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Work in Progress: Developing an Engineering Community in a Fablab

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Work in Progress: Developing an Engineering Community in a Fablab

Background

This Track Two NSF S-STEM grant project builds on the past experience of two previous S-STEM scholarship programs at the College of Lake County (CLC). In reviewing the outcomes from the two consecutive grants, the following became evident. First, the graduation rate of the NSF Scholars, students receiving the S-STEM scholarships and support, was at least 15% higher than that of the comparison group. Second, NSF scholars outperformed the comparison group in transfer rates by at least 10%. In addition, the Scholars increase the diversity within the college's Engineering and Computer Science program. The population of the NSF Scholars was composed of a higher percentage of minoritized as determined by race than both the comparison group and the college as a whole. The percentage of NSF Scholars self-identifying as female was routinely 5% higher than the comparison group.

All of these outcomes are well aligned with the S-STEM programs goal to enable low-income, talented domestic students to pursue successful careers in promising STEM fields. While applicants are not chosen based on their racial background, the lower income communities in the local county are represented by these scholars.

The current CLC grant program intends to continue supporting these academic successes for the overall Engineering and Computer Science (ECS) program at the college by targeting three primary objectives. Objective 1: Active recruitment of academically talented students with financial need into the NSF Scholars program will focus on both currently enrolled community college students and students from area high schools. Successful recruitment efforts would increase the number of female students and the proportion of recent high school graduates with high need enrolled in ECS. Objective 2: The necessary academic and student support services will be provided to NSF Scholars to achieve a high cohort persistence through transfer rate to 4-year Engineering and Computer Science programs. Objective 3: Activities will be increased, in comparison to past grants, to develop the soft skills necessary to thrive in the fields chosen, gain confidence, and succeed in furthering employment experience through internships. Activities and interventions will be adjusted based on success and student surveys.

The increased emphasis on soft skills and advancing our understanding of how the interventions and co-curricular activities affect the success, retention, transfer, academic pathways, and graduation of low-income students in STEM brings student voice to the forefront of the program. The first steps in these efforts focuses on comparing academic sense of belonging and self-efficacy of the NSF Scholars to the overall ECS student population.

Sense of belonging is typically described as a student's sense that he or she belongs at a college and fits in well, and is socially integrated. Research shows that students with a higher sense of belonging in STEM are "more likely to report having friends in the major, socializing with peers and faculty in the field, and feeling like their 'friends would miss [them]' if they left" college [1], [2]. Considering the objectives to recruit more women and low-income students, who are often first generation, it is essential that the college creates an environment where they feel welcome and have opportunities to become a member of the ECS student community. The Scholar activities that support this concept include the cohort model, team based projects and role models

introduced within the curriculum, weekly meeting for tutoring and advising, high school partnerships to acclimate students early and the CLC Baxter Innovation Lab which will serve as an ECS cultural hub and meeting ground.

Since the introduction of the lab in 2018, an increased sense of community, collaboration, and interest in the "making" culture had been witnessed. It has been suggested that makerspaces/fab labs, such as the CLC Baxter Innovation Lab, could increase retention of students in STEM related fields and improve their confidence when solving technical problems because they highlight the creative aspects of engineering and build a community of practice that increases students' sense of belonging [3], [4]. These two competencies, sense of belonging and academic efficacy, are among the eight outlined in Supporting Students' College Success: The Role of Assessment of Intrapersonal and Interpersonal Competencies [5]. However, there is a limited amount of quantitative data connecting whether and under what conditions these competencies are related to persistence and success in college. In addition, there is even less experimental evidence available focused on students' success in community colleges.

Academic self-efficacy is a student's belief that he or she can succeed in academic tasks. Additionally, self-efficacy has been found to positively affect the retention of students in difficult courses (for instance, engineering courses) [6], [7]. Prior research has also shown a strong relationship between the amount of engineering experiences and engineering design self-efficacy [8]. While design self-efficacy is a narrow construct within academic efficacy, it is something many ECS students value. The scholar activities that support this concept include the required weekly meetings and additional tutoring options as well as the introduction of the CLC Baxter Innovation Lab for social activities to increase the number of hands-on engineering experiences.

Research Design/ Program Description

Each semester students are selected based on financial need, program of choice, level of mathematic preparation and a personal essay. Once selected, these students attend weekly tutoring or advising and provide updates on their academic progress. In addition, near the start of the fall semester and towards the end of the spring semester the scholars along with the entire ECS population will receive a survey to provide a measure of their self-efficacy relative to engineering, tinkering and design, sense of belonging, and inclusion.

The CLC Baxter Innovation Lab was selected as an integral part of the expanded NSF Scholars program, including team building activities with NSF Scholars, using the lab as a tutoring hub, and employing NSF scholars as student lab interns. The intent was to examine the tutoring and experiential learning in the lab with respect to developing a sense of belonging and academic self-efficacy and determine if there is a direct correlation. In addition, as a student run lab, it is open and available each weekday for informal student use as a design or study space.

However, with on campus activities being central to the initial research design, the observations shared at this time will be based on a modified version of the original research study. The first recipients of the NSF scholarship were awarded during the spring semester of 2020. Since March of that semester the majority of the tutoring and advising have occurred remotely. The original requirement to spend two hours in study hall or tutoring each week was also decreased as Zoom fatigue and limited computer access were concerns our scholars were addressing.

Instead, scholars were required to check in virtually once a week and attend tutoring only as needed.

Without as in-depth of interventions in place and increased barriers to social engagements, the survey data collected is being viewed as a baseline rather than examine correlations. The survey was developed using the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) developed via the NSF-funded Assessing Women in Engineering (AWE) project. [9]. Some items were modified in reference to background preparation activities as well as those referencing junior or senior standing which is not relevant at a community college. Additional items were included to address specific concerns. Nine new items were focused on engineering self-efficacy as related to experimental skills, design skills and tinkering [10]. Sense of belonging was addressed with three items on belonging within the college community and three more on belonging to the specific ECS major [11].

Results / Evaluation

The current S-STEM program at CLC had a slow start with only seven NSF scholars in the first semester in the spring of 2020. In the following semesters, the number of active scholars continued to increase steadily to twenty two students in the fall of 2021. One third of the students were receiving the maximum allowable amount of financial support. With this high level of need, twenty two was the maximum number of students that could be supported within a semester. Over the four semesters a total of 34 unique students have received scholarships.

Table 1 shows a snapshot data collection of all the ECS students that were eligible to take the survey in comparison to the NSF Scholars over the last four semesters. The ECS population (591 students) consists of students who had declared an Engineering or Computer Science major at any point over the four semester period, were full-time (12 or more hours) in their starting term and were eligible to take College Algebra or higher based on test scores and prior course history. Gender and ethnicity were extracted from the students' records. While students can select male, female and non-binary, within this dataset students only reported either male or female. The comparison group is a subset the ECS population who completed the survey but does not include NSF Scholars. The NSF Scholars data only includes those students who completed the survey.

Table 1. Comparison of NSF Scholars and other ECS students from Jan. 2020 to Dec. 2021

	ECS population	NSF Scholars N = 32	Comparison Group N= 96
Gender (% Male)	88%	71%	88%
Gender (% Female)	12%	29%	12%
Race (% Asian)	13%	16%	18%
Race (% African-American)	4%	0%	4%
Race (% Latinx)	31%	51%	20%
Race (% White)	44%	27%	53%
Race (% Unspecified)	7%	6%	5%
Average # Semesters (cumulative)	4.5	5.5	4.0
Cumulative GPA	2.8	3.1	3.2

It was observed that the students in the NSF Scholars program have similar racial and gender identities to the previous grant. There is a higher percentage of female students and a consistently higher percentage of Latinx students in the scholarship program than the comparison group. The total number of students in the ECS program of study in any recent semester, around 500, is more than double the number of students in the program, 214, when the first grant was received in 2006.

Academically it was observed that the NSF Scholars have completed more credits and more cumulative semesters. The grade point average is similar. Caution should be applied when comparing grade point averages since three of the four terms evaluated have had D and F grades replaced with P and N. These P and N grades, which were a short term measure during the pandemic, had no impact when calculating grade point average whereas a D or F would have lowered the average. This resulted in artificially higher averages for some students.

The survey to evaluate belonging and self-efficacy was completed by a smaller sample of students, approximately 20%. In addition, some students skipped items which resulted in even smaller n sizes. The survey collects information regarding the students' engagement in outreach and on campus activities, work experience, transition to college skills as well as the student's perceptions of self-efficacy and sense of belonging. Figure 1 summarizes eleven themes based on the students' perceptions, each of which represent anywhere from 2 to 5 individual items that students rated on a 4-point Likert scale. The values represent a mean of the four survey means.

With the relatively small sample sizes the scale means do not allow for statistically significant analysis. The variation between the NSF Scholars and comparison group is less than the standard deviation. It is interesting to note however, all the students express a stronger sense of belonging to their major than to the community college. This is further supported by their response to a question inquiring on how they would respond to having difficulties with a professor. The majority of students would feel comfortable talking directly to the professor. Furthermore, when having difficulty deciding which courses to take, the students are as likely to reach out to a professor as an advisor.

The two underlying items with the lowest values were related to coping self-efficacy and feelings of inclusion. The mean for "I feel confident that... - I can cope with doing poorly (or not as good as I had hoped) on tests in my engineering classes" was 2.98. The mean for "other students in my classes share my personal interests" was 2.96.

The data was further examined, and it was determined that gender and ethnicity do not have a significant impact on the scores. This was noteworthy since past studies have shown that men enrolled in engineering courses tend to report higher self-efficacy scores than women [12], [13]. All of the data displayed the same trends with Belonging to Major having one of the highest scores. The slight drop in the Feeling of Inclusion scale for women can be attributed to the item discussed previously - other students in my classes share my personal interests.

Two questions in the survey directly inquire if the students perceive gender or ethnicity as an issue. They are "I can cope with being the only person of my gender in a class" and "I can cope with being the only person of my race or ethnicity in a class," respectively. The results indicate that students feel they can cope with those situations. The value for women was 3.8 compared to

3.6 for men with regards to being isolated by gender. The response to being isolated by race or ethnicity was 3.7 for White and Asian students compared to 3.6 for Latinx and African American students. Based on the overall demographics of the ECS program the women and African American students would be more likely to experience these scenarios than other students.

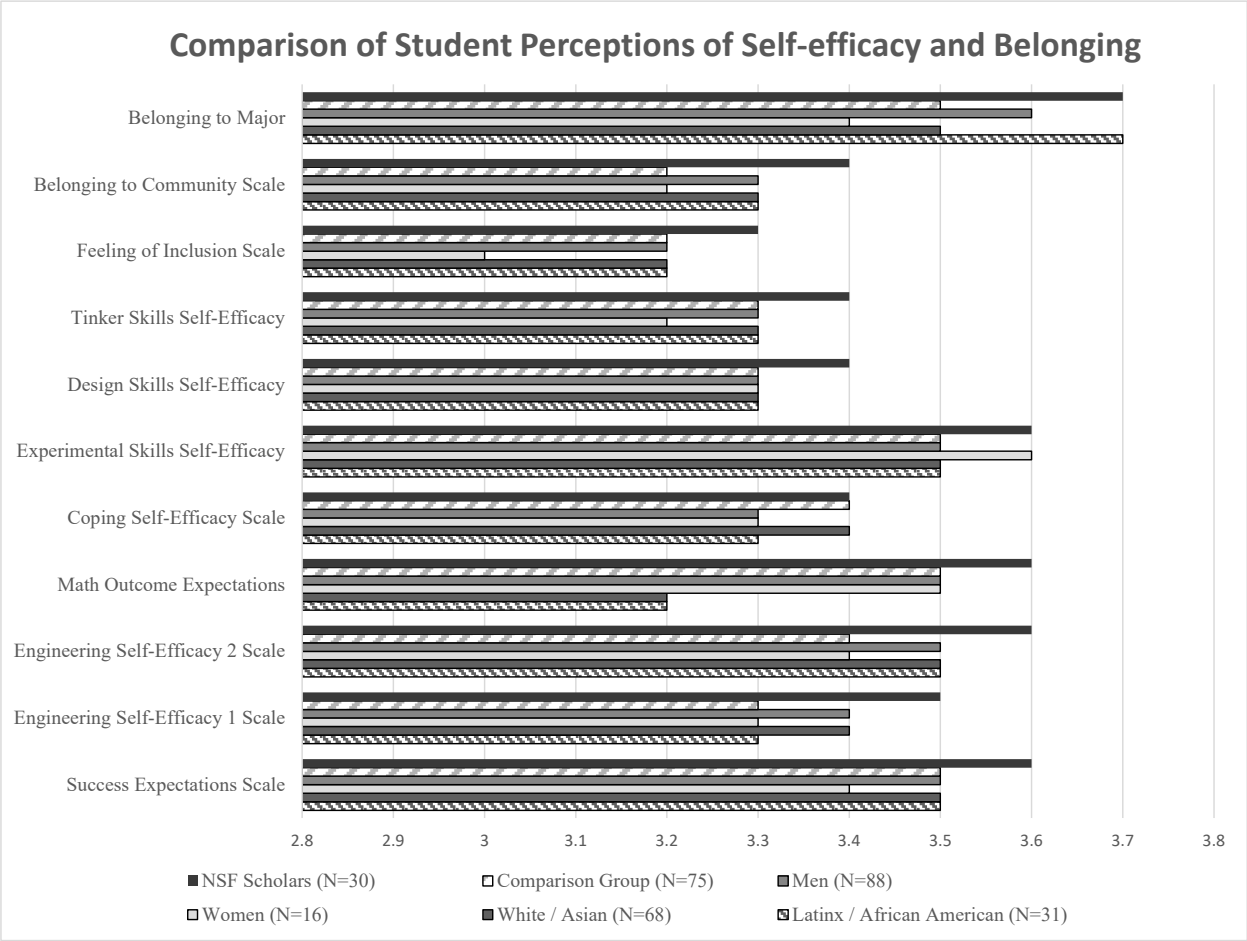

Figure 1. A comparison of student perceptions reported as a mean of four surveys

Future Plans

To better understand the data collected to date, more opportunities for open ended responses will be provided in the form of additional survey questions and/or focus groups. Future analysis will include tracking the journey of individual students through the program and the impact of the lab activities both for NSF Scholar engagement and within our curriculum. Recent campus changes to the student advising structure and software upgrades will enable student engagement activities to be more accurately quantified and compared to student perceptions.

Starting with the fall semester of 2021, student access to campus has returned. This will enable the CLC Baxter Innovation lab to once again be a central hub for the overall program and community building activities. In addition, it is anticipated that more direct interaction with the students will aid in higher survey response rates. The return to campus was also accompanied by the traditional grading structure which will provide for clearer academic comparisons.

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