

Supporting the Success of Low-Income Engineering Students through Community-Building (Evaluation)

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Abstract

Over the past twelve years, the ESTEEM program, funded by the NSF S-STEM, at University of California Santa Barbara (UCSB) has supported 161 low-income undergraduate students in engineering. This paper emphasizes the students' changing needs and what they found supportive over time with a special focus on the shifting needs for community building before, during, and after COVID-19 pandemic remote learning. Without additional support, low-income engineering students, who often reflect additional intersecting minoritized identities and are more likely to be the first in their family to attend college, leave the field at higher rates than their peers. Students who are likely to persist in engineering reported supportive relationships with mentors, positive near peer role models, a strong sense of community, and an intention to complete their engineering major. Yet, accessing these support systems is often challenging for low-income students, who are more likely to work long hours and spend more time off campus and less likely to have adequate opportunities to interact with others in their major and see themselves in role models and as part of that community. The COVID-19 pandemic disrupted the higher education plans and financial viability of UCSB engineering students, especially those from low-income families. In addition to increased financial hardships, these students lacked access to campus educational resources like tutoring and mentors and were more isolated from their on-campus engineering communities. While research has identified needs and programmatic supports likely to encourage student retention in engineering, little is known about the specific needs of low-income students in engineering and how these needs have changed over time. We examined the needs and financial and educational supports of 161 low-income students using ESTEEM evaluation data from 2011 to 2023 who pursued engineering bachelor's degrees at the University of California at Santa Barbara. Our findings emphasize the types of

programmatic supports that were most helpful for students' education and career pathways in engineering. These results indicate shifting needs for physical space, social interactions with mentors and peers, and have implications for evolving how engineering departments and programs support low-income students to meet their changing needs for persisting in engineering.

Background and Motivation

Engineering fields historically have had challenges retaining low-income students, going beyond the need for financial support. Research consistently points out that though insufficient funds are one of the most common reasons why low-income students drop out of college or transfer out of STEM fields, financial support alone is usually not enough to keep retention rates high [1], [2]. In fact, it has been found that low-income students lose out on opportunities that would give them advantages in STEM as early as high school, such as engaging in upper-level mathematics opportunities and developing mathematics identities important for engineering [3].

However, support systems offer substantial benefits for low-income students in academically rigorous fields like engineering [4]. Specifically, resources such as professional development, incentives, and community building interventions have demonstrated success in reducing barriers and promoting success in underrepresented minority (URM) students in STEM, further reinforcing the need for community building [5]. Programs that fostered a sense of belonging, supported students through challenges, and kept students on consistent academic trajectories have had increased retention and persistence of URM students in STEM fields [6].

The abrupt change to online learning and not being able to access faculty further affected the academic performances of minority students during the COVID-19 pandemic [7]. Research demonstrated a significantly negative shift in student engagement after the pandemic and shift to remote-learning, which in-turn led to a decreased positive attitude toward science [8]. This leads to the question, if low-income students already have a historically low retention rate in engineering, what effect did the pandemic have, and what interventions can be put in place to help retain undergraduate students? This paper emphasizes the need for understanding low-income undergraduate students' ongoing needs in engineering before, during, and after the COVID-19 pandemic.

ESTEEM Program

The Enhanced Support in Technology Entrepreneurship for Engineering Majors (ESTEEM 1) and Enhancing Success in Transfer Education for Engineering Majors (ESTEEM 2) programs led by the University of California, Santa Barbara (UCSB) were funded by the National Science Foundation (NSF) through the Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) Program. ESTEEM 1 (2011-2016) emphasized technology entrepreneurship support for first-generation undergraduate engineering majors already at UCSB, while ESTEEM 2 (2016-present) emphasizes transitions in engineering that included both undergraduate engineering majors and transfer students from four community college partner institutions. In an effort to look at engineering undergraduate's experiences over time, this paper includes evaluation findings from both awards who attended the 4-year undergraduate engineering degree program at UCSB. It is important to note that in ESTEEM 2, some of these

Scholars first joined ESTEEM as community college students and continued as Scholars after transferring if they transferred into an engineering major at UCSB.

Methods

This paper focuses on a secondary analysis of evaluation reports and data from UCSB Scholars who participated in ESTEEM from 2011 to 2023, spanning two project funding cycles.

Evaluation reports included both quantitative data from tracking surveys and qualitative data from open-ended survey questions and focus groups. Evaluation data included Scholar demographic information, degree completion, career pathways, and feedback on programmatic supports and impact.

Participants

ESTEEM Scholars were recruited from all engineering majors at UCSB and applied to participate in the program. Because ESTEEM is an NSF-funded S-STEM program, all students had to have demonstrated financial need as determined by the FAFSA and thus are considered to be from low-income backgrounds. Table 1 below shows the demographic information from UCSB Scholar participants.

Table 1

ESTEEM Scholars and Demographics

Scholars by Group	2011-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	All
All Undergraduate Scholars*	48	18	62	77	41	33	69	50	161
Women	21%	11%	13%	21%	18%	33%	19%	13%	19%
Hispanic	38%	44%	44%	58%	29%	33%	44%	20%	39%
Underrepresented Race	12%	6%	19%	26%	12%	8%	6%	13%	13%

First Generation College Student	98%*	61%	44%	68%	47%	58%	63%	40%	68%
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*The program in 2011-16 specifically focused on recruiting and supporting first generation college students

Findings

The findings in this paper are based on evaluation data from UCSB Scholars who participated in the ESTEEM program from 2011-2023. This dataset includes tracking survey responses from program graduates reflecting on their past experiences, focus group interviews conducted while Scholars were actively participating in the program, and thematic analysis across reports to examine trends over time in the needs, supports, and pathways of Scholars.

Table 1 shows the overall supports program graduates found most beneficial from three different points in time. These reflections do not represent the year in which students participated, rather the year they completed the tracking survey. The 2016 tracking survey included graduates who participated in ESTEEM 1 between 2011 and 2016, the 2021 tracking survey included graduates who participated in ESTEEM 2 between 2016 and 2021, and the 2023 tracking survey included graduates who participated in ESTEEM 2 between 2016 and 2023. The findings sections below explain trends in how graduates perceived supports using focus group data from while Scholars were active in ESTEEM.

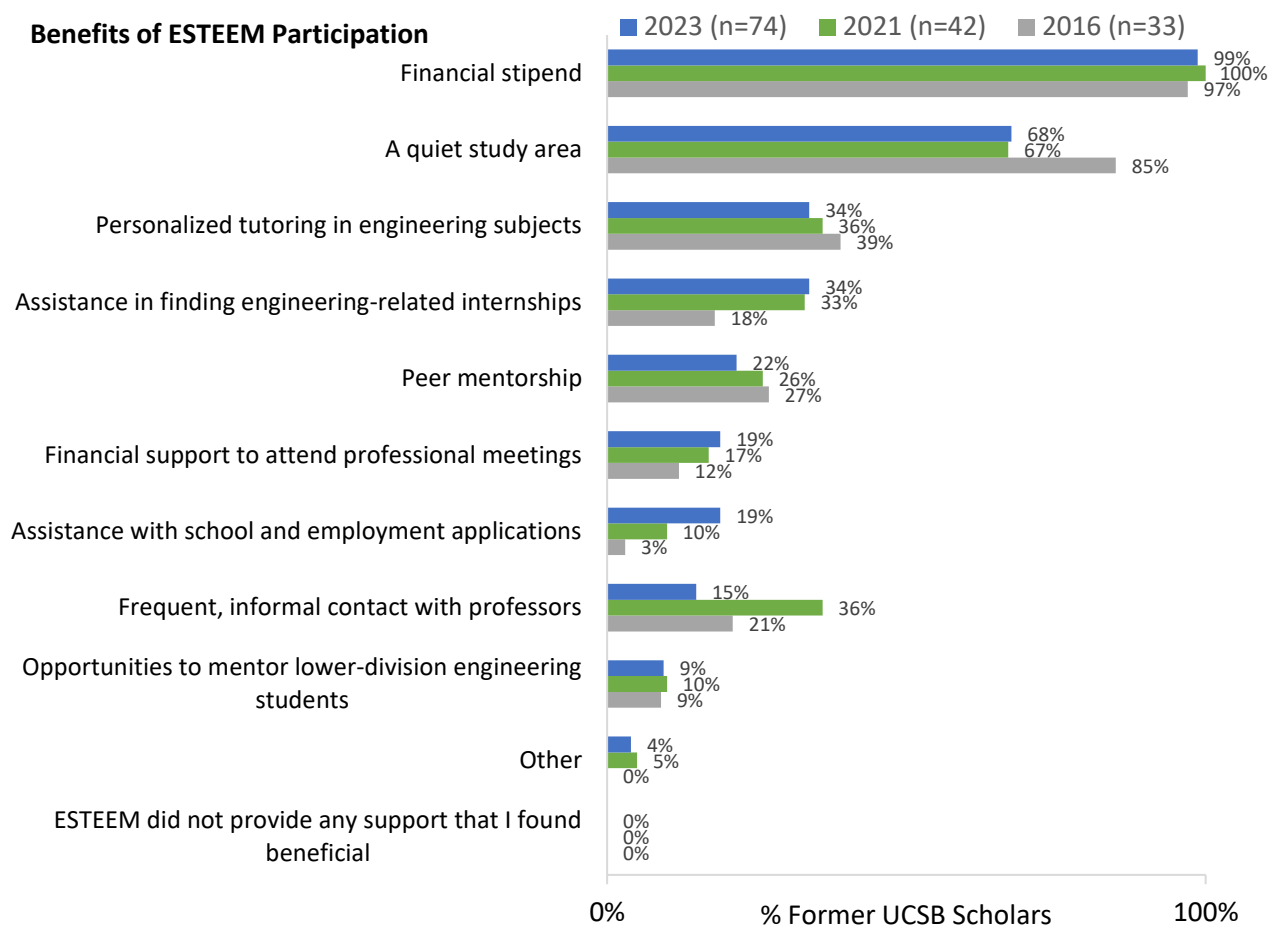


Figure 1. Aspects of ESTEEM reported to be most beneficial by former UCSB Scholars surveyed in 2016 (n=33), 2021 (n=42), and 2023 (n=74).

Consistent need for financial support

Over 12 years of the ESTEEM program evaluations, Scholars consistently benefitted from the financial support provided. Figure 1 shows the consistency in financial support being reported as a substantial benefit on tracking surveys with program Alumni. As the Scholars were from low-income backgrounds, the financial support allowed some Scholars to reduce the time they worked in jobs unrelated to their STEM careers, increased the time they had available for studying and succeeding in their courses, and enabled others to pursue research and internship

opportunities. Not all Scholars reduced their time working, yet they still demonstrated both relief and a shift in their focus toward academics knowing that they had additional financial support. Pre-COVID-19, Scholars demonstrated financial need and reiterated that the scholarship removed much of the financial burden off of them, freeing them from working jobs unrelated to STEM and opening up time in their schedules to succeed in classes. During the pandemic, the needs for financial support were still very much consistent. Unfortunately, due to impacts of the pandemic on university staffing, scholarships were processed many weeks later than usual, which caused a lot of stress for the Scholars.

Shifting need for interactions with faculty, alumni, and industry

In addition to financial support, the ESTEEM program focused on improving students' connections with faculty, tutors, and industry professionals. Early in the program, Scholars reported challenges in reaching out to faculty and made recommendations for improving these connections through events and more intentional mentoring check-ins. Scholars reflected on the usefulness of talking with faculty about research and internship opportunities, receiving advice on their academics and careers, and feeling that they have connections to their department.

Figure 1 shows that 21% of Scholars reported frequent, informal contact with professors as a benefit. Over time, Scholars discussed their need for interactions, yet the benefit alumni reported for such interactions showed an increase during tracking surveys conducted in 2020 and 2021, indicating a shift in how they valued the benefit.

In more recent years, post-COVID-19 remote learning, some Scholars continued to reflect on the benefit of informal, frequent contact with faculty in focus group interviews; yet, many

recommended increasing opportunities to engage with and develop connections with ESTEEM alumni. Scholars indicated an expressed interest in graduate school panels to navigate life after university. Scholars also desired more interactions with individuals in their majors. Shifting needs of Scholars demonstrate more desire to get interactions from fellow peers and alumni rather than solely faculty, and that they would rather depend on career and graduate school panels to get information about life after university.

Scholars shared several concrete recommendations for increasing their connections with alumni, including inviting alumni to participate in panels to discuss graduate school and industry careers and scheduling “Coffee Chats” to set up times for Scholars to talk with alumni one-on-one or in small groups. Scholars organically began connecting with alumni on Slack; however, they preferred to meet with alumni through events or through a different online platform. Some Scholars expressed preference for Discord as a communication platform with alumni because it allows for voice messages, as opposed to Slack which only offers message chatting and can feel impersonal when people do not have a profile picture.

In addition to connecting with alumni, more recent focus group interviews and surveys highlighted an increasing interest in Scholars connecting with industry. Prior to COVID-19, Scholars participated in ESTEEM networking events such as Breakfast with Industry and were excited to return to in-person networking events like these. Many Scholars expressed concerns that invited companies may not be looking to hire, which would discourage them from attending such events. In spite of these fears, they hoped to see more companies, including local companies (especially in fields of technology and electric vehicles) attend. Many Scholars felt that inviting

industry speakers is particularly helpful in learning about different industry areas because it provides them with the opportunity to directly ask the industry professionals questions. In the most recent evaluation reports, Scholars expressed a strong interest in increasing the number of career development and networking activities related to the program in general. In addition to an interest in networking with people from industry, many expressed an interest in faculty-guided mentoring sessions on research and career preparation and additional career-oriented activities such as resume and cover letter writing, negotiation workshops, and mock interviews.

Shifting need for community building

One need of Scholars that has remained consistent across the years of evaluating ESTEEM is the need for students to belong to a community. Scholars reflected that ESTEEM provided them with a community of peers with similar backgrounds and experiences that were there to help them navigate engineering. Though ESTEEM included Scholars from different engineering majors, they often developed relationships across majors because of their shared involvement in ESTEEM. From its first year, ESTEEM provided students with a study room next door to the program lead's office. This allowed Scholars to have a place where they could work, use computers with software needed for classes, and use the printer. For community building, it was also a place for forming study groups, informally interacting with other Scholars, and a place where they could meet with tutors or reach out to the program lead for advice. Scholars were given a key for 24-hour access to the room, and it was secure enough for them to leave personal possessions behind when needed. Having access to the ESTEEM study room was seen as a great advantage of the program, as there was always space in there even during midterms and finals when other study spaces on campus were typically full. Knowing that Scholars could also find

food in the ESTEEM study room during finals week (ESTEEM often provided snacks and occasionally meals) also reduced their need to worry about their meals during this intense study time. Scholars then did not have to spend money to buy food or waste their time either making food or walking home. Essentially, from its conception, the room provided Scholars with a home away from home while they were on campus, which helped them stay on campus for longer periods of time during the day.

The need for a quiet study room has shifted over time, though. It was widely used and described as a very useful resource to Scholars pre-COVID-19, yet, it was reported as less of a benefit during the COVID-19 pandemic and continuing in recent years. The shift in how the space benefitted Scholars was due in part because the room became overcrowded as ESTEEM grew, and in part because Scholars were attending courses remotely. As a result of these changes, Scholars mentioned missing out on community engagement often facilitated by these areas, especially the opportunities to engage with their peers. More recently, Scholars recognized benefits of using the shared space once again, specifically for collaboration and socializing, though it was clearly not used as much as it was pre-pandemic.

It can also be seen that pre-COVID-19, this study space was able to facilitate community-building and academic support systems among participants. However, during the pandemic Scholars reported not feeling very connected to their fellow Scholars, and the lack of opportunities to interact with one another made it particularly challenging to even get to know fellow Scholars. In more recent reports, the lack of connections with Scholars and community persisted. There were limited in-person events, so Scholars once again missed out on these

opportunities to make meaningful connections with others. The ways in which ESTEEM fostered community-building have drastically shifted since the pandemic, and Scholars demonstrate the need for more opportunities to engage with peers and mentors so that they may benefit from their academic support systems once more. Yet what such community-building looks like will likely need to adapt from community, centered on the physical space of the study room.

Impact on Education and Career Pathways

With the holistic financial, academic, and career support ESTEEM provided, many Scholars were able to continue their engineering studies in graduate school and/or pursue meaningful careers that applied their engineering degrees. While this paper does not make causal claims, it is valuable to understand the direction Scholars went in their education and careers as a way to better understand potential roles and impacts of ESTEEM's support.

At the end of ESTEEM 1's project cycle in 2016, the 34 Scholars who had graduated and responded to surveys reported on their continued education and employment status. Of these Scholars, 12 were pursuing graduate studies in engineering-related fields and 24 Scholars were employed (5 of whom were also attending graduate school). Of the Scholars who were employed, 23 reported that they were working in a STEM field.

As of Spring 2023, 30 of the 97 former ESTEEM 2 Scholars who have graduated reported that they are pursuing or have completed graduate studies. (Table 2).

Table 2

Additional academic pursuits of 30 former ESTEEM 2 Scholars who participated from 2016-23, graduated, and enrolled in a graduate program.

Degree Type	Currently Pursuing	Earned	Left without Earning
Engineering master's degree	7#	17*§	1
Engineering PhD	9*	1	-
Science, math, or technology master's degree	-	2§#	-
Non-STEM master's degree (public policy)		1	-

*Six former UCSB Scholars have completed MS programs in engineering and are currently pursuing PhDs.

§One former UCSB Scholar has completed two master's degrees, one in mechanical engineering and one in movement *science*.

#One former UCSB Scholar has completed a Master of Technology Management and is pursuing an MS in electrical engineering.

In addition to their pathways, 12 former Scholars who continued to graduate school provided feedback on the impact of ESTEEM on their preparation for graduate school. Six of these Scholars felt that ESTEEM definitely impacted their preparation, while five felt that it somewhat prepared them. However, the same themes were brought up by both of these groups when asked to explain their answers. In particular, the funding was crucial, both for allowing them time to study and for enabling them to complete their undergraduate degrees without debt so that they could go on to graduate programs. These Scholars also valued the support and resources ESTEEM provided that allowed them opportunities to learn professional skills including networking, teamwork skills, opportunities to understand expectations for graduate school and tools needed to succeed, access to research opportunities, and access to the study room that provided interactions with fellow Scholars and allowed them to share advice about applying to PhD programs. The last of the 12 Scholars expressed that ESTEEM did not prepare them, as they noticed that during their time in ESTEEM the program lacked events about academia. They

recommended that going forward ESTEEM should host a workshop to help students understand the pros and cons of academia and industry.

The most common pursuit of the ESTEEM 2 Scholars after earning their bachelor's degree was work in a job that requires an engineering degree. Of the 97 former ESTEEM 2 Scholars who have graduated as of Spring 2023, 74 were not in the process of pursuing additional degrees.

Table 3 shows the current career pursuits for these Scholars.

Table 3

Current career pursuits of 74 former ESTEEM 2 Scholars who participated from 2016-23, graduated, and are not currently pursuing other degrees.

Career Outcome	Count
Working – job requires engineering degree	65
Working – job does not require engineering degree	3
Unemployed	6

Overall, Scholars graduated, pursued graduate degrees, and obtained employment at high rates, which is notable given they are from low-income backgrounds. ESTEEM provided a variety of supports along the way, so understanding Scholars' changing needs, supports, and their pathways is beneficial for improving experiences of low-income engineering majors.

Conclusions

By looking across twelve years of evaluation data, our findings highlight low-income Engineering students' changing needs and what they found supportive for their education and career pathways. Specifically, students consistently benefitted from financial scholarships that

allowed them to focus more on their studies and become a part of the engineering community on campus. Over time, students shifted from needing more contact with faculty to seeing the benefits of also connecting with program alumni and industry professionals. Due to increases in the program size and impacts of the COVID-19 pandemic, community-building needs shifted from a shared study space for networking that provided students with a home away from home to more online communication with alumni and a desire to reconnect with peers in person [8]. While the ways in which students used and benefitted from program resources changed over time, their need for financial assistance and connections with the engineering community remained constant.

Our findings reinforce research showing that financial support, while highly beneficial for low-income students, is not enough to retain and support students in engineering careers [1, 2]. Quality mentoring both from faculty, especially those who have multicultural competence and help students feel connected, impacts students' science efficacy, identity, and values [9, 10, 11, 12]. As is true for other URM students in STEM programs, professional development and community building interventions, especially those that support a sense of belonging, have a strong and lasting impact on low-income students' success in engineering [5, 6, 13] and students' future engineering career paths [14, 15].

Because this paper uses secondary analysis of evaluation reports, inferences from findings are limited in scope and generalizability; however, understanding the lived experiences of low-income Engineering students is beneficial for ensuring that these students are given a voice and that others like them receive the support they need to succeed in Engineering. Engineering

education researchers should consider expanding the scope of this study to investigate the interventions from ESTEEM and their impact on retention rates in other Engineering programs, especially focusing on impacts for low-income students. These students are often under-studied and yet, commonly have intersecting marginalized identities in STEM and are therefore especially at risk for attrition.

Overall, our findings highlight students' changing needs from the COVID-19 pandemic, including an increasing need for community building and interactions with peers to feel connected. The need for financial support has stayed consistent over time. Students emphasized a desire to reach out to fellow peers and alumni for career support rather than just faculty, and feeling more comfortable attending graduate and career panels to prepare them for life after university. These evaluation insights have implications for other engineering programs, so that they can provide the support their students need in these changing times.

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