Enhancing STEM Degree Completion: A Framework for the Civil and Mechanical Engineering (CAM) Scholarship Project

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Enhancing STEM Degree Completion: A Framework for the Work in Progress Civil and Mechanical Engineering (CAM) Scholarship Project

Abstract

This paper presents the practical framework for implementing the Civil and Mechanical Engineering (CAM) Scholarship project, funded by a recently received grant from the NSF Scholarships in Science, Technology, Engineering, and Mathematics (NSF-S-STEM) program. This project is focused on supporting the retention and degree completion of low-income and high-achieving students with proven financial need in the Civil and Mechanical Engineering programs at the Scott M. Smith College of Engineering and Technology (CET) at the Utah Valley University (UVU). UVU is an open-admissions public institution of higher education with a dual mission model that aims to combine the resources and rigor of a major university yet keep the accessibility of a community college. The institution's student body is markedly different than those at research focused institutions. Student demographics are like those of a community college with a high proportion of first-generation students, low-income students, part-time students, and students who work while enrolled. For Civil and Mechanical Engineering programs, the first-year retention rate for students starting in 2020 was 64%. Students cited several reasons for leaving, with 35% reporting that they are unable to afford college. Although a 2020 Institutional Research study found that scholarships are the most effective form of financial aid to increase persistence, CET has few dedicated scholarships to award students. Furthermore, the few scholarships available in the college are based on merit and do not factor in financial need or other factors that may impact attrition.

This project aims to generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income and high-achieving students. This project also seeks to advance understanding about the effect of evidence-based, context-specific interventions to ensure success for STEM program students in open-admissions universities. The framework of this project is to study and address several institutionally identified attrition points including: (i) high attrition of first- and second-year students, (ii) slow pace of students to matriculation into the Civil and Mechanical Engineering programs, and (iii) low participation and completion rates of women, underrepresented minorities, and first-generation students. In addition to the scholarship award, several approaches have been identified for implementation to support scholarship recipients' success: (i) Multi-layered Mentoring, (ii) Social and Academic Support via an active, collaborative, and inclusive cohorts, (iii) Professional Preparation, and (iv) High Impact Practices. These approaches will serve as indicators to evaluate the project's effectiveness. Some of the measurable outcomes, which will be elaborated in the text, include graduation, retention and matriculation, and STEM employment or graduate school enrollment upon graduation. This project can be used to inform other institutions with similar populations and/or concerns regarding impactful programs, practices, and interventions that are most impactful for students. This paper provides the framework of what will be implemented in the CAM Scholarship project. This framework was developed based on identified evidence-based high impact practices and previous results from lessons learned from a prior NSF-S-STEM project.

Introduction

The CAM Scholarship program targets low-income, academically talented students in the Civil Engineering (CIVE) and Mechanical Engineering (ME) baccalaureate degree programs in the UVU CET. Both bachelor's degree programs were initiated in Fall 2018 with funding from Utah's state legislature and the state's Engineering and Computer Science Initiative. With an initial enrollment of 220 students (at various academic levels), these two accredited programs now enroll 550 students (see Table 1). Enrollment in these degree programs is likely to increase as the University continues to address workforce demands.

Table 1: Enrollment, Retention, and Completion in Mechanical and Civil Engineering at UVU.

Baccalaureate Major	Enrollment, Fall 2022							Grads 2021-22
	Total	Women	Minority	1st-Gen	*Low-Income	Non-Trad.	Part-time	
Mechanical Engineering	401	37	63	125	156	111	117	38
Civil Engineering	149	22	32	62	56	43	49	22
Total Students **Percent of the total ME/CIVE**	550	59 **11%**	95 **17%**	187 **34%**	212 **39%**	154 **28%**	166 **30%**	60
University Averages		49%	19%	37%	33%	30%	40%	

1st year Retention Rate: ME/CIVE: 64.4% University: 67.7%	**Graduation Rate: ME/CIVE: 35.0% University: 35.4%

*Low-income status is determined by Pell grant eligibility.
**Neither the Mechanical nor Civil Engineering program has existed long enough to produce a 6-year graduation rate data. Thus, the graduation rate of a comparable baccalaureate program in the CET is given instead.
Source: UVU Office of Institutional Research

The regional need for engineers is spurred on by the robust growth of the state's technology sectors. According to a report from the University of Utah Kem C. Gardner Policy Institute, the growth in the engineering employment has outpaced the U.S. engineering employment more than fivefold since 2000 (Pace, Spolsdoff, & Becker, 2022). Yet, despite an increase of engineering graduates of 115% over the past two decades, the report indicates that the rate of growth in technology has outpaced the in-state labor availability and is predicted to continue to outpace it. Job offers continue to outpace graduation numbers. One conclusion of the report is that: "*Investment in low-income student opportunities can boost graduation rates, address labor shortages, and enable sustained growth in the engineering fields.*"

Institutional Context

UVU enrolls 43,000 students and has a dual mission—that of a comprehensive university, offering 91 bachelor's and 11 master's degrees, and that of an open-admissions community college, offering 65 associate degrees and 44 certificates and diplomas. Student demographics are similar to those of a community college. There is no University housing, so all students are commuters. The University has a high percentage of low-income (33%) and first-generation (37%) students. Among degree-seeking students, there is a high number of non-traditional students (30%), students with spouses (37%) and students with children under age 12 (19%). While tuition is low, part-time attendance is high at 36% of students. These factors affect the overall graduation rate, which is low at 35% (nationally standardized IPEDS rate for completions in 150% time) and the overall 1-year retention rate of 68% for baccalaureate-degree seeking students. Institutionally, UVU receives by far the greatest amount of Pell grants awarded to students at any public institution of higher education in its state (NCES 2020/21).

Demographics for the ME/CIVE degree programs are like those of the institution with one noticeable difference – only 11% of students in these programs are women, compared to 49% of students at the University. Minority student and first-generation student participation are 2–3% lower. Table 1 shows the Fall 2022 enrollment and demographics of students and the 2021/22 graduation in the target programs.

Attrition Points and Needs in UVU's Civil and Mechanical Engineering Programs

Several critical attrition points, described below, have been identified through data and reports provided by Institutional Research and by the CET:

Attrition of First- and Second-Year Students. Students who begin at UVU can declare their major as CIVE or ME, and then apply to matriculate into the respective program after they have completed the required series of courses ideally taken in their First and Second years. It is during these first two foundational years that most attrition takes place. As shown in Table 1, the 1st year retention rate for students beginning ME/CIVE programs in 2020 was 64%. That is, of the 65 students who began the programs as first-year students, 23 did not continue to their second year. Of these, 12 students changed majors and 6 took a leave of absence. Another 6 students did not return to a ME/CIVE program after their 2nd year. Thus, 29 students (45.6%) did not return, though historically, a few of those will return within a year or two after returning from a religious mission. The Non-Returning Student Survey for the most recent year prior to the COVID-19 pandemic (2019) indicates several reasons that the proposed program has the capacity to change: could not afford college (35%); not doing well in classes (22%); lack of friends at the University (8%).

Slow Pace of Students Through the Program. Many students who are retained move slowly through the program. Few students complete the courses that are mapped for the first two years of study within two years. One problem may be that university academic advisors are not advising according to the degree flow chart and instead encouraging students to complete their general education requirements before they begin their engineering courses. Students who matriculate often take over 2 years, meaning they will continue to a 5th or 6th year of study. Some students take additional time in their later years because of heavy courseload, part-time employment, and family responsibilities.

Lack of Scholarships. A 2020 Institutional Research study at the University shows that scholarships are the most effective form of financial aid to increase persistence—more than grants, loans, and other forms of aid, and 23% more than self-pay. However, the CET has few dedicated scholarships to award to students in its programs. Unlike the established programs in

Engineering at other public baccalaureate granting universities in the state, Engineering at UVU has almost no scholarships to recruit, retain, and incentivize students. Further, all institutional scholarships are based on merit only (not considering low-income status), and most are $2,000 (or approximately just 16.7% of the tuition fee) per year or less. The prior NSF S-STEM program for students in Computer Science at this same University has been a tremendous benefit to participating students. Most students surveyed for that program indicated that the scholarships helped them stay in school and progress toward a degree more quickly.

Low Academic Preparedness. Many students enrolled in ME/CIVE majors are underprepared in STEM subjects, particularly mathematics. ME and CIVE largely share the same curricular plan for the first two years, which assumes that first-year students enter the program "calculus ready." Students who are unprepared to take calculus often take one or more semesters of preparatory math which can delay their progress in their engineering curriculum or lead them to give up their pursuit of an engineering degree. Also, in the first two years, students take the required mechanics core courses which include Statics, Dynamics, and Mechanics of Materials. These courses are the students' first experience with engineering analysis techniques. It is common for them to do poorly in these courses. Poor performance in these courses often requires students to repeat the course or leads them to drop out of engineering altogether.

Need to Build Sense of Community and Support. As a commuter school, UVU has long worked to address the need for students to feel a sense of belonging, community, and support. While institutional initiatives are in place to address this issue, specific departments and programs also share the load. In the targeted engineering programs, there are few women, few minorities, and a sizable proportion of non-traditional students and students with children. These and other issues may contribute to some students feeling isolated, friendless, or lonely to the point it affects their academic performance or desire to remain enrolled. Surveyed students in the prior S-STEM program report that interactions with other scholarship recipients, interactions with faculty, and networking opportunities helped them build relationships with others, aiding in their persistence.

CAM Project Goals

The goal of the CAM project is to increase the graduation and retention rates for students in ME and CIVE at the University and develop their potential for success in the STEM workforce by providing scholarships to academically talented students with financial need. The project aims to achieve this by providing CAM scholars with evidence-based support and activities. The following are the *Process Objectives* of the program:

I. Scholarship Awards. Increase financial support for low-income students with academic ability/talent or potential for engineering degree programs by offering an average of 24 scholarships per year over a 6-year period to at least 36 unique students. Attention will be given to recruiting students from backgrounds that are underrepresented in engineering at the University.

II. Multi-Layered Mentoring. Support student's academic success, matriculation, sense of belonging, persistence, and career aspirations with faculty mentors, peer mentors and industry mentors; coordinate with academic advising.

III. Social and Academic Support. Foster cohort formation through collaborative design team projects for introductory engineering design courses, regular S-STEM activities, and support of design competitions; provide tutoring for key 2nd year-level engineering mechanics core courses.

IV. Professional Preparation to Meet Regional Job Demand. Support robust, accredited curricular preparation with guest speakers and industry field trips conducted jointly with the

local American Society of Civil Engineers (ASCE) and American Society of Mechanical Engineers (ASME) chapters, Career and Internship Center hosted workshops, internship coordination and professional network connections, and conference participation and presentation.

V. High Impact Practices. Engage students in evidence-based, high-impact learning activities (both curricular and co-curricular) including capstone projects, internships, collaborative projects, and *E-portfolios*.

CAM Mentoring Approach: Multi-Layered Mentoring

"Mentorship is one catalytic factor to unleash individuals' potential for discovery, curiosity, and participation in STEMM and subsequently improve the training environment in which that STEMM potential is fostered" (National Academies of Sciences, 2019). Given the critical potential of mentoring, the CAM project has designed a program with several key layers of mentoring:

Faculty mentoring is an evidence-based strategy for increasing academic success and retention, especially among students from underrepresented groups (Kendricks, Nedunuri, & Arment, 2013). In the proposed program, faculty mentors will utilize an intentional mentor strategy that approaches the mentoring relationship with forethought and planning (Ramirez, 2012). A faculty mentor will be assigned to each scholarship recipient. Faculty mentors will establish a cordial, working relationship with students and will be available to meet with them at minimum monthly for the first year and twice per semester thereafter. Faculty mentors will review and advise on the student's planned coursework in the institution's degree audit and tracking system with the help of their academic advisors. Mentors will assist scholars to create an Individual Education and Development Plan (IEDP) that creates a map toward graduation and career, including the sequence of courses, needed tutoring, participation in CAM and other career-building activities (including internships and capstone projects), and development of soft-skills and attributes valued by the student and future employers or graduate schools. Mentors will also interact with scholars at CAM activities. They will submit documentation on these activities for assessment and tracking progress. Faculty mentors also meet annually to discuss and review their efforts. The CAM Project Management Team will also investigate the impact of these mentoring and group-based activities on faculty workload. It is noted that each faculty member of the CAM Project Management Team will devote 1 month of his/her 9-month annual contract to this project.

Peer mentoring is recognized as a best-practice strategy for promoting college student success (Collier, 2017). Undergraduate mentors may provide student-relevant perspectives and guidance on how to responsibly navigate students' academic and social life. Peer mentoring also benefits the mentors. It has been found that undergraduate mentors developed experiences and confidence that helped to ensure long-term engagement with STEM as professionals (National Academies of Sciences, 2019; Simon, et al., 2021). Peer mentoring will be provided to first-year CAM scholars by sophomore to senior-level engineering students to support new students' transition to the university environment and the CAM program. Student perspectives on navigating campus/off-campus life, housing, and other matters will be best provided by peers. Peer mentors will be recruited and oriented to their responsibilities annually in September.

Industry Mentors are equally important to provide career guidance, encouragement, advice on important courses and skills related to industry requirements, and networking opportunities. The Mechanical and Civil Engineering Industry Advisory Board will help recruit professionals to mentor small groups of students in the S-STEM program. The constructive collaboration of this multi-layered mentoring effort should help students build momentum early toward degree

completion and maintain that momentum as they progress through their degree toward a career. Practicing engineers from local industry will be invited by CAM project management team, and the Engineering Industry Advisory Board to mentor small groups of students in the CAM program. Mentors will meet with their students about once a semester to talk about student's career ambitions, what companies are looking for in their new hires, potential networking opportunities, and other topics of interest to the students. Industry mentors will be invited to speak at CAM meetings.

CAM High Impact Practices (HIPs)

The ME/CIVE programs have been designed to meet ABET Accreditation standards and to incorporate several evidence-based, high-impact practices. The ABET 2022-2023 Criteria for Student Outcomes is compatible with the implementation and characteristics of high-impact practices, though at a discipline-specific level. HIPs are specific active learning practices, both inside and outside the classroom, that considerable educational research has shown to increase rates of student retention and higher levels of learning success (Kuh, 2008; Kuh, 2013; Pusca & Northwood, 2018; Peters, Tisdale, & Swinton, 2019).

When well implemented, HIPs can be effective in providing deep learning and transformational learning experiences that address many of the attrition points and programmatic concerns described earlier. Research conducted at the University has corroborated national studies which report that students who participate in HIPs are more likely to persist in higher education (Qudisat & White, 2022). Moreover, research findings of Kuh and others indicate that HIPs are especially impactful for students from underserved populations (Kuh, 2008; Brownell & Swaner, 2009; Finley & McNair, 2013).

HIPs included in the University's ME/CIVE curricula include collaborative projects, capstone courses, internships, and writing enriched/intensive courses, and mentored undergraduate research. The proposed program plans to enhance these activities for S-STEM participants. For instance, the project will fund equipment and supplies for capstone projects, enhance networking opportunities for targeted internships, and provide opportunities for students to engage in competitive collaborative projects and documentation of their work.

Furthermore, a constructive collaboration exists among this collection of HIPs that could be strengthened by more intentional awareness of their potential collective impact. We intend to have students plan their HIP participation with their faculty mentors. By intentionally structuring HIPs so that students participate in at least one each year, students will build and sustain academic momentum toward timely completion (Kuh, High-impact Practices: what are they, who has access to them, and why they matter, 2008)

Additional Evidence-Based Elements in CAM

The following are among the evidence-based programs and practices that the CAM project will employ. Table 2 summarizes some of these planned HIPs for the CAM scholars.

E-Portfolios. The research team plans to introduce *E-portfolios* where students can reflect on and synthesize their work in various courses and activities. Here they can collect, organize, and exhibit their work on collaborative projects, capstone projects, or undergraduate research, describe their internships or leadership activities, and highlight important course assignments or extra-curricular activities. Tucker and colleagues explain: "*E-portfolios* 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" (Tucker, Wolf, Dancholvichit, & Liebenberg, 2021). The *E-portfolios* are not

intended to create more work for the faculty mentors, but to encourage students to take responsibility for their own career preparation and to provide them with a solid framework to do so. The *E-portfolios* will be implemented as a co-curricular activity for development, reflection, and highlighting work for potential employers or graduate schools. Students will be introduced to *E-portfolios* at a CAM meeting. Mentored laboratory time will give them an opportunity to get started, potentially using the essays on their professional goals from their CAM scholarship application. Faculty mentors will follow up and give encouragement. Scholars will create energy and motivation for the project as they work together and share their work. This will be a unique, value-added component of the CAM program within Engineering.

CAM Participant Meetings. CAM meetings will be used to create a bond between participants and allow for involvement in activities of common interest. Meetings will be held at least monthly during the academic year and will include: 1) Meet Your Faculty Mentor Night, each September; 2) *E-portfolio* workshops; 3) guest speakers on careers and topics of interest; 4) field trips to industry; 5) career development workshops, some involving the Career and Internship Center; and 6) student presentations on collaborative projects. Some meetings, such as the annual *Meet Your Faculty Mentor Night*, will involve CAM participants only. However, other meetings such as guest speakers and field trips may be integrated with the ASME/ASCE chapter meetings to broaden student participation.

Conference Participation. CAM scholars will have the opportunity to prepare for continued education and/or their professions by conference attendance and presentation. These will be tied to their capstone project and/or mentored undergraduate research. They will then formally present their work at CAM meetings, and Spring Capstone Showcase event. Opportunities to attend conferences are important to students as they learn more about their disciplines, meet with other professionals, network about jobs and career opportunities, and communicate their work to others.

Web Page for Scholarship Recipients. The CET plans to develop a web page, linked from the college web pages, to highlight scholarship recipients. The website will allow them to post information about themselves and the engineering field they expect to pursue. Scholars may share elements of their E-portfolios highlighting their projects, research, lessons learned, experience gained, and activities pursued that help them enhance their college experience. The goal of the website is to encourage other students to pursue engineering degrees, apply for CAM scholarships, and get involved in opportunities.

Table 2 CAM Program Elements

	Required	Highly Encouraged	Option Available
Faculty Mentor		Yr. 1, meet monthly. Yrs. 2-4, twice/semester Communicate often	In-person or on-line meetings
Common Coursework	Introduction to Engineering (ENGR 1000)	Dedicated CAM teams in ENGR 1000 CAM teams in other classes	Possibly waived for transfer students
CAM Participant Meetings		All meetings	Excused absence
Internship Course (paid)		Summer after Junior year	Options possible
Capstone Project	Required for degree	Present beyond UVU	Funding available
E-portfolio		Training & support	
Conference Participation		Funding available	

Current Academic Infrastructure and Student Supports on which the Project Builds

Quality Educational Programs. UVU is regionally accredited at the institution level by the *Northwest Commission of Colleges and Universities*. The ME/CIVE programs are separately accredited by ABET. Both programs have advisory boards comprised of representatives of local industry who assist in aligning the program to industry needs and helping to acquire industry support and resources for programs and students.

1. Current Collaborative Assignments and Projects: Introduction to Engineering Design. Collaborative projects are a key component of several classes beginning with the Introduction to Engineering course (ENGR 1000). Students in this course form teams for a semester-long project; they identify and research a problem, brainstorm and select a solution using design thinking, develop drawings and a prototype, and evaluate their selected solution. The students additionally prepare and present oral presentations and written reports on the project. Many courses in the program require teamwork on projects and the associated reports. Students also may participate in undergraduate research projects led by faculty members and are encouraged to participate in competition teams. Collaborative experiences help students learn to work and solve problems with others and help improve comprehension through sharing and listening to the insights of others. *Planned Strategies for the CAM program:* While it is impractical to have all entering CAM scholars take the same ENGR 1000 section together, the project will require that they take one of the 3-4 sections offered in their first semester. To facilitate cohort-building, CAM scholars within the same ENGR 1000 section will be teamed together. In other early courses, CAM scholars will be teamed together as well, where feasible. Project funds will also be used for CAM scholar participation on competition teams. Scholars will use their *E-portfolios* to organize, archive, and display their collaborative work.

2. Current Collaborative Assignments and Projects: Capstone Design Project. Students in the ME/CIVE programs are required to take their program's Capstone 2-semesters long courses in their senior year. Capstone projects are an integral part of the engineering experience at the

University. Capstone projects allow students to demonstrate the understanding developed throughout the program of study by working on meaningful and impactful projects that interest them (Todd, Magleby, Sorensen, Swan, & Anthony, 1995; Mosher, 2015; Viswanathan, 2017). Projects typically have student groups of 3-6 students and fall into three main categories: local industry project design teams, competition teams, or research teams. Industry project design teams work with agencies to develop solutions to existing problems; many projects are sponsored or mentored by industry partners (Aktan, Polasek, & Phillips, 2011; Su, Nie, Wang, & Lin, 2016). Competition teams may be solely comprised of or led by students enrolled in the capstone course. Students are given instruction and coaching on many soft skills highly valued by the engineering industry employers. The soft skills addressed in capstone include communication through team participation, report writing, drawing, and oral presentations; leadership and team management skills; scheduling, budgeting, and cost analysis (de Campos, de Resende, & Fagundes, 2020). Each capstone class has a formal faculty instructor who provides general coaching and supervision. Each capstone team also has an assigned faculty project mentor to provide coaching, advice, technical assistance, and resources. *Planned Strategies for the CAM program:* The CAM program will offer support for the capstone projects through faculty mentors and funding of materials for projects which students otherwise might obtain through department funding or pay for themselves, which can sometimes limit the quality of a low-income student's project. CAM scholars may apply for up to $900 in materials funding through the CAM project. *E-portfolios* will provide a platform to highlight the project and an opportunity for students to reflect on lessons learned and soft-skill development. The CAM program will also help fund travel money to present their projects at conferences if appropriate.

3. Current Internships. The ME/CIVE programs encourage all students to take internships and provide academic credits as a technical elective for the experience. The College's Internship Coordinator provides resources to help students find appropriate internships (paid) and conduct them successfully. A faculty member teaching the internship course supervises the intern's progress through submitted reports and performance reviews. Students acquire direct experience in a work setting related to their career interests and benefit from a professionals' direct supervision and mentoring. Internships help students explore careers and gain job experience; they often turn into full-time jobs (Marshall, 2012). *Planned Strategies for the CAM program:* An internship will be required for all scholars. The course will not increase the time to degree completion. Justifiable exceptions will be allowed. Students will plan early on with their faculty mentor for internship experiences prior to their senior year of study. The CAM program will employ its networking capabilities to assist students in finding appropriate internships.

4. Current Career Preparation Seminars Courses. The ME/CIVE programs each offer an upper-division seminar course designed to prepare students for a career in their engineering profession. The course invites speakers from varying aspects of the field and at various stages of their careers to discuss their career path, the difficulties, or the challenges they have overcome, and the achievements or satisfaction they have experienced as they progressed in their career. The course also has lecture days related to job searching tools including discussing resume creation/editing, interviewing skills, and benefits to consider when negotiating job offers. Other topics include graduate school options and application, the licensure process, professional organizations, and engineering ethics. *Planned Strategies for the CAM program:* CAM scholar meetings will include career and graduate school preparedness topics every year (with the assistance of the Career and Internship Center) so that the students are prepared at all academic levels. *E-portfolios* will be created with applications for internships, jobs, and graduate schools in mind.

5. Current Academic Tutoring. In addition to general academic tutoring available through the University, the CET offers tutoring specific to engineering in lower-level classes at the Engineering Tutoring Lab. Tutors are advanced upper-level students. CAM scholarship recipients will receive tutoring as needed. P*lanned Strategies for the CAM program:* Additional tutors will

be hired to provide dedicated tutoring hours for CAM scholars in Statics, Dynamics, and Mechanics of Materials. The tutors will be available for in-person and real-time virtual tutoring sessions to increase the likelihood that students will use this resource. Faculty mentors, through their mid-semester meetings, will help direct students in academic trouble to tutoring. The CAM project grant allocates 10 hours of tutoring per week for 30 weeks, compensating the student tutors at $17/hour. The CET also has a dedicated tutoring center funded by the college.

6. Current Academic Advising. In addition to the general academic advising offered by the University, the CET programs share two dedicated academic advisors. Students will meet with one of these academic advisors at least once a semester to review their academic plan, register for courses, assess the need for campus resources and services, and plan for graduate school or job application. *Planned Strategies for the CAM program:* The Lead Faculty will coordinate with general academic advising and the CET academic advisors to inform them of the scholarship program and its requirements for both recruitment and for more timely progression through the degree programs. Students who are not calculus ready will be advised to take a specialized course in the Department of Physics that teaches students the tools they need to solve problems encountered in the first two years of physics and engineering courses while taking the calculus courses they will eventually need for higher division engineering courses. Research indicates that students who successfully complete a mathematics course in their first year are more likely to succeed in college (Lee, 2012).

7. Current Wrap-around Student Support. The University has a full array of student support services relevant to the students in the proposed CAM program. Key resources include the Career and Internship Center (assisting with employment and admissions to graduate school), Women's Success Center, Multicultural Student Services, Student Health Services, I Am First (for first-generation students), Money Management Resource Center, and the University CARE Hub to address food, housing, safety, and health concerns with university and community resources. *Planned Strategies for the CAM program:* The CAM project management team will compile a list of relevant student support services and review these with faculty mentors during mentor training. Faculty mentors will help connect their students to these resources as needed.

Generation of Knowledge

This project aims to advance knowledge about evidence-based, context-specific interventions for STEM programs at an open-admissions university. The project team will examine statistics between CAM students and a comparison group comparing first-year attrition, matriculation, and graduation rates, along with feedback from CAM student surveys, to determine which interventions had the greatest impact on student outcomes. The assumption is that faculty mentoring early in students' college career and the multi-layered mentoring approach will prove impactful and worthy of dissemination. The study will also examine high-impact, career-preparation strategies (e-portfolios, internships, collaborative and capstone projects) and the role they play in motivating student's academic momentum toward graduation and preparation for career.

Evaluation

External Evaluator. An external evaluator will meet with the project management team, during the initial 6 months of the program, to coordinate data collection, create or refine survey instruments, and initiate other evaluation activities. The evaluation of the *Process Objectives* will comprise a formative evaluation of the project to assist the project team in monitoring and improving project services. The *Outcome Objectives* are designed to provide summative

evaluation of the project's effectiveness. The project evaluation will be instrumental in assessing the University's adaptation and implementation of evidence-based practices that may inform the scholarly community.

Theory of Change. The project is guided by the *Process Objectives*, which in turn aims at achieving the following *Outcome Objectives*:

1. *Graduation.* A minimum of 18 scholarship recipients will graduate with a bachelor's degree in ME or CIVE by the end of year six and up to 13 will still be enrolled (total 86%.)
2. *Retention and Matriculation.* Rates of scholarship recipients will show an increase from the departmental baseline and a comparison cohort.
3. *STEM Employment or Graduate School.* At least 90% of BS degree graduates will be employed in a STEM field or enrolled in graduate school within 6 months of graduation.

The CAM project evaluation plan is outlined in Table 3.

Table 3: Evaluation of Project Objectives

Process Objectives	Research Questions	Method
1: *Scholarship Awards. Award an average of 24 scholarships per year over a 6-year period to at least 36 unique students (including students from underrepresented groups).	What proportion of scholars are women, minority, and first-generation students? Which recruitment strategies are most effective? Do scholars honor their contracts?	Track: - number of scholarships awarded annually. - demographics of scholars. - method by which each scholar was recruited (question on application).
2: Multi-Layered Mentoring. Support scholars' academic success, matriculation, sense of belonging, persistence, and career aspirations with faculty peer and industry mentors.	Are scholars meeting with faculty mentors? Are mentors reporting? Are peer and industry mentors recruited and meeting students? Are mentors effective in promoting academic growth, persistence, and matriculation?	Track scholars' participation in mentoring & tutoring. Track GPA, matriculation, and degree progress. Survey scholars annually about mentors & tutors. Faculty mentor reports.
3. Social and Academic Support. Foster cohort formation through collaborative design team projects for ENGR 1000, regular S-STEM activities, and support of design competitions; provide tutoring for key 2000-level required courses.	Are CAM collaborative groups being formed successfully? Are students from underrepresented groups participating fully? Do students feel CAM camaraderie through collaborative projects? Is tutoring assistance sufficient to meet the needs of scholars?	Track students' participation in collaborative groups. Survey scholars annually & at completion to gage their value of these HIPs. Conduct random-sample interviews or focus groups on key topics.
4: Professional Preparation. Support curricular preparation with guest speakers, industry field trips, Career and Internship Center hosted workshops, internship	Evaluate each type of activity– what worked & what needs adjustment. Which types of activities do scholars find most valuable & why?	Track participation in activities for each scholar. Survey scholars annually & at completion to gage their value of the activities. Conduct random-sample

coordination and professional network connections, and conference participation and presentation.	Does this differ by demographics? What additional activities do scholars indicate would be beneficial?	interviews or focus groups on key topics.
5: High Impact Practices. Engage students in evidence-based HIPs including capstone projects, collaborative projects, internships, and E-portfolios.	Evaluate each activity – what worked & what needs adjustment. Which high-impact activities do scholars find most valuable & why? Does this differ by demographics?	Scholar surveys (above). Review E-portfolios created by students. Conduct random-sample interviews or focus groups.

Measurable Outcomes Objectives	Method	Target
A. Graduation. A minimum of 18 scholarship recipients will graduate with a bachelor's degree in engineering or computer science by the end of year five. (13 will still be enrolled)	Track CAM scholars who graduate in ME or CIVE vs. comparison group, track years to graduation.	18 graduates; (50%). 13 still enrolled in STEM (36%).
B. Retention and matriculation. Retention and matriculation rates of scholarship recipients will show an increase from the departmental baseline and a comparison cohort.	Track ME/CIVE persistence and matriculation rates of CAM scholars vs. the comparison group.	31 scholars will persist or graduate in STEM (85%).
C. *STEM Employment or Graduate School.* BS degree graduates will be employed in a STEM field or enrolled in graduate school within 6 months.	Phone interviews or personal reporting (percent of contactable students).	90% of graduates will be employed or in graduate school.
* Over a 6-year period, 12 scholarship recipients will be added per year (for the first 3 years) starting in Fall 2024. In 2025, there will be 24 total recipients, and in 2026 the total will be 36. There will no longer be any additional scholarship recipients after the third year. In summary, the total number of scholars for a given year are 12 (2024), 24 (2025), 36 (2026), 36 (2027), 24 (2028), 12 (2029). Over these years, the average is 24 scholars enrolled in the CAM project per year.		

Summary and Broader Impacts

This project provides a dynamic scholarship program to help low-income, high-achieving undergraduates complete their 4-year degree in Civil or Mechanical Engineering at UVU. There is a strong regional growth in the technology sector which has spurred the demand for engineers in the state of Utah. To address this need, there is potential to increase the output of graduates in this discipline by providing incentives to high-achieving scholars who may face certain hurdles, such as a demonstrated financial need, to complete their education. This project will also aid in strengthening the Civil and Mechanical Engineering academic programs at UVU. As a large open-admissions university, UVU attracts students with backgrounds similar to those who attend a community college. There is a high proportion of first-generation students, part-time students, and students who work while enrolled. Many of these are of low-income status yet still demonstrate ambition and willingness to pursue a college degree. The project team is excited to play a role in providing life-changing avenues for these students. We hope that the high impact practices, infrastructure, and supports the program provides will have a positive impact on the scholars' retention and degree completion. We also hope that the lessons learned from the project will advance knowledge on evidence-based, context specific interventions for STEM programs at

primarily open admissions and undergraduate institutions.

This proposed program will continue to develop the capacity of an open-admissions university with a markedly different student population from those at research-focused institutions to attract, retain, matriculate, and graduate students in Civil and Mechanical Engineering and to prepare them to contribute to their STEM professions. We expect the program to make a substantial difference in keeping talented low-income students in school, helping them to complete their degrees in a timely manner. Among the broader impacts that are expected from the program include:

Recruitment and Retention of Underrepresented Groups. The CAM project also aims at the increase and participation of women and students from other underrepresented groups in ME/CIVE engineering, as well as ensuring their retention and graduation. It is hoped that interventions as proposed by the project will contribute significantly towards this end.

Products. The CAM project ongoing findings and lessons learned will be annually presented at future conferences. The progress and impact of the program will be studied and disseminated to the scholarly community. It is hoped that the lessons learned will provide insight on the best and evidence-based practices (as proposed in this project) for ensuring retention and graduation of low-income groups in open admissions institutions. The project management team also aims at involving the CAM scholars in these conferences via poster and/or presentation of papers to provide their personal viewpoint.

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