Final Report on LEAP at UVU: An NSF S-STEM Project

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Abstract

Utah Valley University (UVU) received an NSF Scholarships in STEM (S-STEM) award in 2014 for \$617,396 over a five-years period (with a one-year extension) to strengthen outcomes for students in computer science and engineering through Leadership, Engagement, Academic Mentoring, and Preparation (LEAP).

This scholarship program, now in its sixth and final year, is increasing the graduation rate for students in Computer Science and Engineering at UVU, an open enrollment university and better preparing them for continued education and/or success in the STEM workforce. The project provides scholarships to academically talented students with financial need and offers leadership opportunities, engaged learning activities, and mentoring. Sixty-three students meeting the selection criteria have been recruited and awarded scholarships. This paper presents the final report of this scholarship program and its impact on the students, the institution, the Computer Science and Engineering Programs, and workforce development in the region.

This NSF Scholarship program has increased student retention, success, and graduation in relation to a comparison group by helping students overcome some of the factors that often limit their educational ambitions. These successes were especially notable for women and first-generation students. The program's requirement that LEAP students participate in the departments' professional organizations (IEEE student chapter and Computer Engineering Club) and encouragement to serve in leadership positions strengthened these organizations for all students in the departments. The LEAP program has contributed to meeting the goals of Utah's Engineering and Computer Science initiative by graduating 28 students in Computer Engineering and Computer Science B.S. programs in the past five years.

Background Information

UVU is a comprehensive regional university with over 41,000 students, charged with serving Utah County, the second largest county in the state. UVU has a dual mission – that of a comprehensive university offering 91 bachelor's degrees and 11 master's degrees, and that of a community college offering 65 associate degrees and 44 certificate programs. To fill its community college mission, the institution maintains an open-enrollment policy. To facilitate academic robustness, UVU has implemented a structured enrollment policy that establishes requirements which students must meet before they can engage in all the courses of their major and provides additional access to advising and other resources [1]. These additional preparatory courses increase students' time to graduation but help them to succeed.

As a large public university UVU has a very high number of low-income students (42%) – the highest in the state. Around 35% of students are classified as non-traditional students (age 25 or older), more than half of whom are married. Nineteen percent of students have children under the age of five. UVU's students live at home or in off-campus housing, which often makes it difficult for them to participate in co-curricular and extracurricular activities. Many students do

not have time to spend much time outside of class on campus, leading some to feel little connection with other students. About 80% of UVU's students will remain in their communities and pursue employment in this region [2].

One of the hallmarks of the institution in the past three decades has been its rapid growth and transformation in response to the tremendous demographic and economic changes in the service region. Utah County has been one of the fastest growing regions in the country with its population increasing from 263,590 in 1990 to 663,590 in 2019[3]. New minority populations (18%, and 23% for those under age 24) have higher rates of poverty and lower income levels, which risk being perpetuated to the next generation. In response to community need, the institution transitioned from a community college to a state college in 1993 and to a regional university in 2008. The demand for education has been met by an increase in baccalaureate degrees, revised associates degrees, and master's degree programs in area of high regional need, including Computer Science. The rapid institutional transition has strained state and community resources and created numerous challenges, particularly in the availability of scholarship funds.

At the same time, Utah County's robust technology sector is bringing well-paying jobs into the region that require the support of an educated, well-trained workforce. The strategic location of technology companies in the area—Adobe, IM Flash, L3 Technologies, Northrop Grumman, Ancestry, Boeing, BAE Systems, and Overstock—are attracting other companies and providing jobs engineering and computer science graduates in the region. Without deliberate programming at UVU, like that provided by the NSF S-STEM program, that targets academically talented, low-income students, this region risks greater socioeconomic stratification and the marginalization of many intelligent, talented, potentially successful individuals.

Computer Science and Engineering Departments

Baccalaureate degree programs included in UVU's LEAP scholarship program are Computer Science, Software Engineering, Computer Engineering, and Pre-engineering. When the program began in 2014, all of these programs were housed in the Department of Computer Science, one of UVU's oldest programs with a diverse range of programs and courses. The department's goal has been to provide a quality program that meets accreditation standards while providing the students with a skill set that allows them to succeed in computing careers. Over 1,200 students are currently enrolled in Computer Science programs.

In 2018, the Computer Engineering and Pre-engineering programs were moved to a new Department of Engineering when UVU initiated three new engineering programs – Electrical Engineering, Civil Engineering, and Mechanical Engineering. The new programs were created with funding from Utah's Engineering and Computer Science Initiative to address critical regional workforce needs. The new programs were immediately popular with students, with 300 students enrolling for Fall 2018. Currently, the new Engineering Department has more than 800 students in its programs. Several students in Electrical Engineering were included in the LEAP scholarship program.

The four established programs are accredited by ABET (Accreditation Board for Engineering & Technology). The new engineering programs are making application for accreditation by ABET

now that its first students are graduating (Spring 2020). Tables 1 and 2 show the enrollment and graduation trends in the Computer Science and Engineering programs.

Program		Enrollment Numbers				
	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020
Computer Science	769	870	971	1,013	1,058	1,015
Computer Engineering	185	201	253	281	248	263
Software Engineering	103	111	107	133	173	170
Pre-Engineering	350	386	422	416	227	142

Table 1: Enrollment Numbers in Computer Science and Engineering Departments

Program		Graduation Numbers				
	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020
Computer Science	58	69	91	74	95	65
Computer Engineering	7	2	5	13	12	14
Software Engineering	7	14	19	13	23	6
Pre-Engineering	18	17	18	21	26	10

Table 2: Graduation Numbers in Computer Science and Engineering Departments

As can be seen from the Tables 1 and 2, the number of students enrolling in these degree programs has increased over the past six years, however, the graduation remains low. Several factors decrease graduation numbers, factors the LEAP program has sought to address. For instance, many students, particularly juniors and seniors, work over 20 hours a week to support their families while attending school, thus slowing down their progress and delaying their graduation. Most of our students are married and have several children. These students often leave their programs of study early to accept employment in an industry anxious for employees. When students attend school part-time, they increase the number of years it takes to graduate as well as reduce the likelihood that they will graduate at all. The Utah Department of Workforce job forecasts and other job trends surveys indicate that while these students can earn strong salaries without degrees, their careers will not advance as they would with degrees [4]. Employers are also feeling the disadvantage of too few job candidates with the adequate training provided by a baccalaureate degree [5]. The lack of adequate number of scholarships in Computer Science and Engineering programs is a significant inhibitor in graduating and enrolling more students.

The LEAP Scholarship Program

LEAP Project Goal and Objectives

The goal of the LEAP project was 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 (both student-to-student and faculty-to-student).

The objectives of the NSF LEAP project were 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 a student chapter of a professional organization, through multidisciplinary projects, and through student-to-student mentoring.
4. Strengthen engaged learning opportunities for students through a CS 1400 (Fundamentals of Programming) course project (freshman level) and through multidisciplinary IEEE student section 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.
6. Establish mechanisms for acquiring ongoing sources of funds to sustain at least five annual full-tuition scholarships after the grant is over.

LEAP Project Management Plan

As part of the LEAP grant application to the NSF, UVU developed a project management plan for the S-STEM scholarship program. Specifically, the PI had the overall administrative responsibility for the project and for interacting with NSF. She coordinated the activities of the Project Management Team, including such activities as advertising and recruitment of students, selection of students, maintenance of LEAP records, and oversight of student support services. She had fiscal oversight and reporting responsibilities for the project. Co-PI's were responsible for conducting selection of scholarship recipients, ensuring that recipients understood their obligations to the program, assigning mentors, meeting with students regularly, and monitoring their progress.

LEAP Scholar Selection Criteria

Students were selected based on the following criteria:

- 1) U.S. Citizen or Permanent Resident.

- 2) Must be admitted in a four-year Computer Science program at UVU or a two-year Pre-Engineering program at UVU with the plan to transfer into an Engineering four-year program.
- 3) Demonstration of financial need in accordance with the U.S. Department of Education rules for Federal financial aid.
- 4) Full-time student majoring in Computer Science, Computer Engineering, Software Engineering, or Pre-engineering.

LEAP Scholar Agreement

The selected LEAP Scholars were committed to progressing in their major by signing a contract between the student and the institution/department. Scholarships were awarded on a semester basis and the contract was signed with each award. This contract set 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 Section and Computer Engineering Club; participants were encouraged to accept a leadership role as they became available.
- 6) Where possible, return service to the program or the community, in the form of tutoring, service learning, mentoring, visits to high school classrooms, or other activity (not required).
- 7) Compile a portfolio of work that includes a short annual report to the faculty mentor that outlines the year's goals and accomplishments.

Students' required out-of-class time commitments were not extensive and focused on the most important activities for program coherence and student success. The most important element of the student contract was the student's academic performance. There was some flexibility in evaluating the student's eligibility to continue regarding other contract elements.

Major Engagement Activities

Currently, the LEAP program is in its sixth year and final year. One of the goals of this project was to increase the retention rate of the students in the computer science and engineering programs by providing engaged learning opportunities, high impact practices, and enrichment activities. The scholarship recipients participated in interdisciplinary engaged learning opportunities through the Computer Engineering Club and IEEE student section projects, a required for-credit capstone project, and optional internships and faculty mentored research. Enrichment activities included leadership training and opportunities, monthly LEAP participant meetings, involvement in student professional organizations or other student service organizations, field trips, guest speakers, networking opportunities, and faculty mentoring. Students were also encouraged to attend and present at professional conferences. Ten LEAP scholars have presented 14 papers or posters at regional and national conferences.

NSF LEAP Scholarship Report

Sixty-three NSF LEAP scholars in eight different STEM programs at UVU have participated in the NSF LEAP program. Table 3 lists students from different programs that participated in the NSF LEAP program.

Programs	NSF Scholars
Computer Engineering	32
Computer Science	23
Software Engineering	4
Pre-Engineering	1
Electrical Engineering	3
Total	63

Table 3: Number of Scholars from Different Programs

The LEAP project aimed to award 84 full-year (168 one-semester) scholarships to 40 unique students on a schedule that averaged 21 per year over four years. Scholarships were first awarded in January 2015. Since that time, 78 full-year and 27 one-semester scholarships have been awarded, averaging 18 full-year scholarships per year over five years (including the one-year extension). A total of 63 students have received scholarships. Of those, 28 (45%) scholars have graduated with BS degrees (3 times the rate of the comparison group as shown in Table 4) and 13 (20%) currently participate in the LEAP program (3 of whom will graduate in April 2020). Of the 22 scholars (35%) who have left the LEAP program: 5 are on a leave of absence while employed full-time; 10 were dropped from the scholarship program because they had low grades, changed majors, accepted a different scholarship, or decided to attend school part-time; 1 scholar passed away, 3 dropped out of school, and 3 transferred.

LEAP Scholar Outcomes

In order to assess the outcome of our NSF LEAP program, a study was conducted by UVU's Institutional Research office 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 the LEAP student counterpart received the scholarship. The comparison group was randomized and then matched by major, gender, class level, and race/ethnicity.

The NSF LEAP project has increased retention, student success, and graduation in STEM. Due to the challenges of excessive work and family obligations, increasing the graduation rate and reducing completion time were major objectives of the LEAP program. LEAP scholarship recipients graduated at three times the rate of the comparison group (defined in Table 4). Specifically, 28 scholars in the LEAP program received bachelor's degrees compared to 10 in the comparison group. (In addition, 8 LEAP scholars completed AS degrees before continuing to a BS degree.) The scholarships also helped 8 students to complete their degrees in 8 or fewer

semesters at UVU (2 had dual enrollment and 1 had transfer credit). Scholarships assisted 10 students to complete their degrees who had attended UVU part-time for over 12 semesters.

Student Group (see text for explanation)	LEAP Participants	Comparison Group**
Total # students	63*	63
Graduated - BS in STEM	28 (45%)	10 (15%)
Retained in STEM major	20	20
Changed to non-STEM	3	8
Dropped out of school	3	13
Leave of absence	5	0
Transferred	3	11
GPA average	3.45	2.86
Semesters to graduation	11.5	14.4
* One LEAP student passed away. ** 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 IR researcher. Source: UVU Office of Institutional Research (IR).		

Table 4: Comparison between S-STEM Recipients and Comparison Group

Another success of the LEAP program was greater retention of students at UVU and in their STEM programs of study. As Table 4 indicates, of 63 LEAP scholars, only 3 dropped out of school, 3 transferred to other institutions, and 3 changed to non-STEM majors. In the comparison group of 63 students, 13 dropped out, 11 transferred to other institutions, and 8 changed to non-STEM majors. (These were not 2-year degree recipients who transferred into 4-year programs.) Moreover, LEAP scholars were more successful in their programs: the average GPA for LEAP scholars, already higher than the comparison group because of its use in scholarship selection, increased by 13%, while the average GPA of non-LEAP students regressed by 3%. All participants of a telephone survey (36/36) indicated that the scholarships incentivized them to maintain high academic standards. Responses included: “I didn’t have to focus so much on work, so I could put more time into my school work”; “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, so it helped me stay focused;” “I was grateful for the scholarship and wanted to try harder to keep it.”

Impacts of the LEAP Scholarship Program

Recruitment and Retention of Underrepresented Groups

Another significant aim of the LEAP program has been to increase participation of women and students from other groups underrepresented in Electrical Engineering, Computer Engineering, Software Engineering, and Computer Science. The participation of women in these programs at UVU has been abysmally low. Women comprised only 4.0% of program enrollment at the beginning of the LEAP program in 2015. Research conducted by the PI and others over the last decade has shown a lack of interest of young women in this region in Computer Science and Engineering, probably due to cultural barriers [6, 7, 8]. Through considerable efforts of faculty

leading the LEAP program, the participation rate of women in Computer Engineering and Computer Science has increased to 10.1% (112 women/1,110 students). In the LEAP program, women participated at the rate of 12.7% (8 women/63 students). Notably, 5 of these women have graduated and 2 have been retained in the LEAP program. Conversely, of the 8 women in the comparison group, *none have graduated*, while 4 have transferred, 1 dropped out of school, 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 section where they are role models to other women and participate in outreach activities. Notably, first-generation students, who typically struggle at UVU, have succeeded in the LEAP program. Thirteen 1st-gen students participated in LEAP, of whom 6 have graduated and 5 are retained in their STEM programs; none have dropped out. In the comparison group, 17 1st-gen students participated, of whom 2 have graduated and 4 are retained in STEM; 10 left UVU.

Strengthening Student Organizations for all Students

LEAP program enrichment and professional development have been delivered largely through the existing Computer Engineering (CS) Club and UVU's IEEE section. The LEAP students serve in leadership positions and form 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 have been extended to all the students in the CE/CS programs who desired to participate. Second, LEAP students who serve in leadership positions become role models. They have actively improved the educational environment for other students in the departments.

Impact on New Engineering Programs

The LEAP program is having an impact on three new engineering programs that were initiated in Fall 2018 in UVU's College of Engineering & Technology – Electrical Engineering, Mechanical Engineering, and Civil Engineering, all within the Department of Engineering. The Chair of this department, who is also the PI for the S-STEM LEAP program, has looked to successes in the scholarship program in designing student support programs for the new degree programs. While the scholarships are, in themselves, a considerable incentive for retaining and graduating students, several LEAP strategies and activities have been found to be useful to carry forward into the new engineering programs, even without the scholarships. Namely, the focus on student participation and leadership opportunities in professional organization sections and similar student clubs has been very beneficial and will 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 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 can be carried out by 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 will be fostered by the Department to the extent possible.

Degree Completion and Workforce Development

The State of Utah has such a critical shortage of engineers and computer scientists that it has sustained a “Engineering and Computer Science Initiative” since 2011. The LEAP program has contributed to meeting the goals of this initiative by graduating 28 students in Computer Engineering and Computer Science B.S. programs in the past five years. The graduation of the three women in the past year was noteworthy as they graduated in Computer Science, a program in which only 5 of the 69 graduates last year were women. The LEAP program contributed significantly to their graduation. One woman was a scholarship recipient for four years, one for three years, and the other for two years. In addition, one man who had taken a leave of absence from the LEAP program to accept a well-paying job, returned to UVU this year to complete his degree, and then returning to work at higher salary. The LEAP program has made it possible for other students who work to support their families to remain in school and complete their degrees, making them more valuable employees for the companies that employ them.

Career Preparation and Employment

LEAP participants have reported through surveys that the activities of the LEAP program directly assisted them in obtaining employment in their field. All of the LEAP graduates interviewed (12/12) are now employed in their fields. They report that activities such as career speakers and field trips to companies helped them network with employers and land good jobs. Computer Science Club and IEEE student chapter activities have provided valuable leadership opportunities and taught students useful job skills through hands-on workshops. All LEAP students who have graduated have completed a senior design or senior capstone project, which is a significant factor in the hiring process. One student reported: “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.” Several students have conducted faculty-mentored research and a number have given presentations at regional and national conferences. Moreover, the faculty mentoring program has also been especially helpful in developing human resources, particularly in helping students complete their degree programs with an eye toward employment.

Conclusion

This paper is a presentation of final report of UVU’s LEAP program which is an NSF supported S-STEM project whose goal is to enable academically talented and financially needy students to pursue college degree in computer science and engineering. This project, now in its sixth and final year, is increasing the graduation rate for students in Computer Science and Engineering at Utah Valley University, an open enrollment university, and better preparing 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 opportunities, engaged learning activities, and mentoring. Overall, the NSF-supported LEAP program has been an effective tool in helping to recruit, retain, graduate, and promote computer science and engineering programs.

Acknowledgements

This project is supported by the National Science Foundation through the S-STEM program, Award No. S-STEM 1356716. Any opinions, findings, and recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

1. Utah Code and Board of Regent's Policy Statements Regarding UVU's Mission and Role: Planning, Budget, and Human Resources, UVU Planning, Budget, and Human Resources, September 21, 2018.
2. Information and statistics provided by the UVU Office of Institutional Research and Information – IRI.
3. U.S. Census Bureau, 2011, http://www.census.gov/popest/data/historical/2010s/vintage_2011/, accessed on 3-14-2016.
4. Utah Department of Workforce Services, "College to career: Projected job openings in occupations that typically require a bachelor's degree," Occupational Outlook Quarterly, Summer 2013.
5. Sutherland, John, Chair, Utah Technology Council, Budget Impacts on Engineering Education, 2012.
6. Minaie, A., Love, K., Sanati-Mehrizi, P., and Sanati-Mehrizi, R. "Recruitment and Retention of Women in Computer Science & Engineering," Proceedings of ASEE Annual Conference, June 2010.
7. UWEP – Utah Women and Education Project, Madsen, S.R., Hanewicz, C., Thackeray, S., & King, D. (2010). Women and Higher Education in Utah: A Glimpse at the Past and Present, Research and Policy Brief. Utah Valley University. Retrieved from <https://www.uvu.edu/uwlp/docs/uwlpbrief2.pdf>.
8. UWLP – Utah Women in Leadership Project, Jeppsen, C. (2018). Utah Women in Higher Education: A Progress Report, Research Brief, Utah Valley University. Retrieved from <https://www.utah.gov/women/documents/Utah-Women-in-higher-education-brief.pdf>.