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High Impact Practices in LEAP: an NSF S-STEM Scholarship Program

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High-Impact Practices in LEAP: an NSF S-STEM Scholarship Program

Abstract

Utah Valley University (UVU) was awarded an NSF Scholarships in STEM (S-STEM) grant in 2014 to strengthen outcomes for students in computer science, software engineering, computer engineering, and electrical engineering through Leadership, Engagement, Academic Mentoring, and Preparation (LEAP). The LEAP project was completed in September 2021. This paper presents the impact of the program on the institution and its computing and engineering programs. Also, it presents the effect of the high-impact practices in this program in retention and completion of computer science and engineering students. High-impact practices reported on include Capstone Courses, Collaborative Projects, First-Year Experiences, Internships, Undergraduate Research, and Writing Intensive Courses.

Introduction

To address the national need to increase substantially the number of American scientists and engineers, the National Science Foundation (NSF) established the Scholarships in STEM (S-STEM) program in accordance with the American Competitiveness and Workforce Improvement Act of 1998 [1]. S-STEM programs award scholarships to academically talented students who demonstrate financial need. S-STEM programs are designed to increase the number and diversity of students entering science and engineering programs as well as to retain more students in their STEM programs through graduation and to increase the quality and preparedness of graduates entering the science and engineering workforce. This article addresses the retention, graduation, and preparation of students in computer science and engineering as part of an S-STEM program but can apply to all undergraduate students in these degree programs as well. In particular, this paper addresses one S-STEM program's growing awareness of the value of utilizing high-impact practices in this endeavor.

High-impact practices (HIPs) are specific active learning practices that educational research has shown to increase rates of student retention and higher levels of learning success [2]. HIPs are innovative and transformational learning opportunities for students inside and outside of the classroom (like capstone courses and internships) that provide a variety of learning benefits aimed at promoting the success of students – the core objective of any institution of higher education. In the 2008 Association of American College and Universities (AAC&U) report cited above, George D. Kuh describes a strong positive effect of participating in high-impact activities as measured by the National Survey of Student Engagement (NSSE) [2]. He also observes that HIPs help level the playing field for students who have been historically underserved. Kuh recommends that to enhance student engagement and increase student success, *every student* should participate in at least two HIPs during their academic career – one taken in their first year, and one taken later in relation to their major field of study – but ideally, every student should participate in one HIP each year in college. Many other researchers have addressed the benefits and application of HIPs as well [3], [4], [5], [6], [7]. A common outcome studied across high-impact practices is undergraduate student retention and academic performance (grade point average). For both measures, the result is positive: students who participate in HIPs are consistently retained in the programs at a higher rate than those who do not, and HIPs have a positive impact on student performance.

Kuh acknowledges in his 2008 article that: “These practices take many different forms, depending upon learner characteristics and on institutional priorities and contexts.” However, for a 2013 article for *Inside Higher Ed*, Kuh and Kinzie address a most important but often overlooked consideration about high-impact practices: “institutional context and implementation quality matter.” They write: “Simply offering and labeling an activity an HIP does not necessarily guarantee that students who participate in it will benefit in the ways much of the extant literature claims” [8]. Kuh and O’Donnell elaborate this consideration in their 2013 book, “Ensuring Quality and Taking High-Impact Practices to Scale” [9]. Here, they list eight key characteristics of impactful HIPs:

- Performance expectations set at appropriately high levels
- Significant investment of time and effort by students over an extended period of time
- Interactions with faculty and peers about substantive matters
- Experiences with diversity, wherein students are exposed to and must contend with people and circumstances that differ from those with which students are familiar
- Frequent, timely, and constructive feedback
- Periodic, structured opportunities to reflect and integrate learning
- Opportunities to discover relevance of learning through real-world applications
- Public demonstration of competence.

While not all HIPs will not address each characteristic to the same degree, the list provides a standard for judging the quality of implementation. It could potentially be used to assess the quality of other evidence-based curricular and co-curricular activities as well.

Application of HIPs in UVU’s S-STEM Program

Utah Valley University (UVU) is an open admissions university of 41,200 students, but at the time the S-STEM began in 2014, UVU’s student enrollment was 31,300 students. UVU had an established Department of Computer Science that offered bachelor’s degree programs in computer science, computer engineering, and software engineering, and an associate degree in pre-engineering. (By the conclusion of the project in 2021, a new Department of Engineering had been created that housed the computer engineering program, electrical engineering, and two other engineering programs.) Institutional challenges the S-STEM program was designed to address were excessive time to completion, excessive part-time work, a high dropout rate, and low participation and graduation rates of women, minorities, and first-generation students. In UVU's area, plentiful work in the technology industry pulls students away from their studies, diverting them from full-time enrollment and from degree completion. Later on, many are kept from advancement, higher wages, and significant workforce contribution because of the lack of a degree. Those who return to complete or spend years as part-time students are frequently faced with the additional challenge of family obligations. With these challenges in mind, the project team sought to design an NSF scholarship program with high-value, impactful student supports.

UVU began its S-STEM project, called LEAP, in 2014 for students in computer science (CS), computer engineering (CE), and software engineering (SE), and later electrical engineering (EE). When the proposal for the project was written in 2013, it addressed the NSF requirement to "have or develop support programs to enhance student learning, confidence, academic performance, retention to graduation, and career of higher education placement" [1]. Support programs were balanced to include some required elements that are flexible enough to allow students with other responsibilities to participate, as well as some optional elements that do not make the scholarship appear to be a payment of services. ***Curricular support programs*** included a common course at the freshman level and a two-semester capstone course/project (computer engineering students) or senior class design course/project (computer science students). ***Required co-curricular elements*** included faculty mentors and participation in monthly LEAP Activities (that included multidisciplinary projects, guest speakers, skills-building workshops, and field trips). ***Optional co-curricular elements*** included leadership opportunities within a professionally-focused student organization, faculty-mentored research, and internships. All planned support programs were grounded in evidence-based strategies and research pointing to likelihood of their increasing student success and completion.

It should be noted that UVU's S-STEM proposal did not specifically mention the use of "high-impact practices." The term was not yet integrated into UVU's academic culture. However, of the eleven types of HIPs endorsed by Kuh and AAC&U [10], six HIPs were employed by the project: Capstone Courses and Projects, Writing Intensive Courses, First-Year Experiences, Collaborative Projects, Undergraduate Research, and Internships. Over time, however, as HIPs began to take hold at UVU, the LEAP faculty team began to shift their focus toward the HIPs and to refine the use of some of these HIPs to fit contemporary best practices and address institutional needs. Now, as one S-STEM program concludes at UVU and another begins, it seems appropriate to take stock of what worked well with these HIPs and what could be improved.

Several institutional shifts toward HIPs occurred at UVU during the same period as the LEAP program. First, UVU received a Title III Strengthening Institutions Program grant (2014–2021) that focused in large part on expanding opportunities for meaningful student engagement, which came to be defined as HIPs. Evaluation activities conducted under the Title III grant showed the value of HIPs at increasing student retention at UVU, an open admissions institution. It also demonstrated the *collective impact of HIPs*, which takes into consideration how HIPs work together to increase student outcomes. For instance, one internal study found that students who participated in three HIPs (study abroad, service learning, and a global/intercultural course) graduated at a rate of 72% compared to 43% for students who participated in less than three [11]. Second, in November of 2017, the Utah Board of Higher Education, the governing body for UVU, prioritized high-impact practices and set a goal that institutions ensure 100% of their students participate in at least two HIPs, one in the first 30 credits and one within their major. And third, the new engineering programs were being designed with the aim of ABET (Accreditation Board for Engineering & Technology) accreditation. (The computer science and computer engineering programs were already ABET accredited, and each of the new engineering programs have now been accredited.) The ABET Criteria for Student Outcomes are compatible with the practice and characteristics of impactful HIPs, though at the more discipline-specific level [12]. These three elements worked together to open dialogs, increase understanding, create opportunities, and demonstrate the value of HIPs for UVU students.

Thus, working with what the LEAP program already had in place, and with Kuh's 2008 recommendation that "institutions structure the curriculum and other learning opportunities so that one high-impact activity is available to every student every year," the project team refined its thinking to give greater emphasis and support to HIPs within the program. While the COVID-19 epidemic curtailed some of these intentions, the general thrust continued and was carried forward into UVU's plans for its subsequent S-STEM program (awarded in 2021). Table 1 shows the structure of HIPs within the LEAP program. A discussion of the implementation of each HIP and high-impact activity follows the table.

Table 1: Application of HIPs in UVU's S-STEM LEAP Program

Year in bachelor's degree Program	Type of High-Impact Practice (or activity)	Method	Implementation
1st year	First-year course Collaborative project	curricular co-curricular	Required: LEAP support LEAP program
2nd year	Collaborative project	co-curricular	LEAP program
3rd year	Collaborative project Internship Undergraduate research	co-curricular curricular* co-curricular	LEAP Program optional* optional
4th year	Capstone course & project Writing intensive course Undergraduate research	curricular curricular co-curricular	Required: LEAP support required optional
All years *(other impactful program activities)*	Faculty mentor Leadership opportunities	co-curricular co-curricular	required for LEAP optional; LEAP support

*Internships changed from a non-credit option to a credit-bearing elective in 2019 to emphasize their importance and encourage participation. Internships are now required for scholarship recipients in UVU's new S-STEM program.

First-Year Experiences. Several first-year experiences were available to students in the LEAP program. First, LEAP students were to take a basic required course together – CS1400, Fundamentals of Program. This was planned as a community-building element for first-year students. However, students had such differing scheduling requirements that getting all or even many of first-year students into one section of the course was not feasible. However, as the engineering program advanced, the ENGR1000, Introduction to Engineering, course was redesigned as first-year experience, facilitated by a sub-award from the Title III grant mentioned earlier. For CE/EE students, the course became ECE1000, Introduction to Electrical and Computer Engineering. Students in the course work together in teams on a semester-long project of their choosing. They go through the process of researching the topic, deciding which is the best solution for their problem, creating a physical prototype, then testing and presenting the prototype. In addition to this large project, the course was also redesigned to devote classroom time to smaller projects that give students hands-on experience of what it's like to be an engineer [13]. For the CE/EE program, oscilloscope training boards were purchased for student use in a series of small projects with an online component. CS/SE students, on the other hand, took one of many sections of CS1400, Fundamentals of Programming, where students work individually on 7-8 programming products. While not specifically designed as a first-year experience course, CS1400 provided significant hands-on, problem-solving challenges in student's major field of study. In addition, the Collaborative Projects for LEAP students, discussed later, also served as a first-year experience.

While these courses are not exclusive to students in the LEAP program, they did provide a meaningful HIP experience to LEAP students at the beginning of their program of study (though not always in their freshman year, since some students declare a major later). The faculty on the CE/EE curricular design teams included members of the S-STEM project team and addressed LEAP project aims. As described in Kuh's *High-Impact Educational Practices* [2] these first-year experiences brought small groups of students together with faculty on a regular basis and placed strong emphasis on critical inquiry, information literacy, collaborative learning, and other skills that develop students' intellectual and practical competencies. HIP characteristics they emphasized were: "interactions with faculty and peers about substantive matters;" "experiences with diversity;" and "opportunities to discover relevance of learning through real-world applications." Importantly, LEAP students in all programs used the Computer and Electrical Engineering Lab to work collaboratively on their projects. Moreover, faculty mentors provided support to LEAP students in the introductory classes by answering questions, monitoring student progress, and directing students to tutoring as needed. This program element also demonstrates that successful S-STEM projects can and should integrate and coordinate with departmental/ institutional resources.

Collaborative Projects. The LEAP Activities became the strongest community-building element in the program. It was planned that within these LEAP Activities, one collaborative project would take place each semester, hosted by the Computer Engineering Club and/or the IEEE Student Chapter. The projects were sponsored by LEAP but included both scholarship and non-scholarship recipients. Projects were chosen that would allow both computing and engineering students to work collaboratively. For example, for one project, students took a bicycle and designed it to be an e-bike with sensors and a user console. The collaborative projects were multidisciplinary as they generally involved LEAP students from the four targeted disciplines. The projects also involved students from all grade levels, which proved to be beneficial because upper-class students mentored first- and second-year students. The projects were an excellent way for LEAP students to build a sense of community. They also provided a HIP opportunity for students in their middle years of college.

Over the seven-year LEAP program, the collaborative projects were strong in the key HIP characteristics of "interactions with faculty and peers about substantive matters" and "opportunities to discover relevance of learning through real-world applications." Since the LEAP program had to be respectful of students' time constraints, projects did generally not require a "significant investment of time and effort." Projects were of varying length of time, averaging about 2-3 hours per week. Projects also had varying participation rates from LEAP students. Looking forward, future projects would benefit from more "frequent, timely, and constructive feedback" and from a "public demonstration of competence." The latter might be a presentation to the whole LEAP group so that presenters can reflect on their design and learn more from the experience as they answer other's questions, and to encourage more LEAP students to participate.

Internships. When the S-STEM project began, non-credit-bearing internships were available to LEAP students who requested them through the College of Engineering and Technology (CET)'s internship coordinator. While the various schools and colleges of the university have long had internship coordinators specific to their programs, internship programs at UVU are now overseen by Internship Services in the Office of Engaged Learning (OEL). In 2017, in conjunction with UVU's Title III project, OEL centralized the coordination of internships to ensure that all meet the criteria of an HIP so that student experience with internships across all programs would be of high quality [11]. The Internship Coordinator for CET supports a website that details internship opportunities for each degree program. It sets forth clear procedures for students in initiating, completing, and receiving credit for an internship. An essential tool of the program is a six-part course on *Canvas* (UVU's learning management system). The course requires a learning agreement with four student goals, progress reports, a final report, a student survey, a supervisor survey, and a log for hours worked (60 hrs. per credit). A faculty member of the LEAP project team generally oversees the internship course. As now designed, the internships include all eight key characteristics of impactful HIPs. They are particularly strong in "opportunities to discover relevance of learning through real-world applications;" "significant investment of time and effort by students over an extended period of time;" and "periodic, structured opportunities to reflect and integrate learning."

While LEAP students were always encouraged to participate in internships, only several students did because internships did not offer credit and students had difficulty fitting them into their schedules. In the last two years of the program, however, internships were integrated into the academic curriculum as an elective course for all four degree programs. This action was taken to emphasize the importance of internships and to encourage student participation. Internships are now required for scholarship recipients in UVU's new S-STEM program. Faculty mentors will encourage S-STEM participants to plan for and carry out an internship, probably in their junior year. Students will receive credit toward graduation. Most internships are paid at an average rate of $18.00 per hour.

Capstone Projects. Capstone courses play a crucial role in the Electrical and Computer Engineering curricula. The principal purposes of a capstone project are to offer a summative opportunity for graduating senior engineering students to apply their professional skills and knowledge in a single experience and prepare them for professional work. When the LEAP project began, students conducted their capstone projects in a one-semester capstone course. In recent years, like many engineering programs, students at UVU now complete their requirements for graduation with two semester-long capstone design project courses. The intention of these courses is to apply competencies gained during students' first three years toward the solution of a design problem. As the students are required to design, build, and troubleshoot a fully functional project, they find these courses both challenging and rewarding. These projects have been very successful at integrating knowledge and preparing students for the workforce.

Capstone projects include all eight key characteristics of impactful HIPs. Among the most prominent are: "performance expectations set at appropriately high levels;" "significant investment of time and effort by students over an extended period of time;" "frequent, timely, and constructive feedback;" and "public demonstration of competence." This public demonstration has been a presentation to faculty and students in the CE/EE or CS/SE departments, but this year, the CE/EE Advisory Board, representatives from industry, and the public were also invited to broaden the outreach of these presentations. Because capstone projects are a required part of the curriculum, all LEAP students who graduated participated in this high-impact practice. The LEAP program provided support for the capstone projects through faculty mentors, materials for projects (which students otherwise have to pay for themselves or chose a less suitable project), and workshops on essential skills. The LEAP program also paid for some students to present the results of their projects at professional conferences, and faculty mentors worked with them to prepare papers for publication. The capstone research of at least fifteen LEAP students was presented and/or published.

Writing Intensive Courses. The capstone courses are writing-intensive courses. This was not the case when the LEAP project began but was initiated as UVU sought to incorporate more HIPs into the curriculum. Each program was charged with designating two required courses as Writing Intensive Courses. The Writing Enriched Committee recommended that faculty of these courses need to intervene in students' writing processes by providing in-class instruction, guiding feedback on plans and drafts, and engaging in one-to-one conversations with students about writing. Key HIP characteristics of the writing intensive courses dovetail with the capstone projects but reinforce “interactions with faculty and peers about substantive matters” and “periodic, structured opportunities to reflect and integrate learning.” Students in the Capstone Courses submit weekly reports (low-stakes writing) and a very detailed technical report at the end of the semester (high-stakes writing). They are required to work with tutors from the Writing Center on their on their end-of-semester reports. They also receive feedback from faculty and other students. Students often use this written report in applications for employment or graduate programs.

Undergraduate Research. A few LEAP students had the opportunity to participate in faculty-mentored undergraduate research activities outside of their capstone project. One NSF-funded project, entitled *Integrating Environmentally Improved Photolithography Technology and Virtual Reality Games into Advanced Nanotechnology Education* provided paid mentored research opportunities to three LEAP students. These undergraduate research projects were strong in the key HIP characteristics of “performance expectations set at appropriately high levels;” “significant investment of time and effort by students over an extended period of time;” “frequent, timely, and constructive feedback;” and “public demonstration of competence,” as students worked with faculty mentors to prepare conference presentations and papers. For the new S-STEM program, there will be more opportunities for faculty-mentored research in addition to the research done through the capstone projects because a number of new engineering faculty have been hired who have plans for undergraduate research that complements their commitment to teaching. A growing number of faculty have received research grants from the Utah System of Higher Education and the NSF. S-STEM students as well as other undergraduate students in the departments will be eligible to participate. Faculty researchers, in coordination with the S-STEM team, could be encouraged to implement key HIP characteristics into the structure of their undergraduate research projects.

Faculty Mentors. Faculty mentors are not listed among the recognized HIPs, but they are recognized as an invaluable aspect of successful undergraduate STEM programs. Studies have shown that early and consistent interaction with a faculty mentor makes the transition to college smoother, increases academic success, and increases year-to-year persistence, especially for women and students from underrepresented groups [14], [15]. One of the objectives of the LEAP program was to provide a faculty mentor to each program participant. Each NSF LEAP scholar was assigned a faculty mentor. Four faculty members served as mentors to LEAP participants. Typically, students were introduced to their faculty mentors at the Meet Your Faculty Mentor Night conducted each September. Faculty mentors generally met with their students every semester and more often if needed; some met monthly. Faculty mentors advised LEAP students about educational success, degree progress, potential fields of interest, career preparation, job seeking, and graduate school preparation. They connected students to tutoring resources as needed, and to various academic and career opportunities, such as research or internships. Some LEAP students worked with their faculty mentors on research projects. During the COVID-19 pandemic, faculty mentors were a vital link between students and the university. Key HIP characteristics of the mentor/student relationship were “interactions with faculty about substantive matters,” and “frequent, timely, and constructive feedback.” Some participants in the project evaluation surveys pointed to faculty mentoring was one of the most valuable elements of LEAP.

Leadership Opportunities within a Professionally-focused Student Organization. Although not an acknowledged HIP, leadership opportunities within the IEEE student chapter or the Computer Engineering Club were an impactful activity of the LEAP program. LEAP students served in positions of President, Vice President, Social Media Chair, VP of Publications, and VP for University Relations. LEAP enrichment and professional development activities were delivered largely through these organizations, which gave other students in the departments an opportunity to benefit as well. Under faculty supervision, student leaders took responsibility for planning LEAP activities, inviting and introducing guest speakers, arranging for field trips to local industries and employers, hosting or conducting workshops, and organizing LEAP design (collaborative) projects. For example, 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). Sometimes students’ leaders of the two organizations worked together to plan joint activities, such as the annual *Meet Your Faculty Mentor Night* where new student officers are elected. Also, IEEE hosts an annual regional Student Leadership Training Seminar and an IEEE Rising Stars Conference for promising students at which LEAP students also participated.

Key HIP characteristics this activity emphasized were “interactions with peers and faculty about substantive matters,” “experiences with diversity,” and “public demonstration of competence.” Since student leadership was an optional activity, students’ time commitment varied, depending on their position, the activity, and their availability. Overall, LEAP students who served in the leadership positions of the organizations became role models and actively improved the educational environment for other students in the departments. They had the opportunity to develop leadership skills “in a low-stakes environment” that will be important to them as professionals. Students reported by survey that leadership in the organizations helped them develop a sense of community with other students and provided opportunities for career exploration and networking with professionals. Some found this the most valuable support activity of the LEAP program.

Results and Discussion

LEAP Program Outcomes. This S-STEM project has completed its seventh and final year. The original 5-year project was twice granted a one-year extension, the latter of which ended on September 30, 2021. 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, 82 full-year scholarships of $6,000 and 25 one-semester scholarships of $3,000 have been awarded. An average of 20 full scholarships were awarded per year in the four years prior to the extension period. Sixty students meeting the selection criteria have been recruited and awarded scholarships. Of these, 77% have graduated. This nearly triples the baseline graduation rate of 25% for baccalaureate degree programs at UVU in 2014 as well as exceeds UVU's current graduation rate for baccalaureate degree programs at 33%.

The PI has maintained records of awards and demographics of participants, and of participant participation in LEAP program activities. The UVU Office of Institutional Research (IR) provided additional information on the scholarship recipients relative to their retention and success. In addition, IR created comparison group by matching LEAP scholarship recipients with nonrecipients who attended during the same first semester as each participant. The comparison group was randomized and then matched by major, gender, class level, and race/ethnicity by a qualified IR researcher. Table 2 reports the comparison of scholarship recipients with nonrecipients.

Table 2: Comparison between S-STEM Recipients and Comparison Group, 2014-2021

	LEAP Participants	Comparison Group
Total # of students awarded scholarships	60	60
Positive Student Outcomes		
Graduated with BS STEM degree	46 (77%)	20 (33%)
Transferred with AS STEM degree	1	2
Retained in STEM BS degree program	5	4
*Negative Student Outcomes**		
Changed to non-STEM	2	4
Left school without BS degree	3	21
Transferred without AS degree	2	9
Student Success Predictors		
GPA average	3.45	2.86
Semesters to graduation	11.5	14.4

* One scholarship recipient died.
Sources: PI records & UVU Office of Institutional Research (IR).

As Table 2 indicates, over the entirety of the program, LEAP scholarship recipients graduated at more than twice the rate of the comparison group. To break this down, 46 of 60 students in the LEAP program (77%) received 4-year degrees compared to 20 (33%) in the comparison group. More students in the LEAP program were retained in their STEM majors. Also, first-generation students, who typically struggle at UVU, have succeeded in the LEAP program. Thirteen 1st-gen students participated in LEAP, of whom 9 have graduated, 2 are retained in their STEM programs, and 2 left UVU. In the comparison group, 17 1st-gen students participated, of whom 6 have graduated and 10 left UVU.

Employment Outcomes. In September 2021, a survey was conducted of LEAP graduates to determine their employment rate. The survey was designed by the evaluator in collaboration with Institutional Research (IR) and was conducted on the phone by a member of the IR staff. As of September 30, 2021, of the 60 students who had participated in LEAP, 49 were currently employed in Computer Science/Computer Engineering-related fields, one is employed in another STEM field, 2 are in school and not employed, and 7 are not employed in a STEM field or their employment status is unknown (Table 3). In addition, LEAP participants reported through the surveys how the activities of the LEAP program directly assisted them in obtaining employment in their field. Students referred their capstone and senior design projects, internships, opportunities for networking through field trips and guest speakers, resume-building activities, and specific classes, in addition to the scholarships that allowed them to complete their degrees.

Table 3: Employment Outcomes for LEAP Participants, as of September 2021	
Employed	
LEAP CS/CE graduates employed in CS/CE STEM fields	40
LEAP students graduated and employed in another STEM field	1
LEAP graduates enrolled in graduate school, employed in CS/CE field	4
LEAP students not graduated, but employed in CS/CE STEM fields	5
Total LEAP students employed in STEM fields	50
Other Outcomes	
LEAP graduates enrolled in graduate school, not employed	1
LEAP student, enrolled in undergraduate school, not employed	1
LEAP students not employed or not employed in STEM fields	3
LEAP students with unknown current employment	5
Total LEAP Students	60

Outcomes for Students from Underrepresented Groups. A significant aim of the LEAP program was to increase participation of women in computing and engineering. Women comprised only 4% of the target degree program enrollment at the beginning of the project. In the LEAP program, seven women participated (a rate of 12%), and all seven have graduated. Conversely, of the seven women in the matched comparison group, only one graduated, while five transferred or dropped out, and one was retained in CS. Women in the LEAP program have also served in leadership positions in the Computer Engineering Club and IEEE student section where they have been role models to other women. Another success of the program is that minority and first-generation students (who frequently struggle at UVU) have succeeded in the LEAP program in greater numbers than those in the comparison group: nine first-generation students and five minority students in the LEAP program graduated in their STEM degree programs, compared six first-generation students and two minority students in the matched comparison group. Certainly, the scholarships themselves were a major contributor to completion outcomes of these students; however, these outcomes also appear to align with the research findings of Kuh and others that high-impact practices are especially impactful for students from underserved populations [2], [3], [16].

Impact on the Institution. 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 PI for the S-STEM LEAP program also served as the Chair of the Engineering Department from July 2018 through June 2021. In heading up the new programs, she has looked to successes in the LEAP scholarship program in designing student support programs. While the scholarships are, in themselves, a considerable incentive for retaining and graduating students, the key LEAP activities have been found to be useful to carry forward into the new engineering programs, even without the scholarships. Namely, the integration of high-impact practices, such as capstone projects and internships into the curriculum. The opportunities for leadership in professionally-focused student organizations have been very beneficial as have been their sponsorship of collaborative design projects as mid-degree HIP activities. Faculty mentoring has also proved a valuable LEAP element, which can be carried out to the other programs. 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.

Impact on Disciplinary Knowledge. The outcomes of the capstone and undergraduate research projects demonstrate that they have employed the HIP key characteristics of "high expectation levels" and "public demonstration of competence." In addition to presentation of their projects to the department, LEAP students with exceptional projects are supported in presenting their work at professional conferences and submitting their written work for publication. For example, during the final project year, three students with their advisors, reported at the ASEE 2021 virtual conference on their capstone projects, thus expanding the knowledge base about effective use of the capstone project in Computer Engineering.

Efficacy of HIPs in the LEAP Program. The financial benefits to students of receiving the NSF scholarships were tremendous: the scholarships helped students attend school, focus on their schoolwork, get better grades, complete their degrees and complete them more quickly. The benefits of the LEAP project support activities, framed within HIPs, were also invaluable to students in retaining them in the program and better preparing them for their careers or continued education. The LEAP Program Survey asked students several open-ended question about what aspects of the program they found most valuable, and then followed with questions about the value of specific activities within the program. Student responses were diverse but expressed value for the range of project supports within the context of the students' lives and aspirations. Their responses are not given here but were part of an earlier paper [17]. They do, however, give credence to our assertion that the HIPs included in this S-STEM project were, both individually and collectively, impactful and valuable to students and did in fact help students complete their degrees and obtain employment related to their fields of study, as well as receive a host of less tangible benefits.

Our growing investment in HIPs in this program, and at UVU more broadly, has led to revisions and improvements. Revising the introductory course to provide an engaging, hands-on first-year experience has laid a stronger foundation for students in their major field of study. The departmental decision to integrate internships into the academic curriculum as an elective course for all four degree programs will increase the number of students who will participate and benefit. The capstone course was strengthened when it was designed as a writing-intensive course so that students are learning to communicate in their disciplines about technical subjects. And integrating student leadership opportunities into the design and delivery of LEAP activities has benefited students more than simple participation in faculty-designed activities would have done. In evaluating these activities, however, we see that some could be strengthen by our considering if there are key characteristics of impactful HIPs that would be useful to include or improve upon.

Strategies for Increasing the Collective Impact of HIPs. What is of interested to the authors in both evaluating this S-STEM program and moving forward to the next is the collective impact of the HIPs selected for this program. We see a synergy among this collection of HIPs that could be strengthened by more intentional awareness of their potential collective impact. Finley and McNair suggest that "by treating these practices [HIPs] as a *set* of effective tools rather than as discrete experiences, faculty, administrators, and other campus professionals could begin to conceptualize the *collective* impact these practices have on indicators of student success and learning" [16]. In application to UVU's new S-STEM project, the project team might consider a skill they desire participants to develop, such as "an ability to communicate effectively with a range of audiences "(ABET Student Outcome #3), and then plan a progression from the first-year experience, through the collaborative projects and internship, culminating in the capstone project. Individually, each of these HIPs can be designed to develop student communication skills, but together, they could have a tremendous impact on student growth and career preparation.

To facilitate a more intentional focus on the potential for collective impact of HIPs in the new S-STEM program, we intend to have students plan their HIP participating with their faculty mentors and to encourage the use of ePortfolios. Individual students work will with their faculty mentors the create an Individual Education and Development Plan (IEDP) that provides a map toward graduation and career [18], [19]. IEDPs will include the purpose and sequence of HIPs in which students participate. If students have a clearer idea of which soft skills they wish to develop – such as problem solving and critical thinking, oral and written communication, team work, ethical perspective, leadership, emotional intelligence etc. [20], [21] – they could more purposefully plan and engage in HIPs.

In addition, ePortfolios could provide a useful way to strengthen the collective impact of the HIPs. In ePortfolios, students can document their significant work during their undergraduate studies for prospective employers or graduate schools. Here they can collect, organize, and exhibit their work on collaborative projects, capstone projects, or undergraduate research, describe their internships or leadership activities, and showcase important course assignments or extra-curricular activities. They can also acknowledge connections as well as offer their reflections on this work. Tucker and colleagues explain: "ePortfolios have the potential to facilitate deeper understanding of course content, make the curriculum more relevant for students, and to help build connections between classroom and professional learning competencies" [22]. ePortfolios can be introduced at S-STEM activities, followed up with by faculty mentors, and presented to fellow S-STEM students. The use of IEDPs and ePortfolios is not intended to create more work for the faculty mentors, but rather to encourage students to take responsibility for their own career preparation and to provide them with a concrete framework for so doing. After all, the real impact of "high-impact practices" is on the students themselves, so they should play a role in shaping these outcomes.

Conclusion

Utah Valley University's NSF S-STEM project has completed its final year, having awarded the equivalent of 97 full-tuition scholarships to 60 unique students over a seven-year period. The LEAP project met its goal of increasing the graduation rate for low-income, academically talented students in computing and engineering at UVU, an open enrollment university. Of 60 participants, 46 students graduated (77%) compared to 20 students (33%) in the comparison group. All seven women in the LEAP program graduated in contrast to one woman in the comparison group. The project also met its aim of preparing students for the STEM workforce and/or continued education. By the project end, 40 students were known to be employed in computing and engineering fields and 5 students enrolled in graduate school. In addition to the tremendous benefit students received from the NSF scholarships, the high-impact practices (HIPs) which were implemented as projects supports appear to have provided substantial benefits to students' retention, engagement, graduation, career preparation, and overall success. A refinement of these HIPs over the course of the project, based on current research and increased institutional commitment, is likely to have resulted in a stronger delivery and strengthened student outcomes. The project team plans to continue refining the use of HIPs as it moves forward with its next NSF S-STEM program.

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