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Mentoring and Monitoring To Enhance Engineering Education for Low-Income Students

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Mentoring and Monitoring to Enhance Engineering Education for Low-Income Students

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Background

Commonly, college students who come from low-income households are the first generation to pursue a college degree (Gennel, 2017). These college students face multiple barriers they must navigate, with limited potential for family support beyond encouragement (Hebert, 2017). While families may be very supportive of their students attending college (Verdin & Godwin, 2015), the complexity of academic content, degree requirements, achievement expectations, securing academic support, and connecting with others at the institution are likely to be very unfamiliar and, therefore, very challenging to provide support to achieve success (Engle & Tinto, 2008). First-generation students commonly experience a range of challenges (see Figure 1) in achieving success in college (Kamalumpundi et al., 2024).

Figure 1. The challenges faced by first-generation students.

To address this issue, we submitted a proposal for a National Science Foundation (NSF) Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) award. We received the award and admitted our first and second cohorts of 17 and 18 students, respectively, in Fall 2024 and Fall 2025. As the principal investigators, we designed the program to provide scholarships and support for four years per cohort.

The focus of our S-STEM program goes beyond providing financial support for engineering students. Our program addresses a range of needs unique to low-income, first-generation college students (Means & Pyne, 2017). In particular, we embraced the significant role that faculty members play in college student success, especially for first-generation students who cannot rely on family members to understand their academic challenges (McCallen & Johnson, 2020). Considering the first two years of college appreciably impact students' professional foundation as developing engineers, our project focuses on building self-confidence and a sense of belonging to mitigate the challenges faced by first-generation college students and enhance the potential for the students' academic success.

Additionally, we have incorporated multiple high-impact practices that have been documented to increase the academic success of first-generation students (Conefrey, 2021; Gregg, 2019). These practices included:

- building a community of S-STEM scholars to support each other and work together;
- providing academic and professional mentoring, including academic advising;
- strengthening professional relationships among engineering faculty members and the student scholars;

- creating opportunities for the students to be more involved in professional engineering activities, such as research, membership in related academic clubs, and attending conferences for students studying engineering or STEM in general.

Method

To determine the impact of the program on the selected scholars, we collected qualitative and quantitative data from the first cohort of S-STEM scholars. The initial trend revealed that our initiatives are having a notable impact on students' identities as scholars, academic success, knowledge of engineering, commitment to academic pursuit, and sense of community.

Research Question. Our primary research question was: How is being a scholar in our S-STEM program for engineering majors impacting the professional development and academic success of the participating students, and how does it align with the needs of first-generation students?

Participants: The participants in our research were the 33 first- and second-year undergraduate engineering students selected for our S-STEM scholarship program. The engineering students' majors included electrical, civil, mechanical, computer, and geomatics engineering.

Methodology: Given our research goal, we determined the most effective research framework was phenomenology (Creswell & Poth, 2016), as we sought to empirically document the lived experiences of the students. We also determined that a combination of thematic and content analysis (Kalpokaite & Radivojevic, 2019) would enable us to accurately detail the students' thoughts and experiences.

Data Collection: We gathered data through interviews of groups of four to 6 student. Thus, we conducted focus group interviews with groups ranging from three to seven students. We used an interview protocol to ensure consistency and maintain alignment with our research focus. The interview protocol included prompts such as, "How is being an S-STEM scholar beneficial to you?" and "Is being an S-STEM scholar consistent with your expectations?"

The data collection took place using Zoom with the students located in the same physical space and the researcher leading the interviews working remotely. The sessions were recorded, and the audio was transcribed for analysis.

Data Conditioning: We decided our data should be compiled into two documents, one for the interviews of the first-year students and another for the second-year students. Thus, our dataset consisted of two distinct documents. We removed the interview prompts and other unrelated narrative from the transcripts. The resulting documents contained the students' responses to the interview prompts.

Analysis: To analyze our data, we used a combination of inductive and deductive coding, seeking to document evidence explicitly aligned with our research questions. Given the exploratory nature of our research, we sought to document trends in the data rather than to quantify the data or rigorously maintain continuity in the analysis. Regardless, we did verify our coding using the demonstration version of Atlas TI (https://Atlasti.com) and determined there was a high level of consistency, suggesting we effectively captured the trends in the data.

Trustworthiness: As expected, when conducting and reporting qualitative research, we took several steps to ensure the trustworthiness of our research (Saldana, 2011). First, we created and used an interview protocol, which helped us maintain consistency in our data collection and increased the replicability of our research. Second, we recorded and transcribed the data to ensure accurate documentation of the participants' responses, thereby enhancing our dependability. We achieved credibility by conducting multiple focus groups, which reflects extended research engagement. Combined, our efforts enable replication of our research process and improve the accuracy of our data's representation as aligned with the lived experiences of our study participants.

Results - First Year Scholars

In our analysis of data from first-year S-STEM scholars (our second cohort), we identified five major themes (see Table 1), to which we aligned the observed impacts and representative responses with the first-generation challenges our approach addressed.

Table 1: ***Theme, Impact, Representative Response, and Addressed First-Generation Challenge***

Theme	Impact	Representative Response	First Generation Challenge Addressed
Feeling Special	Increasing Confidence	"It gives me sort of a confidence boost that since I am being chosen to be part of this program, that I have the ability to go further than the expectations of a normal student."	Impostor Syndrome
Goals for the Scholarship Program	Lowering Barriers	"It makes me really think that I can do this… one step at a time."	Pressure to Succeed
Motivation and Accountability	Important to be Successful	"It gives me sort of a confidence boost that I have the ability to go further than the expectations of a normal student."	College Readiness
Sense of Belonging	Increased Sense of Belonging	"This is the one group that I felt like, oh, gave me the community that I wanted in order to succeed in engineering."	Belonging
Understanding of Engineering as a Profession	Multiple Professional Pathways	"Before, I didn't know there were all these different subsections… now I know what I actually want to pursue.".	Lack of Family Guidance

Perceptions of Being Special: In our analysis of the data gathered from students in their first year as S-STEM scholars (our second cohort), we found five major themes. The first theme was focused on the students' perceptions of being special and their recognition of having a high potential for success. As a result, the students perceived they were being invested results in increases in their confidence due to being selected for the program.

Shift in Perceptions and Goals of the Program: The second major theme was a shift in the students' perceptions and goals for the scholarship program. Many of the students indicated that their initial motivation for applying for the scholarship was financially based, but once they were on campus and started to engage in other program activities, their perceptions broadened. Many of the scholars also recognized the financial award of the scholarship lowered the barriers to focusing on their academics and related opportunities.

Shifts in Motivation and Accountability: The major theme was focused on the influence of the scholarship award on the students' motivation and accountability. Thus, we found by simply receiving the award and then engaging in the additional activities designed to enhance the scholars' success, the students recognized the opportunity was unique, and they needed to put forth the effort to achieve and be successful.

Sense of Belonging: The fourth theme was aligned with our goal to build a sense of community and, thereby, increase the students' sense of belonging, which we recognized as a fundamental aspect of student persistence and success. The responses of the students reflected their recognition and commitment to the community we were striving to create and the resulting sense of belonging.

Deeper Understanding of Engineering as a Profession: The final major theme we exposed was focused on gaining a deeper understanding of engineering as a profession. Through the program, students are exposed to an array of opportunities to enhance their understanding of the multiple pathways to being a professional engineer. Thus, through the additional programming we provide as part of the scholarship program we are increasing the scholars' knowledge of the diversity of professional opportunities in engineering.

Second-Year Scholars

In our analysis of data from second-year S-STEM scholars (our first cohort), we again identified five major themes (see Table 2), and thus, we repeated our process of aligning the impact and representative responses with the first-generation challenge our approach addressed.

Table 2: Theme, Impact, Representative Response, and Addressed First-Generation Challenge

Theme	Impact	Representative Response	First Generation Challenge Addressed
Being a Scholar is Prestigious	Standing Out	It really is just an opportunity to stand out among your peers… it keeps us unique among the crowd."	Impostor Syndrome
Comprehensive Support Team	More than money	"At first I thought it was just money… now I see it as more than just helping me pay for school—it's helping me through school."	Lack of Family Guidance
Community and Peer Influence	Motivated by Others	"You look around and see people getting internships, so you want to do better too."	Belonging (social isolation)
Growth as a Scholar	Potential to Succeed	"It makes me feel like someone sees potential in me that I didn't see myself."	Pressure to Succeed
Understanding of Engineering as a Profession	Being an engineer in attainable	"I had no idea what engineering really was before… now it feels more attainable and realistic,"	Lack of Family Guidance

Being a Scholar is Prestigious: The first theme focused on the scholars' continued recognition of being an S-STEM scholar as prestigious, which we interpreted as standing out. Based on the responses, we perceived our approach as addressing issues associated with impostor syndrome.

Comprehensive Support Team: Our second theme, which we found was aligned with perceptions of the scholarship program as more than a source of funding, also included a comprehensive support team. The additional professional support reflects the students'

perception of the scholarship as more than funding and providing a range of support that is commonly unavailable from the family members of first-generation students.

Community and Peer Influence: Our third theme is aligned with a sense of community and the associated peer influence. Thus, our approach notably addressed issues of belonging.

Growth as a Scholar: Our fourth theme represented growth as a scholar through program involvement. The representative response reflects our program's influence on the pressure to succeed by fostering a sense of potential to be successful.

Being an Engineer: The final major theme we found was aligned with understanding engineering as a profession. The aligned response reflected a perception that becoming an engineer is attainable. We perceive that our approach addressed the first-generation limitation of the potential lack of family guidance in academic direction.

Discussion

The goal of this research project was to empirically document the impact of our S-STEM scholarship program on low-income engineering majors. The results indicate the programming was attending to multiple aspects of the students' development. We intended to address elements aligned with the challenges of being a first-generation student, such as a sense of belonging and academic guidance. The responses of the year two cohort indicate that the community continued to develop and solidify, further addressing challenges faced by first-generation students.

Our results also reflected the diversity of programming, and additional support was diversifying and expanding the scholars' perceptions of being a professional engineer and their experiences with professional engagement. The expansion of their knowledge of engineering as a profession and the opportunities for professional engagement are likely to enhance their persistence through the program and sustained engagement as professional engineers.

The sense of motivation and responsibility toward their cohort is likely to further enhance their persistence and commitment to the program and the completion of their degree. We speculate we can further leverage this aspect of the program by expanding opportunities for the students to engage in professional engineering opportunities, such as conferences, research, and internships.

Limitations: There are a couple of limitations to our research that are worth noting. First is the nature of our data collection, which was focus group interviews. It is possible some of the students responded in ways they felt were appropriate to maintain social norms. The students may have responded differently if they were being interviewed individually or had another way to share their experiences and perspectives anonymously. The consideration of other meanings of the collected data is important for our future research.

A second limitation is the inability to triangulate the data with other sources, such as the scholars' families. Future research may involve reaching out to the scholars' family members to ask them about their perceptions or knowledge of how the scholarship program may be impacting their students' success.

Conclusion

Overall, our research indicates the structure and programming of our S-STEM scholarship program is having an early and ongoing impact on our scholars. We aligned the program with the

anticipated and documented needs of low-income first-generation college students. The students recognized themselves as unique and advantaged because of the program, which is critical for this population of students, as they commonly perceive themselves as impostors and outsiders. We addressed these issues, and our data suggests we are having a positive impact on the students' professional development as engineers.

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