prospective math and science courses taken in the freshman year, while at the same time building their self-confidence, strengthening their academic skills, and acclimatizing them to the campus environment. The SSBP experience is further enhanced by
Figure 2: FSSP Program Structure

Program Components

Cohort Building
- Summer Bridge Scholars Program
- Supplemental Cooperative Learning Courses
- Course Instructor Reports
- URM S-STEM Learning Community

Career Driven Education
- Professional Development
- Monthly Socials To:
  - Build 21st Century Skills
  - Build Entrepreneurship Skills

Networking
- Academic Advising
- Community Engagement
- E-Portfolio
- Mentoring
  - Peer Mentoring
  - S-STEM Program Mentoring and Safety Net
  - Research Mentoring

Pathway to Graduate School
- “Ready For Research” Workshop
- Obtain Discipline- and Research-Specific Certifications
- Advanced Prep. for S-STEM
  - Develop a CV
  - Research Interest Statement
  - Attend and Present at UG Research Conf.

Desired Outcomes

- Enhanced Retention of URM Students
- Develop Strong S-STEM Candidates
- Build Interest in Graduate School Programs
requiring the Bridge students to enroll in cooperative learning courses that supplement the more
difficult freshman year mathematics and science courses (such as Calculus and Physics). An S-
STEM learning community is also created in the *Engineering Foundations* course that all
students are required to enroll in during their freshman year. Refer to Section 2.4 for more
information on this learning community. **Student to faculty** relationships are often neglected,
especially among freshman, many of whom are too timid to directly approach faculty members
for help with academic or personal issues. The FSSP program aims to bring students and faculty
closer together through the implementation of a course progress reporting system. This reporting
system requires students to meet with each of their course instructors two times during each
semester and have a discussion regarding their academic performance. Students with and without
academic deficiencies benefit from these interactions, high-performing students will have the
opportunity to enhance their skills at developing relationships with authority figures, and low-
performing students will additionally receive timely feedback on their performance, giving them
adequate time to make changes to successfully complete the course. **Student to professional**
relationships are extremely important, especially for freshman students at the University of
Cincinnati, as they begin the co-op program during their sophomore year. Monthly socials are
organized for the FSSP students, with a number of them relating to professional development.
Examples of past socials include: technical writing, public speaking, poster making and
presentation, and ethics. All cohort building activities have a prescribed e-Portfolio form to be
completed by the appropriate person (student/academic advisor/instructor) and submitted to
the student’s e-Portfolio. **Career Driven Education:** While the sophomore to senior year S-STEM
program incorporates more formal content-related career driven education, the FSSP program
prepares students both for admission into the S-STEM program and their future careers through
organized workshops and seminars. These are selected such that the students receive exposure to
a wide variety of important 21st Century Skills (critical thinking and problem solving, creativity
and innovation, and communication and collaboration). As mentioned previously, these
workshops and seminars are devoted to building these professional skills through research
communication workshops (technical writing and public speaking, PowerPoint presentation, and
poster presentation), a team-based experiential learning workshop on entrepreneurship,
enrichment seminars on engineering ethics conduct of research in an academic setting, and
graduate education opportunities and application process. For example, to provide a
comprehensive new venture creation experiential learning experience, the entrepreneurship
workshop includes *The Team Toy Works Company*, in which the students in teams (of 2 or 3
students) developed the concept of a small start-up toy company to introduce a new line of
unique concept toys for children ages 3 to 12.

**Networking:** Networking is a critical skill for college graduates, directly impacting their ability
to find a suitable career or opportunity for graduate study. The networking experiences are
designed to help students become more comfortable in their college, the university and their
future work environment. These experiences provide the skills for students to work and
communicate in small or large groups, and to interact with peers and professionals in ways that
will benefit both their academic and professional careers. Many of the cohort building strategies
mentioned above significantly improve the students’ networking skills; however, the addition of
academic advising, community engagement, and proactive and just-in-time mentoring in the S-
STEM program build on these skills in a formalized manner. **Academic advising**, while available
to all students, for S-STEM students it is formalized and required by all participants. Students
must meet their degree program academic advisor each semester during the pre-registration week to plan their course schedule for next semester, and document the results of the meeting and any suggestions made in the student’s e-Portfolio by the academic advisor. Each department has a full-time academic advisor assigned to a student. These regular meetings will also ensure that the students stay on track academically, increasing their chances of graduating on time. Fifteen hours of community engagement are required of the students each semester, giving them an opportunity to interact with local community leaders. Prior approval of the community service planned is required. Regular interactions of this kind will build the students’ networks, enhance their social skills, enhance their appreciation of the value of service to the university and community, and reflect positively on the university and the FSSP. The FSSP includes proactive and just-in-time mentoring of three types: peer mentoring provided by the University of Cincinnati’s McNair RECON Peer Mentor Program, mentoring from an assigned S-STEM project faculty member, and research mentoring provided by the University of Cincinnati’s Office of Undergraduate Research, Scholarly Endeavors and Creative Practice (URSC). These three mentoring networks are supported by a custom-made online e-Portfolio for tracking compliance, collecting evaluations, and to implement intervention strategies if student progress is not satisfactory. The peer mentoring is the most thorough and involves the students’ regularly meeting with assigned, trained upperclassman mentors to complete specific objectives. Even though the specifics of the mentoring vary depending on each students’ needs, the students are required to work with their mentor to obtain discipline-and-research-specific certifications, develop a draft of a CV and a research interest statement (for future use), and shadow a graduate student. The role of the S-STEM faculty mentor is different than that of the degree program academic advisor. The S-STEM mentor provides social mentoring, which is a form of informal mentoring in which mentoring opportunities arise ad hoc, starting and ending quickly based on a specific learning need. Besides face-to-face mentoring, it also integrates online tools as part of the mentoring process. A member of the S-STEM project management team serves as an S-STEM mentor and tracks student’s progress in meeting program requirements and implement early interventions for students in academic distress. A student meets their assigned S-STEM mentor once a semester, after submitting the first set of course instructor reports and meeting the degree program academic advisor. Prior to the meeting, the S-STEM mentor reviews and approves completed online forms submitted to the student’s e-Portfolio and forwards them to a Project Coordinator, who, after checking all requirements, gives final online approval. Each e-Portfolio from is assigned a Relative Importance Compliance Score (RICS) that is tallied and displayed after approval. The semester-end composite RICS is used: to inform students if they are meeting program requirements, to identify needs for early intervention, and to assist the overall program management. An unsatisfactory course performance identified in an instructor course report, automatically triggers an intervention plan mutually developed by the S-STEM mentor and student and tracked for compliance by the Project Coordinator. Thus in the program, peer mentoring has been combined with S-STEM faculty mentoring, as both can work together to provide a more complete mentoring experience. For example, students who may not want to discuss certain personal issues with a faculty member may be more open with their peer mentor. Finally, research mentoring is provided though a three-hour workshop certifying the students as “Ready For Research,” and requiring the students to volunteer for and present a poster at the University of Cincinnati’s Undergraduate Research Conference held each year in April. FSSP Scholars who participate in a faculty-led research project are encouraged to present their work at
the conference, and others are guided to present a poster reflecting their freshman-year FSSP experience at the conference.

**Pathway to Graduate School:** The pathway to graduate school is just introduced for the students in their first year through the FSSP activities and is formerly offered as part of their sophomore to senior year degree program if they remain in the S-STEM program until graduation. The skills workshops and seminars offered as part of the FSSP Career Driven Education Program are used to show to the students how research is conducted in a research intensive university, and the professional technical writing and presentation skills used by researchers to effectively communicate their research findings. A past example of a monthly social relating to graduate school preparation was titled *Research in an Academic Setting*, which was jointly given by a faculty researcher and an engineering doctoral student, and detailed how to find research opportunities and what it is like to work on a laboratory research project as an undergraduate and graduate student. The “*Ready For Research*” workshop provided by the University of Cincinnati’s Office of Undergraduate Research, Scholarly Endeavors and Creative Practice (URSC) provides the FSSP Scholars with a basic understanding of the culture of undergraduate research, including its importance to the university and student achievement. Completion of the workshop certifies the students as ready for undergraduate research. Furthermore, the UCRC’s support in requiring the students to volunteer and at the University of Cincinnati’s Undergraduate Research Conference in the freshman spring semester, provides an opportunity for the FSSP Scholars to first hand see successful examples of undergraduate research and meet faculty who mentored and provided this opportunity to them. Thus, it provides an opportunity for the FSSP Scholars to network with these researchers. Additionally, each FSSP Scholar is paired with a trained McNair-RECON peer mentor, who guides them to prepare a professional CV and a research interest statement, which the FSSP Scholars use when applying for the S-STEM program in the freshman spring semester. This enables them to receive advanced preparation for admission into the S-STEM program. The FSSP and S-STEM programs are structured very similarly, and students who complete the FSSP program will be well prepared to be competitive candidates for S-STEM admission. Even if a student does not continue on into the S-STEM program, their freshman year experience will provide them with the tools they need to pursue graduate education in the future.

### 2.3. S-STEM Scholars Program Structure

The S-STEM program will only be briefly presented, as its structure is not the focus of this paper. An overview of the S-STEM program can be seen in Figure 3, and a brief discussion of each program component follows. **Recruitment** for the S-STEM program was performed similarly to the FSSP program; however, admission into the program was open to all rising U.S. citizen and permanent resident sophomores meeting a set minimum academic standard. In the case of the first cohort of S-STEM scholars, this standard was set at a cumulative college GPA of 3.2 or greater. The only difference in recruitment was the advertising of the S-STEM program through the S-STEM learning community created in the freshman Engineering Foundations course which is explained in Section 2.4. The **Networking** S-STEM program components draw from the same academic advising system, course reporting system, professional skills building workshops and seminars, community engagement, and S-STEM faculty mentoring from the FSSP program; and adds on to it specific undergraduate credit earning research courses,
Figure 3: S-STEM Program Structure

Program Components

- **Cohort Building**
  - Summer Bridge Scholars Program
  - Supplemental Cooperative Learning Courses
  - Course Instructor Reports
  - S-STEM Learning Community Created In:
    - FSSP
    - Engineering Foundations Course

- **Career Driven Education**
  - Research Methods Course
  - Formal Research Experience
    - Research I, II, III Courses
  - Research Co-op
  - Senior Research Capstone
  - MS Coursework with Thesis
  - MBA Coursework
  - Entrepreneurship Minor/Grad. Cert.

- **Networking**
  - Academic Advising
  - Course Instructor Reports
  - Professional Development Monthly Socials
  - Community Engagement
  - Professional Meeting Presentations
  - Entrepreneurship Competition Participation

- **Pathway to Advanced Degree Tracks**
  - BS with MS in Engr.
  - BS with MBA and Grad. Cert. in Entrepreneurship
  - BS with Minor in Entrepreneurship
  - BS with Advanced Grad. School Prep.
  - Professional Experiences for Career Advancement (PhD, MD, etc.)

Desired Outcomes

- Graduates Initiate Start-up Companies
- 100% BS Degree Completion
- Majority of Participants Pursue Graduate Degrees

Recruitment

- Freshman S-STEM Scholars Program
- Engineering Foundations Course
- Direct Solicitation
advanced degree tracks, and formalized research and entrepreneurship experiences, as indicated in Figure 3 under Career Driven Education and Pathway to Advanced Degree Tracks. The S-STEM program offers four separate tracks: Bachelor’s degree with a Master of Science, Bachelor’s degree with a Master of Business Administration and Graduate Certificate in Entrepreneurship, Bachelor’s degree with a Minor in Entrepreneurship, and a Bachelor’s degree with Advanced Graduate School Preparation. Thus, each track students complete all standard BS degree requirements, and a research- and team-based senior capstone experience that meets ABET standards for integration of technical knowledge: safety, environmental, and health compliance; economics and business considerations; teamwork; and project management. The biomedical, chemical and environmental programs offer both a research-based and the regular design-based senior capstone experience, structured to meet all ABET standards. The curriculum for these degree tracks are structured to finish all program requirements in 5 years, with an extra summer semester cushion to cover unforeseen academic and co-op rotation situations. It should be mentioned that the undergraduate engineering degree program at University of Cincinnati spans 5 years, including summer, to allow for 5 semesters of required paid co-op, which is the nation's largest mandatory co-op at a public university. Students pursuing a dual degree program (BS+MS or BS+MBA) are allowed to do one less co-op. Implementation of the S-STEM program will allow for the attainment of the three major program goals: 100% completion of Bachelor’s degrees by the participants, the pursuit of graduate degrees by a majority of the participants, and the initiation of start-up companies by graduates who pursue entrepreneurship tracks.

2.4. Engineering Foundations Integration to Create an S-STEM Learning Community

Acting as both a recruiting tool for the S-STEM program and a learning community, like the one created in FSSP, a special project, “Grand Challenge Project,” was implemented during a portion of the required freshman course Engineering Foundations. More details on the specifics and results of the implementation, and the perspectives of the project team members can be found in papers published previously 16-18. All CEAS freshman (~1100) enroll in Engineering Foundations during the Fall semester. This course introduces all fields of engineering and computer science and uses a common curriculum across all sections (20 to 21) to achieve the same learning outcomes. The course includes lectures and four "hands-on" experimental lab modules that enable students to explore mechanical, chemical, and electrical systems in teams of 2-3 students. In addition, students complete a fifth project, called the “Choice Project,” in which the students are asked to design their own experimental investigation, different from the ones completed, using the knowledge and equipment from the four required experiments. Usually, teams extend one of the required projects for the Choice Project, for example, doubling the energy production from a fuel cell. The Choice Project was replaced by the Grand Challenge Project in the four sections which were primarily meant for the freshmen admitted in the Department of Biomedical, Chemical, and Environmental Engineering. The Grand Challenge Project was implemented utilizing the Challenge Based Learning (CBL) pedagogy. The use of CBL in the classroom was pioneered by the Apple Computer Corporation and is designed to enhance student buy-in by having the students themselves define the project challenge and then work to develop a unique solution 19. Specifically pertaining to the S-STEM program, the project challenge was defined by the students collectively in a course section such that it required students to utilize two methodologies to develop the solution to the challenge: the Engineering
Research Process (ERP) and the Entrepreneurial Process Model (EPM). ERP was used to find the best solution to the challenge that met the specified research constraints in an optimum manner, and EPM was used to look at the best business plan to market the proposed solution. Each student team submitted a typed project report and gave a 10-minute PowerPoint presentation defending their challenge solution and its commercial potential. Integrating the two methodologies, ERP and EPM, serves the purpose of the S-STEM learning community, i.e., exposing the students to the critical concepts (research and entrepreneurship) that are promoted in the S-STEM program for building college careers being pursued and for future professional careers. A brochure presenting the educational opportunities of the S-STEM program, and the recruitment and application process was also disseminated during the course implementation.

3. Early Results
3.1. Freshman S-STEM Scholars Program (FSSP)

The FSSP individual program activities were evaluated by participants completing surveys throughout the school year, for feedback on specific activities as they occurred. The activity surveys included reflection questions related to the student learning outcomes (SLOs) targeted in the activity. At the end of the school year, to gauge student participation in and satisfaction with the FSSP activities, a comprehensive online survey was created and administered to all five FSSP Scholars. The survey consisted of 170 questions. The evaluation plan was developed, conducted and reported by an external evaluator. The number of survey participants was small at five students; however, after the currently active second cohort concludes, the total number of participants will increase to nine. In all surveys the following scale was used to interpret the participant responses: 4=strongly agree, 3=agree, 2=disagree, and 1=strongly disagree. Results of only the comprehensive online survey are only presented in this paper.

As an overview, four out of five freshman scholars applied and were accepted into the S-STEM Scholars Program for their sophomore year through graduation, confirming that the program was successful in developing strong S-STEM program candidates. All four Freshman Scholars picked a different first choice for the S-STEM track indicating their varied interests. The fifth FSSP Scholar is planning to attend graduate school in a STEM major outside the College of Engineering and Applied Science (CEAS) and so decided not to apply. Overall, this program built a strong cohort of students. When asked to rank order the individual program activities, three out of five (60%) FSSP Scholars ranked the McNair-RECON Peer Mentor Program most beneficial, one (20%) ranked the Orientation Session most beneficial, and one (20%) ranked their Course Instructor Meetings and Reports most beneficial. Table 1 contains the results of the survey questions pertaining to the overall program experience. It can be seen from the results that the students self-report between agree and strongly agree that participation in the program improved their academic performance and made them more likely to succeed. Representative comments from students are included below the table. This result directly supports the program goal of increasing retention of URM students in the college.

“I think the program was well worth while. I feel like I am ahead of many of my peers. I have also gained two mentors through this program whom I regularly go to for help.”
Table 1: Scaled Results from the FSSP Student Survey - Overall Experience

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>2015-Freshmen</th>
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<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>I am more confident in my ability to succeed in Engineering because of my participation in the S-STEM Freshman Scholars Program.</td>
<td>5</td>
</tr>
<tr>
<td>Participation in the S-STEM Freshman Scholars Program improved my academic performance in the 2014-2015 Academic Year.</td>
<td>5</td>
</tr>
</tbody>
</table>

“It was a good fulfilling experience in which I grew and got better as a student.”

“The overall experience has been positive. It has been beneficial to talk with faculty who are involved in research at UC and learn about programs and opportunities to pursue research.”

“The S-STEM Freshman Scholars program has definitely been worthwhile. I'm now aware of research in engineering, I have more connections through mentors, I've had more learning opportunities, and I've been given a better chance of getting into the S-STEM program.”

Highest-rated amongst the major program components was the McNair-RECON Peer Mentoring Program. Table 2 contains the results of the survey questions pertaining to this program. The results show that the program was successful in exposing students to undergraduate research through its shadowing program and preparing them both for graduate school and their future careers by assisting them to complete a professional CV and a research interest and career objective statement, which included a reference-supported background that places the student’s interest(s) into an academic and actionable context. The survey results provided further confirmation of the success of the program in meeting the goal of building interest in graduate school. It is anticipated that the students will continue into the S-STEM program and make use of the products from the peer mentoring to gain an advantage in finding a co-op or research positions. When students were asked about their post-Bachelor’s degree plans, four out of five (80%) of the students indicated they were interested in pursuing graduate degrees, with three out of four (75%) interested in S-STEM majors, and one out of 4 (25%) interested in MBA.

3.2 Engineering Foundations

The Grand Challenge Project implemented in the four sections of Engineering Foundations course in which a majority of Biomedical, Chemical and Environmental Engineering (BCEE) incoming freshman enrolled, helped the students to learn about the S-STEM program and make an informed decision to apply to participate in it starting as sophomores and until graduation. This was evident when comparing the input provided by the students from the four BCEE sections of Engineering Foundations with two comparison sections that did not have BCEE students but were taught by two of the same instructors and were given a parallel end-of course survey. These surveys included two questions related to the S-STEM program: “Are you aware of the National Science Foundation’s Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) that was awarded to the Department of Biomedical, Chemical, and Environmental Engineering in CEAS?” and “If you know about the program, are you interested
Table 2: Scaled Results from the FSSP Student Survey - McNair-RECON Peer Mentoring Program

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>2015-Freshmen</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>My McNair-RECON Mentor seemed genuinely concerned about my academic success.</td>
<td>5</td>
<td>3.80</td>
<td>0.447</td>
</tr>
<tr>
<td>The career objective statement preparation activity under the guidance of my McNair-RECON Mentor was worthwhile.</td>
<td>5</td>
<td>3.60</td>
<td>0.548</td>
</tr>
<tr>
<td>The cited research interest statement preparation activity under the guidance of the McNair-RECON Mentor was worthwhile.</td>
<td>5</td>
<td>4.00</td>
<td>0.000</td>
</tr>
<tr>
<td>The CV preparation activity under the guidance of the McNair-RECON Mentor was worthwhile.</td>
<td>5</td>
<td>3.80</td>
<td>0.447</td>
</tr>
<tr>
<td>The shadowing or lab tour opportunity program organized by the McNair-RECON Mentor was worthwhile.</td>
<td>5</td>
<td>3.80</td>
<td>0.447</td>
</tr>
<tr>
<td>The lab shadowing or tour opportunity provided me an opportunity to see research facilities and ongoing research project(s).</td>
<td>4</td>
<td>3.50</td>
<td>0.577</td>
</tr>
<tr>
<td>The lab shadowing or tour opportunity provided me an opportunity to interact with research faculty and/or graduate students</td>
<td>4</td>
<td>3.75</td>
<td>0.500</td>
</tr>
<tr>
<td>The McNair-RECON Mentorship Program helped me better understand the role of research through my interactions with faculty members and graduate students pursuing research.</td>
<td>5</td>
<td>3.80</td>
<td>0.447</td>
</tr>
<tr>
<td>My association with the McNair-RECON Mentor helped me better understand how undergraduate students can participate in ongoing research in the university.</td>
<td>5</td>
<td>3.40</td>
<td>0.894</td>
</tr>
<tr>
<td>My association with the McNair-RECON Mentor helped me better understand the research opportunities available in the university to undergraduate students.</td>
<td>5</td>
<td>3.40</td>
<td>0.894</td>
</tr>
<tr>
<td>My McNair-RECON Mentor helped me to clarify how I could reach my academic or personal goals.</td>
<td>5</td>
<td>3.60</td>
<td>0.548</td>
</tr>
<tr>
<td>I created a high quality career objective statement with guidance from my McNair-RECON mentor.</td>
<td>4</td>
<td>4.00</td>
<td>0.000</td>
</tr>
<tr>
<td>My research interest statement helped identify where my research interests fit into an actionable academic context.</td>
<td>4</td>
<td>4.00</td>
<td>0.000</td>
</tr>
<tr>
<td>I plan to use the research interest statement prepared to apply for an undergraduate research opportunity.</td>
<td>4</td>
<td>4.00</td>
<td>0.000</td>
</tr>
<tr>
<td>I created a high quality CV that is suitable for submission to obtain a research position.</td>
<td>4</td>
<td>4.00</td>
<td>0.000</td>
</tr>
<tr>
<td>I plan to use the CV developed, with updates, when applying for co-op jobs.</td>
<td>4</td>
<td>3.50</td>
<td>0.577</td>
</tr>
</tbody>
</table>

Importantly, when students were asked if they knew about the S-STEM Program and if they were interested in applying for an S-STEM scholarship, 34% of the students in the BCEE sections knew about the S-STEM program and 89 (45%) expressed interest in applying for the scholarship. These numbers were much higher than the students in the two comparison sections, in which 9% knew about the program and 12 (26%) were interested in for the S-STEM scholarship.
In addition to the positive impact on recruiting for the S-STEM program, the educational goals of the creation of a freshman S-STEM learning community were also attained. The incorporation of the *Engineering Research Process* and *Entrepreneurial Process Model* has a discernable impact on the students as is described in the following student survey comments:

“The two processes support each other in real world applications, because a product created as a solution for the ERP must be supported by the EPM in selling and supporting the project.”

“The models both were composed of multiple steps. The models required students to consider several different factors that come into play and affect the success of the solution.”

“They [ERP/EPM] work alongside one another to create a realistic view of how to solve a problem in the real world.”

“You have to create a solution that is both viable for the company/consumers [EPM] as well as is a fix/need for the problem [ERP].”

The students, in general, responded well to the integration of entrepreneurial concepts, as it provided them with an experience that they would not normally receive in their freshman year courses. Students that are selected for the S-STEM program will have the opportunity to join an entrepreneurship-oriented track or at minimum have additional exposure to entrepreneurship through the S-STEM extracurricular socials and technical workshops. Additional results and details on the implementation can be found in previous publications 16-18.

4. Conclusions

The limited results from the program at its current stage highlight a number of important takeaways: (a) peer mentoring is well received by freshman students, (b) early exposure to research skills and opportunities are important for developing student interest in research programs and graduate school, and (c) innovative pedagogies and early exposure to important concepts such as research and entrepreneurship can successfully be incorporated into existing courses to develop well-rounded students. From the perspective of student growth, peer mentoring seems to be one of the most effective and easy-to-implement strategies for enhancing retention and student satisfaction. The peer mentoring program, as implemented in this project, required no explicit resources besides coordination of participants with volunteer mentors. In conjunction with the peer mentoring, the deliverables produced through the mentoring process, a CV, a research interest statement, and a career interest statement, were also rated highly by students, with all students responding that they planned to use the documents to find undergraduate research and co-op opportunities. These research opportunities will lead the students toward graduate school, or at the very least, allow them to make more informed decisions about their future career paths. Finally, the implementation of the Grand Challenge Project in *Engineering Foundations* gave the FSSP participants, as well as many other engineering freshman, the opportunity to experience research and entrepreneurship firsthand. The educational outcomes of the learning community, along with broad dissemination of the S-
STEM program opportunities, started early the process of developing competent engineers with the multidisciplinary understanding necessary to meet the needs of the industry.

Overall, the FSSP program has met its goals, and the participant students have grown academically, professionally, and personally. The students were prepared for future co-op and research positions through the peer mentoring program, and were exposed to research, entrepreneurship, and graduate studies well before their peers. The FSSP model presented here is comprehensive, significantly utilizes existing university programs, and can be implemented at minimal cost with support of the college and university administration and faculty. It is hoped that other universities can use this program as a model to develop similar programs to enrich the experiences and increase retention of freshman engineering students.

References


