Improving First-Year Engineering Student Success with Targeted Financial Assistance, Supplemental Instruction, and Cohort Team Building

Dr. Krystal Corbett Cruse, Louisiana Tech University

Dr. Krystal Corbett is the First-Year Engineering Programs Coordinator and Assistant Professor in the Mechanical Engineering Department at Louisiana Tech University. She is also the Co-Director of the Office for Women in Science and Engineering at Louisiana Tech.

Carl Boyet, Louisiana Tech University

Carl Boyet is an Instructor of Mathematics who has worked for Louisiana Tech University for nine years.

Dr. James D. Palmer, Louisiana Tech University

Virgil Orr Professor of Chemical Engineering Director of Biomedical and Chemical Engineering

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Abstract

This complete research paper assesses the first-year implementation of an NSF-funded S-STEM effort, the SUCCESS Scholars Program (SSP), established in the Fall of 2022 at Louisiana Tech University.

Louisiana Tech University is a Carnegie High Research Activity University that has approximately 20% of its 7500 undergraduates as engineering majors, is geographically distanced from large metropolitan areas but draws its student population both statewide and regionally and operates on the quarter calendar. Louisiana Tech University merged the math, chemistry, and physics programs with the engineering, technology, and computer science programs into a single college in 1995 and created an integrated freshman engineering curriculum in 1998. Louisiana Tech University has a long history of educational innovations in engineering education, with a hands-on project-based approach implemented in 2004 and four other NSF-funded programs to increase student success in engineering since 2007.

The SSP builds on these prior efforts by providing financial, academic, personal, and professional support to engineering students starting in their first year of college through four years of academic study. The first cohort of twenty-four students was selected through an application process after learning about the program at orientation. The SSP team focused heavily in the first year on academic support and community building while also providing each student a financial scholarship of up to $10,000 depending on unmet financial need. Throughout the first year, students in the SSP attended a three-day-a-week first-year engineering course instead of the typical two-day-a-week course. This provided additional access to the lab equipment, contact hours with their instructor, practice problems, and helped foster community among the cohort.

Additional academic support was provided through supplemental instruction sessions strategically designed to provide support in both their engineering and mathematics courses. These sessions were led by upper-level peer mentors. Students were connected with faculty mentors in their discipline through lunches that the SSP faculty team provided each week. These lunches helped reduce food insecurity while also providing an inviting atmosphere for interaction between peers and faculty. Lunches also offered an opportunity to have career discussions and bring in professional development speakers like student organization leaders and graduate students.

At the start of the first quarter of their sophomore year, nineteen students were either still on track or just one quarter behind in their engineering curriculum. This record will be compared

with the approximately 420 students who either were eligible or did not take part in this program. Historical data will be reviewed to determine how predictive these initial markers are toward completion of the degree.

Introduction

Science, technology, engineering, and mathematics (STEM) occupations comprise 24% of the overall United States workforce. Of those employed in STEM jobs, 51% have obtained a bachelor's degree or higher [1]. To help support and grow the U.S. STEM workforce, many institutions of higher education are driven to increase the number of graduates within their programs. However, as the cost of higher education has risen, in many cases exceeding the average family income, students and families are left with concerns about the affordability of attending [2].

In the academic year 2020-2021, the National Center for Education Statistics reported that 85% of first-time, full-time students pursuing degrees or certificates at 4-year granting institutions received financial aid. This support came in the form of federal grants, state/local grants, institutional grants, and/or student loans. Notably, students attending public institutions borrowed an average of $7,492 per year in loans [3]. Federal Pell Grants support students from low-income households. The max amount of funding from a Pell Grant in 2022-2023 was $6,895 with 30% of all students enrolled in an undergraduate degree program qualified for the award [4]. Given that the average expenses for attaining a four-year university education (including tuition and fees, as well as room and board) ranged from $23,250 for in-state students to $40,550 for out-of-state students in 2022, individuals, particularly those from low-income backgrounds, can face significant financial challenges and stress [4].

These financial burdens may be a deterrent for students to pursue degrees seen as more challenging, like STEM degrees, in fear of having academic setbacks and incurring additional costs. Therefore, a key factor in strengthening the STEM workforce is creating opportunities to enhance capacity by ensuring accessibility to STEM education for individuals across all socioeconomic groups [2]. Funding opportunities, like the National Science Foundation's S-STEM program, support universities and colleges with resources to provide "scholarships for academically talented low-income students and to study and implement a program of activities that support their recruitment, retention, and graduation in STEM" [5].

First-year students represent a high-risk population for attrition [6], [7]. In 2021, 18.4% of full-time first-year students at 4-year institutions dropped out within their first twelve months [8]. Often first-year students are faced with challenges related to transitioning and adapting to college life in addition to managing new academic demands [9]. Tinto's Model of Integration identifies that both academic and social integration are significant factors in achieving success for first-year students [10]. This model has served as the basis for subsequent models pertaining to retention within engineering programs [9], [11]. Providing first-year engineering students with support in these areas, along with reducing financial stress, could positively increase retention.

Recognizing the vulnerability of students in their first year, many S-STEM programs select that time to begin providing financial, academic, and social support [12] - [14]. Financial support is awarded to each student based on their unmet need. Academic and social support can be implemented in a variety of ways throughout S-STEM programs. An S-STEM program at the University of Nevada provided students with curricular and co-curricular opportunities through peer mentors, faculty mentors, cohort experiences, community engagement, a living-learning community, and career-focused activities in their first year. Seeing the positive outcomes of the program, the engineering department has incorporated elements of it for all incoming first-year engineering students [13]. A learning community offered by an S-STEM project at the University of Houston provided a structured experience program for first- and second-year students. The program has shown positive impacts on the persistence of the students involved. A student engagement instrument collected data on three factors: (1) academic engagement, (2) behavioral engagement, and (3) cognitive and affective engagement while students participated in the program. The data were utilized to generate a dashboard to help understand student engagement and to provide early warning signs that inform potential interventions and help reduce attrition [14].

The focus of this paper is an S-STEM program in its second year at Louisiana Tech University that provides support to engineering students beginning in the first term of their first year. The SUCCESS Scholars Program (SSP) offers students structured academic support, community engagement activities, career readiness resources, and financial assistance [15]. The performance of the first cohort, who has completed one full year, will be assessed. Historical markers that indicate long-term retention will be identified and compared to the SSP students.

Background for the First-Year Engineering Program

As part of a quarter calendar that awards semester credit hours (SCH), all first-year engineering students participate in a three-part engineering course sequence called Living with the Lab (LWTL). These courses are part of the integrated engineering and science curriculum, where the engineering, mathematics, and applicable science classes are blocked together. All students in an engineering section are grouped together in a common section of math. The science class section sizes are larger, and therefore, multiple blocked engineering and science sections are combined together for the science courses. One goal of blocking the classes together is to aid in community building and engagement. Table 1 outlines a typical schedule for first-year engineering students.

To cover a full semester of content in a 10-week quarter, classes meet for longer periods than in a typical semester system. The first-year engineering sequence meets for 110 minutes twice a week, and the mathematics courses have 75-minute sessions three days a week. This accelerated pace may magnify the challenges faced by first-year students. Engineering students must earn a C or better in the engineering, math, and chemistry courses before moving on to the next course in that discipline. Additionally, students cannot progress into the subsequent engineering course if they have not passed the preceding mathematics course.

Table 1. Block schedules taken by first-year engineering students [15].

Fall Quarter	Winter Quarter	Spring Quarter
ENGR 120 (2 SCH) Problem-solving, circuits, CAD, fabrication, programming	**ENGR 121 (2 SCH)** Conservation of energy, heat transfer, forces, control systems	**ENGR 122 (2 SCH)** Statics, engineering economics, design project
Math 240 (3 SCH) Pre-calculus algebra & trigonometry, logic, matrices	**Math 241 (3 SCH)** Single variable differential calculus	**Math 242 (3 SCH)** Integral calculus, introduction to statistics
CHEM 100 (2 SCH) General Chemistry	**CHEM 101 (2 SCH)** General Chemistry	**PHYS 201 (3 SCH)** Mechanics
FYE 100 (1 SCH) First Year seminar	**CHEM 103 (1 SCH)** General chemistry lab	

Year 1 of the SUCCESS Scholars Program

The NSF-funded SUCCESS Scholars Program (SSP) was established to provide academic support, financial assistance, community-building, and career development to first-year engineering students from low-income backgrounds. Spanning five years, the initiative offers four years of support to two cohorts of incoming first-year students, with cohort 1 and cohort 2 starting in Fall 2022 and Fall 2023, respectively. This paper focuses on the first year of the first cohort over the 2022-2023 academic year.

The SSP was promoted during the summer orientation sessions in 2022. Students were invited to complete an interest survey which granted permission to the university's financial aid office to assess financial eligibility. Sixty eligible students were asked to complete a formal application that was reviewed by a team of faculty and staff. Fifty-three of the sixty students submitted the formal application. The formal application consisted of questions that provided insight into each student's goals, high school involvement, and extra-curricular interests. The PI and Co-PIs then used a rubric to assess each applicant. The rubric was broken into three components: academic potential, financial need, and application responses. Following this procedure, the grant team selected twenty-four students to participate in the program out of the fifty-three that were deemed eligible. The majors of the selected students included mechanical, electrical, biomedical, civil, cyber, and chemical engineering.

Academic Support

The SSP students were enrolled together in an ENGR/MATH block for the entire 2022-2023 academic year and followed the same ENGR and MATH instructor for each course. Formal academic support was offered to the students through two primary curricular and co-curricular opportunities. First, the engineering class met for an additional class meeting each week. The second was evening supplemental instruction (SI) sessions led by peer mentors.

While a typical engineering class meets twice a week for 110 minutes, the SSP students met three times a week, adding Friday to their typical Monday/Wednesday meetings. These extra sessions offered increased contact hours with their instructor and access to the laboratory space. The Friday classes began with a quiz on the previous week's material followed by an assortment of activities like community building, working practice problems, open-ended project work, and going deeper with course concepts.

Each quarter, weekly SI sessions led by peer mentors were offered to the SSP students. The two peer mentors were selected from a group of students who participated in a pilot version of the SSP the previous year. SI sessions focused on both the engineering and math classes, providing time for open-ended project work, specialized help on in-class problems, and access to additional problem sets. The session times varied each quarter but were strategically chosen to fit known openings in SSP students' schedules to ensure availability. Content for SI was planned in weekly meetings between the peer mentors and the SSP students' engineering and math instructors. SI sessions lasted two hours and were typically offered four days a week in the fall quarter and three days a week for the winter and spring quarters. Common session types included:

- *Homework/Free Study* - Informal open-ended sessions where students met on one floor at the University Library designed for study groups or a classroom in the Engineering building. Peer mentors were in the room to answer questions and guide the SS students when needed but did not actively lead content sessions. This session type was offered once a week, usually on Monday.
- *Reinforcement/Kahoot!* – The students would be given extra practice problems that are similar to in-class examples and homework problems to reinforce the concepts. Occasionally these problems would be administered through Kahoot! with prizes for students who performed best.
- *Test Prep* - Mock exams and timed challenge problems, usually given within the week before a major exam in engineering or math.

The fall quarter provided the students with thirty-five SI session opportunities with winter and spring providing twenty-five and twenty-three, respectively. Over the full academic year, seventy-nine two-hour sessions were made available to the students with thirteen (spring) to fourteen (fall and winter) students on average attending the sessions.

Community Building

Through the blocked schedules, extra Friday classes, and SI sessions, students were encouraged to form social connections with each other and build study groups, fostering a sense of community within the SSP. In addition to the technical courses, students enrolled in a common First-Year Experience (FYE) seminar course section. This FYE course was led by their ENGR 120 instructor with occasional visits from their Math 240 instructor. This provided more casual contact with their instructors and included icebreakers to increase the students' comfort levels with them and each other early in the year.

In the winter quarter, the faculty and staff associated with the grant introduced a weekly group lunch. Through the lunch, students became acquainted with their discipline-specific faculty mentors. These faculty mentors consist of one representative from each engineering discipline who eventually would become the SSP students' academic advisors and have regular check-ins with their students. The lunches offered a casual, non-threatening environment to help build connections between students and their mentors. Faculty mentors utilized the lunches to provide short Q&A sessions with the group describing their discipline along with academic and professional opportunities.

Throughout the year, social events were planned to provide students with an opportunity to relax and connect with each other and the grant team. A winter quarter kick-off party was held at the on-campus bowling alley. Social barriers were broken down as faculty, staff, and SSP students enjoyed friendly competition, cake, and fun. The SSP students took the initiative to plan a Christmas party for their group. The students took ownership of the event and planned everything from logistics to food to a gift exchange. This event emphasized to the grant team that community among the cohort was established.

Career Development

During the Friday engineering classes, guest speakers were invited to give career perspectives, advice, and resources. Career Center representatives spoke on resources offered through their department like a free career closet, resume workshops, interview tips, and career fairs. An alum, who now works for Dell, provided insights on her experience as an intern at Dell and gave advice for best practices in the students' future internships.

During the Winter Quarter, students built their resumes and were required to attend the career fair. Since first-year students are often not a top choice for internships, students were only required to walk around and get a feel for the environment in preparation for the next academic year. They were encouraged to go together and talk with a couple of companies if they felt comfortable. After the career fair, the students felt excited and empowered. Many SSP students were given interviews, and one student secured a summer internship.

In the Spring Quarter, the SSP students and three faculty mentors attended an industry field trip. A day trip was planned to the Proctor and Gamble factory in Alexandria, Louisiana. The trip included a tour of the factory and a lunchtime Q&A with P&G engineers, affording students the chance to network and establish connections with industry professionals.

Program Achievement

An analysis was performed on first-year engineering students from Fall 2014 to 2021 to determine historical outcomes. Degree outcomes were focused on 2014 to 2016 to allow sufficient time to graduation. As depicted in Figure 1, the degree outcomes of engineering students in this group resulted in approximately 37% earning an engineering degree at Louisiana Tech University, 7% earning a science degree within the College of Engineering and Science

(either computer science, math, chemistry or physics), and 5% earning a technology degree within the College of Engineering and Science. The latter two degree paths were differentiated because the science degrees would require the Math 242 (Calculus II), while the technology degrees would not. 18% of students receive some other degree at Louisiana Tech University, while unfortunately, 33% will not receive a degree at Louisiana Tech University.

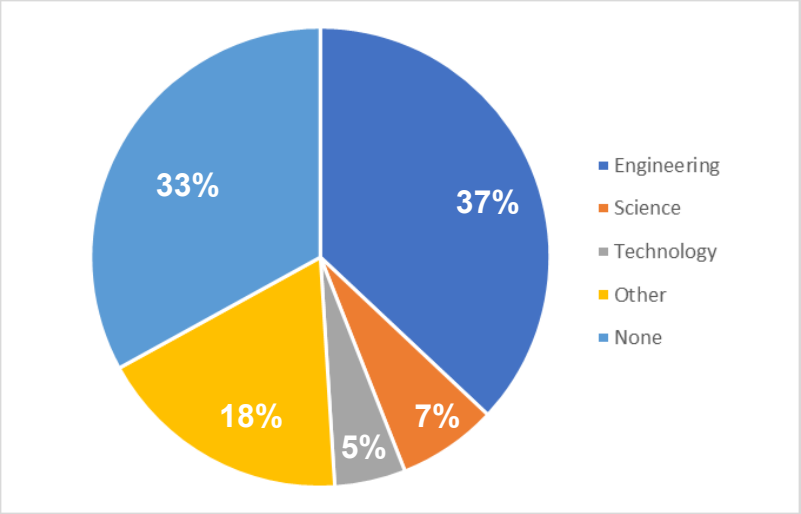

Figure 1. Degree outcomes for engineering first-year cohorts from Fall 2014 to 2016.

In performing this analysis, it was evident that an early marker of success was passing their Spring quarter engineering and math courses by the subsequent Fall quarter, depicted in Table 2. At Louisiana Tech University, these two courses are ENGR 122 and MATH 242. 97% of the 2014 to 2016 engineering students who subsequently earned an engineering degree passed their ENGR 122 course by the Fall quarter of their sophomore year. The MATH 242 was lower at 89%, but still high enough to serve as an early marker of success. Of those who did not receive degrees at Louisiana Tech University, only 20% passed ENGR 122, and 19% passed MATH 242 at that same time.

Table 2. Retrospective analysis of students earning BS Engineering degree at Tech versus not earning a degree for 2014-2016 cohorts. ENGR 122 and MATH 242 percentages are students that passed by summer plus one academic quarter.

	ENGR 122	MATH 242
Students earning a BS Engineering degree within 6 yrs	97%	89%
Students not earning a degree at Tech within 6 yrs	20%	19%

Of all the students that started in engineering from 2014 to 2016, only 49% passed ENGR 122 by this maker period, and only 47% passed MATH 242 by the same time. This remained relatively stable at 47% for ENGR 122 and 42% in MATH 242 for the following two years (Fall 2017 to Fall 2018). It is unclear what impact COVID has had on these pass rates, but success in these courses has risen to 52% and 50%, respectively, for the Fall 2019 to Fall 2021 cohorts.

A comparison of the demographics for the Fall 2022 cohort is provided in Table 3 along with comparisons of the success in ENGR 122 and MATH 242 by the subsequent Fall quarter of the sophomore year. Although ACT scores have risen slightly since the 2014-2018 cohort, the female population was stable in 2019-2022 and rose slightly for 2022. The URM dropped slightly during the recovery from COVID but was slightly higher than previous years for Fall 2022.

Table 3. Demographics of comparison students. ENGR 122 and MATH 242 percentages are students that passed by summer plus one academic quarter.

	Number	ENGR 122	MATH 242	Female	URM	ACT
Fall 2022 - Selected	24	79%	67%	29%	38%	27.0
Fall 2022 - Not selected	29	47%	53%	29%	20%	26.4
Fall 2022 Total	402	60%	59%	22%	15%	27.4
Fall 2019 to 2021	1342	52%	50%	20%	13%	27.5
Fall 2017 to 2018	982	47%	42%	19%	13%	27.2
Fall 2014 to 2016	1602	49%	47%	20%	15%	27.0

Sixty students were asked to apply to the student success program, and 53 provided applications. 24 people were selected, leaving 29 that were not selected. The female population of both groups was higher than the average population of the Fall 2022 cohort, and the URM percentage of the students selected was much higher than the students not chosen. The selected cohort had a median Adjusted Gross Income (AGI) just 26% above the poverty level for a family of 4 (median size for that group). The group not selected had a median AGI of 64% above the poverty line and 30% higher than the group that was selected.

The performance of the students in the SSP was striking, with 79% passing ENGR 122 by the Fall quarter of their sophomore year and 67% passing math during the same time period. It must be noted that common exams are given in the first-year engineering courses, removing the instructor bias, at least in the assessment of this comparison. This was almost 20% higher in

Engineering and 10% higher in Math than the rest of the Fall 2022 cohort, which was overall higher than prior years. The Fall 2022 group that was not selected had a much lower performance. However, it was within historical rates from 2014 to 2021.

Conclusion

Historical data indicated a strong marker for long-term retention is students finishing the first-year math and engineering sequences by the first term of their sophomore year. The SSP students achieved this at a higher percentage than students within engineering who were not in the program. This is an early indicator of the potential success and retention to graduation of the students in the SSP.

It is felt that the identity of the cohort and supplemental instruction had as much impact on the success of this group as the scholarships. In a survey administered at the end of their first year, SSP students indicated overwhelmingly that supplemental instruction, Friday engineering classes, and being grouped together in classes had the most meaningful impact on them. We will be watching to determine if this impact is persistent as students transition from an integrated first-year experience to the natural segmentation that occurs in the various discipline-specific courses, along with the absence of supplemental instruction for their upper-level courses.

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