How an NSF S-STEM LEAP Scholarship Program Can Inform a New Engineering Program

Dr. Afsaneh Minaie, Utah Valley University

Afsaneh Minaie is a Professor and Chair of Engineering Department at Utah Valley University. She received her B.S., M.S., and Ph.D. all in Electrical Engineering from University of Oklahoma. Her research interests include gender issues in the academic sciences and engineering fields, Embedded Systems Design, Mobile Computing, Wireless Sensor Networks, Nanotechnology, Data Mining and Databases.

Dr. Reza Sanati-Mehrizy, Utah Valley University

Reza Sanati-Mehrizy is a professor of Computer Science Department at Utah Valley University, Orem, Utah. He received his M.S. and Ph.D. in Computer Science from the University of Oklahoma, Norman, Oklahoma. His research focuses on diverse areas such as: Database Design, Data Structures, Artificial Intelligence, Robotics, Computer Aided Manufacturing, Data Mining, Data Warehousing, and Machine Learning.

Janis P. Raje,

Janis Raje is a free-lance technical writer for higher education programs. She received her B.A. from Brigham Young University and her M.A. from University of Maine in English. She has a particular interest in STEM programs at the baccalaureate and pre-baccalaureate levels.
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Abstract

In Fall 2014, Utah Valley University was granted a Scholarships in STEM award from the National Science Foundation. Entitled Strengthening Outcomes for Students in Engineering and Computer Science through Leadership, Engagement, Academic Mentoring, and Preparation (LEAP), the program is now in its fifth and final year. The goal of this project is to increase the graduation rate for students in Computer Science and Engineering at UVU, an open enrollment university, and better prepare them for continued education and/or success in the STEM workforce by providing scholarships to academically talented students with financial need and by providing leadership training and opportunities, engaged learning activities, and mentoring.

Now, as Utah Valley University is initiating three new engineering programs within a new Department of Engineering, an examination of the lessons learned by the LEAP scholarship program is particularly useful in light of activities that might be carried forward into the new programs, with or without the continuation of the scholarships. In particular, the project team has found student participation and leadership in profession organization sections like IEEE and similar student clubs to be stimulating for student development. Having student leaders plan enrichment activities such as workshops, speakers, and field trips has benefited both leaders and participants. Students also point to faculty mentoring as a valuable element of the LEAP program. While only preliminary in nature, the findings of the scholarship project can be useful to other institutions, with or without NSF scholarship programs.

Background Information

Utah Valley University (UVU) is a comprehensive regional university. In 2013 when the scholarship project began, UVU had a student population of 31,500 students, which has grown during the project period to nearly 40,000 students in 2019. This growth is just a snapshot of the growth that has characterized the institution for the past several decades. Once a technical college, then a community college, the institution became a state college in 1993 and a university in 2008. Enrollments have nearly quadrupled from its fall 1993 enrollment of 10,500. UVU is now the largest bachelor-degree granting institution in the state. While this institutional transition has been the result of much strategic planning, it has strained state and community resources and continues to create a number of challenges, particularly in the availability of scholarship funds.

UVU has a dual mission – that of a comprehensive university offering bachelor’s degrees and a few master’s degrees, and that of a community college offering associate degrees and certificates. As part of its community college mission, the institution maintains an open-enrollment policy. Student demographics are similar to those of a community college, with many students seeking a “second chance” at education. UVU has a high number of non-traditional students (age 25 or older – 34%), students with spouses (45%) and/or children under age 12 (20%) [1]. It also has the largest percentage of low-income (48%) and first-generation (38%) students of any of the universities in the state. These factors affect the overall graduation
rate, which is low at 33% (nationally standardized IPEDS rate for completions within 150% of time; UVU IR 2019) [1]. UVU’s students live at home or in off-campus housing, which makes it very difficult to organize activities for student programs. Many students do not have time to spend much time outside of class on campus, leading some to feel little connection with other students.

New Engineering Programs

To meet one of the region’s most pressing workforce needs [3, 5, 6], UVU initiated three new engineering programs in Fall 2018 [4]. The new bachelor’s degree programs in Electrical Engineering, Civil Engineering, and Mechanical Engineering have joined UVU’s established programs in Computer Engineering and Pre-Engineering in a new Department of Engineering [7]. The new programs were immediately popular with students, with 300 students enrolling for Fall 2018. As of spring 2019, the new Engineering Department has more than 800 students in the five programs which are housed in that department.

When the LEAP scholarship program began in 2014, Computer Engineering was housed in the Computer Science Department and members of the LEAP Project Management Team were drawn from that department. The B.S. in Computer Science program is accredited by Accreditation Board for Engineering and Technology (ABET) and currently has more than 1200 students. The Computer Engineering degree was established in 2012 and its faculty are providing leadership to the new Engineering programs. Table 1 shows the Fall 2018 enrollment and Academic Year 2017/18 graduation in these programs and the student demographics.

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Civil, Electrical, Mechanical Engr.*</th>
<th>Enrollment</th>
<th>Graduation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Civil Engr.</td>
<td>Computer Science</td>
</tr>
<tr>
<td>Total Students</td>
<td>260</td>
<td>220</td>
<td>1,073</td>
</tr>
<tr>
<td>Women</td>
<td>23 (9%)</td>
<td>14 (6%)</td>
<td>109 (10%)</td>
</tr>
<tr>
<td>Minority</td>
<td>35 (13%)</td>
<td>37 (17%)</td>
<td>127 (12%)</td>
</tr>
<tr>
<td>First-Generation</td>
<td>75 (29%)</td>
<td>46 (21%)</td>
<td>209 (20%)</td>
</tr>
<tr>
<td>Part-time</td>
<td>82 (32%)</td>
<td>89 (40%)</td>
<td>459 (43%)</td>
</tr>
</tbody>
</table>

*New programs in Fall 2018

Source: UVU Office of Institutional Research (IR)

Attrition Points and Needs in Targeted Programs

Longitudinal data show enrollment in Computer Science programs has continued to rise over the past four years, but the graduation rate remains low. Several critical attrition points, described below, have been identified through data and reports provided by the UVU Institutional Research and the College of Engineering & Technology.

Part-time Enrollment

Institutional Research reports that 42% of Computer Science/Computer Engineering students
attended school part-time in Fall 2018, while institutionally, 36% attend part-time. Faculty report that many students in Computer Science/Computer Engineering (CS/CE), particularly juniors and seniors, work full-time or excessive part-time hours (over 20 per week) to support a family while attending school, thus slowing down their progress and delaying their degrees. Part-time status not only slows time to completion but makes scheduling courses difficult for students, especially in the engineering programs, which are small and where courses are offered on a specific schedule.

**Average time to completion**

Institutionally, the average time to completion is 5.3 years (10.6 semesters). However, for students in Computer Science, the average time to completion is 6.6 years (12.8 semesters). (Computer Engineering is a relatively new program and doesn’t have long-term statistics.) By comparison, for STEM students in the College of Science & Mathematics, the average time to completion is 5.7 years (11.3 semesters) [1]. Complete College America’s report *Time is the Enemy*, demonstrates that the longer students take in college, the less likely they are to complete (2011).

**Low Participation and Completion of Underrepresented Groups**

Table 1 above shows the low participation of students from groups that are underrepresented in STEM fields, namely women, minorities, and first-generation students in the targeted programs. For the five degree programs combined, the participation rate of women is 9% (compared to an institutional enrollment of 45%), of self-identifying minorities is 13% (compared to an institutional enrollment of 18%), and of first-generation students is 21% (compared to an institutional enrollment of 38%). [It should be noted however, that the participation rate of women in Computer Science has risen from 4% to 10% in the past five years, due in part to efforts in recruiting by the LEAP project team.] Table 1 also shows that the graduation rate of each targeted underrepresented group is lower than their participation rate.

**LEAP Program Design and Project Implementation**

The goal of the LEAP project is “to increase the graduation rate for students in Computer Science and Engineering programs at UVU and to better prepare them for continued education and/or success in the STEM workforce by providing scholarships to academically talented students with financial need and by providing leadership training and opportunities, engaged learning activities, and mentorship. The objectives of the NSF LEAP project are to:

1. Increase support of financially needy, but academically talented students (including students from underrepresented groups) with an interest and aptitude for computer science and engineering degree programs by offering an average of 21 scholarships per year over a four-year period.
2. Increase the graduation rates of participating students in Computer Science and Engineering.
3. Provide leadership training and opportunities for students within the student section of a professional organization (IEEE or SWE) or club (Computer Engineering (CE) Club) linked to the LEAP program.
4. Strengthen engaged learning opportunities for students through collaborative projects and a required for-credit capstone project.

5. Provide faculty mentors for each program participant; increase the efficacy of faculty mentoring provided to each student participant in the scholarship program by faculty-mentor training and accountability.

**Participant Selection Criteria and Requirements**

As specified by the NSF program guidelines [2], scholarship recipients must meet the following requirements to be eligible to receive scholarship funding: be a U.S. Citizen, foreign national, or refugee; demonstrate financial need in accordance with the Department of Education FAFSA rules for federal financial aid; and be a full-time student majoring in a STEM discipline, in this program, in Computer Science or Computer Engineering.

The selected students commit to progressing in their major by signing a contract between the student and the institution/department. This contract sets out their requirements to accomplish the following: 1) Maintain a grade point average of at least 3.0 in all classes taken; 2) Meet with their faculty mentor monthly. 3) Meet with their academic advisor at least once each semester to plan their program coursework, assess the need for tutoring or other services, plan graduate school application or employment strategy, and/or receive referrals to other campus resources. 4) Attend 80% of the monthly LEAP meetings; 5) Participate in the IEEE Student Chapter and Computer Engineering Club; participants will be encouraged to accept a leadership role as they become available.

**LEAP Program Assessment**

In order to assess the outcome of our NSF LEAP program, a study was conducted by UVU’s Institutional Research office [1] to compare the NSF LEAP students to a comparison group. The comparison group was formed by matching the NSF scholars with non-recipients who were also attending during the first semester they received the scholarship. The comparison group was randomized and then matched by major, gender, class level, and race/ethnicity. This method of choosing a comparison group is flawed, it does provide preliminary evidence of the efficacy of the program. In addition, a telephone survey of LEAP participants was conducted in February 2019 of current and past LEAP participants. Twenty-nine students participated in the survey.

<table>
<thead>
<tr>
<th>Table 2: Comparison between S-STEM Recipients and Comparison Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total # students</td>
</tr>
<tr>
<td>Graduated (see text)</td>
</tr>
<tr>
<td>Retained in STEM major</td>
</tr>
<tr>
<td>Changed to non-STEM</td>
</tr>
<tr>
<td>Dropped out of school</td>
</tr>
<tr>
<td>Transferred</td>
</tr>
</tbody>
</table>
As shown in Table 2, the LEAP scholarship programs show increased retention, student success, and graduation in STEM. Scholarship recipients graduated at more than twice the rate of the comparison group. To break this down, 18 students in the LEAP program received 4-year degrees compared to 7 in the comparison group. Another 10 students in the LEAP group received 2-year degrees, verses 5 in the comparison group. Of those who completed 2-year degrees, most continued to 4-year programs. (In the table, those who completed 2-year programs and left school are included with those graduated.) Moreover, the scholarships allowed 7 students to complete their baccalaureate degrees in under 8 semesters at UVU (some may have had dual enrollment or transfer credit). Scholarships also assisted 6 students who had attended UVU part-time for a number of years to devote the required time to complete their degrees.

Another success of the LEAP program was greater retention of students at UVU and in their STEM programs of study. As Table 1 indicates, only 2 LEAP students dropped out of school and one transferred to another institution; all other students in the LEAP program were retained in STEM majors. In the comparison group, 8 students dropped out and 7 transferred to other institutions; and additional 4 students changed to non-STEM majors. (These were not 2-year degree recipients who transferred into 4-year programs.)

Moreover, LEAP students were more successful in their programs: the average GPA for LEAP students was 3.45 compared to a 2.86 average GPA for students in the comparison group. Since scholarship students were selected in part, based on their GPA, a comparison was done of the GPA of both groups at the point of their beginning the program (or being included in the control group) to the last semester of the program. The average GPA of LEAP students increased from 3.27 to 3.40 while the average GPA of non-LEAP students did not increase (2.88 to 2.84). The student telephone interviews indicate that the scholarships incentivized students to maintain a high GPA and gave them more time to devote to academic studies. Students explained how receiving the scholarship helped them progress toward a degree:

"I didn't have to focus so much on work, so I could put more time into my school work."

"It supports my financial situation, so that I can focus on my education. I can take more classes, for example, than if I don't have the scholarship. I can also focus on my education more.

"I was able to focus learning the material, and not just getting by on the edge of my teeth."

"I knew I had to continue to have a good enough GPA to keep receiving the scholarship,

<table>
<thead>
<tr>
<th>GPA average</th>
<th>3.45</th>
<th>2.86</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semesters to graduation</td>
<td>11.5</td>
<td>14.4</td>
</tr>
</tbody>
</table>

* One scholarship recipient died. ** The comparison group: LEAP participants were matched with non-recipients who attended during the same first semester. The comparison group was randomized and then matched by major, gender, class level, and race/ethnicity by a qualified, unbiased IR researcher.

Source: UVU Office of Institutional Research (IR).
so it helped me stay focused.”

“I was grateful for the scholarship and wanted to try harder to keep it.”

Strategies for the Future

The Engineering and Computer Science Departments will work through the Development and Sponsored Programs Offices to secure more scholarships for their students, in addition to the limited scholarships offered through the college and those that might be awarded from NSF. The evidence that these scholarships were indeed effective at retaining and graduating low-income students and incentivizing them to keep a high GPA can be a compelling argument to potential donors and funders.

Lessons Learned

Integration of LEAP into Academic Programs

In addition to demanding academic schedules for students in Computer Engineering and Computer Science, participants and prospective participants in the LEAP scholarship program frequently have demands of young families and part-time jobs. For some, additional requirements of the LEAP program were prohibitive. We found that the most successful program elements were those that complemented academic programs and provided enrichment in areas that students valued most – professional skills preparation and academic support. The LEAP program, for instance, provided support to the capstone projects which are required for all seniors. LEAP support came, in part, through faculty mentors, funding of materials for projects (which students otherwise might pay for themselves or chose a less expensive project), workshops on essential skills, and association with other students in LEAP.

Of the capstone projects, students in the telephone interview explained:

“The capstone project was a culmination of everything I learned in my degree, and I have used it in many job interviews; I feel like it’s the reason I got the job I have.”

“I learned a ton, it was extremely valuable, and I think it helped me get the job I currently have.”

“Highly valuable for after graduation.”

“I learned knowledge from it that I have learned daily.”

“It was very valuable. I feel like it was something I could use in, in my interviews for finding a job in my field. It gave me a lot of knowledge in the areas that I'm interested in.”

“Well, when you do a capstone project, the industry comes to see it, and that's when you meet future employers, so it's priceless.”

Strategies for the future

The lessons learned about implementing required capstone projects are being incorporated into the new Electrical, Civil, and Mechanical Engineering programs. It will be helpful in the future to support the capstone projects through co-curricular activities of the student organizations, by including offering a workshop on capstone project success strategies, encouraging student
attendance at capstone presentations, and seeking partnerships for capstone projects with industry sponsors.

Integration of LEAP into Student Clubs and Professional Organizations

LEAP program enrichment and professional development have been delivered largely through the existing Computer Engineering (CE) Club and UVU’s Institute of Electrical and Electronics Engineers (IEEE) section. The LEAP cohort of students forms the core of the programs, but other students participate as well. Activities have included guest speakers, field trips to local industries and Hill Air Force Base (regional employer), workshops, and multidisciplinary projects. The workshops have included MATLAB (a multi-paradigm numerical computing environment; led by the MathWorks Company), Introduction to Arduino (microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices), Interfacing Arduino with MATLAB, Soldering Basics, and Career Development (by the Career Development Center). The advantage of this integration has been twofold. First, enrichment and professional development activities could be extended to all the students in the CE/CS programs who desired to participate. Second, LEAP students served in the leadership positions of the organizations (discussed below); thereby, becoming role models and actively improving the educational environment for other students in the departments.

When asked what aspects of the LEAP program, aside from the financial benefits of the scholarship, they found most valuable, a number of students pointed to the club participation:

“I liked that it provides me an opportunity to participate in clubs and activities that are more closely related to the field of computer science, as that might help me with job discovery later in life.”

“Learning about the IEEE and going to the different activities that they had on campus.”

“I joined the IEEE and the group at the school, which helped with networking.”

“I probably would say it introduced me to the IEEE, and the experience that I got from the IEEE has been pretty beneficial for me, at least, I've enjoyed leading and the networking opportunities.

“It’s been nice to be a member of the IEEE and it's been great to have a side project to work on and a club to belong to.

“I could participate in the club, and so it wasn't just a scholarship, it was also an extracurricular activity where I could get together with other programmers and work together with that.”

“I now have an internship at Hill Air Force Base that was due to a field trip we took there and the connections I made.”

“One guest speaker directly influenced my career path.”

Strategies for the future

Participation in student leadership in the academic clubs and organizations should continue to be emphasized by the departments, whether as part of a scholarship program or not. Student sections of ASCE (American Society for Civil Engineers), ASME (American Society for Mechanical Engineers), and SWE (Society of Women Engineers) will also be initiated. Faculty
Leadership Development

By accepting leadership positions in the CE Club and UVU’s IEEE student section (such as President, Vice President, Social Media Chair, VP of Publications, VP for University Relations) LEAP students have the opportunity to develop leadership skills that will be important as professionals. Under faculty supervision, student leaders take the responsibility for planning activities, inviting and introducing guest speakers, arranging for field trips, and organizing hands-on projects. Students have conducted several of the workshops mentioned previously, including the two Arduino workshops and soldering basics, taught by a senior who is a certified soldering professional. Student leaders also help plan the annual Meet Your Faculty Mentor Night where new student officers are elected. Each year, IEEE host a regional Student Leadership Training seminar, at which at least two LEAP students participate, and an IEEE Rising Stars Conference for promising students, at which LEAP students have also participated.

When asked how a leadership position was of value to them, students gave the following responses:

“It got me more involved with other students and I felt like I was more involved in the university than just doing homework and going to classes.”

“I felt more involved in my schooling.”

“It's helped me to network and start working with the students on something other than school projects where we can work together and think about different ideas.”

“It gives me leadership opportunities and it gives me a mindset in how to obtain successfully and how to accomplish certain things in life in general.”

“Okay, I mostly feel like my position was just to have students in leadership, so I didn't really do anything, so it wasn't really valuable.”

“I went to one, I went to one club thing and I talked to people about the club, and then the club never met again... So the club was not very active.”

Strategies for the future

Most student responses to the leadership positions were positive, but we note that all were not. This points out that the clubs and leadership opportunities were not consistently strong and could be better monitored. On the whole, we have found that students are more likely to participate in activities carried out by the efforts of their fellow students. Thus, we will continue to find ways to encourage students to serve in leadership positions in student organizations and in the department. Student leaders will be encouraged to take advantage of leadership training and opportunities provided by IEEE, SWE, ASCE and ASME organizations and the CE Club. The Department will work with UVU’s Center for the Advancement of Leadership to help develop leadership activities specific to the engineering programs.

Participation of Women
Through considerable efforts of faculty leading the LEAP program, the participation rate of women in Computer Engineering and Computer Science has budged up slightly to 8.3% (103 women/1,243 students). In the LEAP program, women participated at the rate of 10.7% (6 women/56 students). Notably, all these women have either graduated (2) or been retained in their degree programs (4). Conversely, of the six women in the comparison group, 3 have transferred or changed majors and 3 are retained in STEM programs. Women in the LEAP program are also serving in leadership positions in the Computer Engineering Club and IEEE Student Chapter where they are role models to other women and participate in outreach activities.

Of the four women who participated in the telephone survey, all pointed to the association with others through the LEAP program as important to them.

“Probably the biggest benefit was having a mentor. Each of us were assigned a teacher that we can go to for any academic problems or questions, but my mentor, he's actually been really, really helpful, so that's been good.”

“It's really good, it's a motivator to me to be active in the program, to continue with the other students and other things, not only concentrate on the education, it motivates me to be active, to be active in other activities, like meeting other students.”

“Well, I know that it helped me get connected through the NSF LEAP socials to different job recruiters who were looking for interns, or just different employment opportunities.”

**Faculty Mentoring**

Each participant in the LEAP scholarship program is assigned a faculty mentor in their discipline, in addition to the academic advisor assigned to each student by the university. LEAP students get acquainted with their mentors at *Meet Your Faculty Mentor Night* and then meet at least twice each semester. Faculty mentors advise about educational success, potential fields of interest, career preparation, job seeking, and graduate school preparation suited to their individual needs and interests. Some students work with their faculty mentors on research projects. Students point to faculty mentoring as a valuable element of the LEAP program.

When asked about the benefits of the LEAP program, a number of students pointed to the faculty mentors:

“I had a mentor who I would meet with once a month that kind of gave me some motivation and also different sources and things. When I was not doing well for that month, they could give me personal assistance with homework when I needed it. They also connected me with different research opportunities. I was able to pick up some additional skills that helped me out with different classes.”

“It was good to have a mentor to speak to in case you have any questions about your education.”

“I would have to say the biggest benefit was the mentoring program. The mentor I had was good and it was helpful to have that kind of feedback from the faculty.”
Summary

Preliminary indicators show the NSF S-STEM LEAP program to have been effective at retaining and graduating students in their degree programs. The scholarships are, in themselves, a considerable incentive; however, several LEAP strategies and activities have been found to be useful to carry forward into the new Engineering baccalaureate programs, even without the scholarships. While more rigorous assessment of these interventions could provide more reliable evidence in the future, we feel confident that this preliminary examination points to practical benefits that can be of value to other institutions. Namely, the focus on student participation and leadership opportunities in professional organization sections and similar student clubs has been very beneficial and could be fostered outside of a scholarship program. The integration of support for required senior capstone projects into the clubs, such as having students work on collaborative projects in their earlier years to prepare for the capstones, has also been beneficial to students. Students point to faculty mentoring as a valuable element of the LEAP program, which could also be carried out be faculty in advisory positions. Students, including women, consistently point to the benefits of socializing with other students, networking with professionals, and in general, being engaged in academic activities outside of just studying and attending classes as important aspects of LEAP. These connections can and should be fostered by departments to every extent possible.

Acknowledgements

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References

6. Demand outpacing supply of Utah tech and engineering grads https://www.deseretnews.com/article/865622637/Demand-outpacing-supply-of-Utah-tech-and-engineering-grads.html , By Jasen Lee@JasenLee1, February 24, 2015 7:00 am