Recruiting and Retaining a Diverse S-STEM Program

Dr. Tim Dallas, Texas Tech University

Tim Dallas is a Professor of Electrical and Computer Engineering at Texas Tech University. Dr. Dallas' research includes MEMS, solar energy, and educational technologies for deployment to under-served regions of the world.

Dr. Heather Greenhalgh-Spencer, Texas Tech University

Heather Greenhalgh-Spencer, PhD, is an Associate Professor in the Department of Curriculum and Instruction at Texas Tech University, as well as the Associate Chair of the department. Her research emerges at the intersection of Educational Technology, Pedagogical Innovation, Personalized Learning, Diversity and Equity Issues, and Global Studies. Greenhalgh-Spencer explores practices of using technology and pedagogical innovation to create engaged learning in both formal and informal learning spaces, and in both national and global contexts. She explores diversity and equity issues in the STEM pipeline, and also researches embodied and transdisciplinary learning practices that increase engagement for under-represented populations in STEM courses. Greenhalgh-Spencer also researches blended / personalized learning (BL/PL) and the ways that BL/PL can create diverse pathways and increased opportunities for all students.

Dr. Kelli M. Frias, American University

Kellilynn M. Frias received her Ph.D. from the University of Arizona. She is currently an Assistant Professor of Marketing at the Kogod School of Business at American University. Her research interests include marketing strategy, business-to-business rel

Recruiting and Retaining a Diverse S-STEM Program

abstract

Studies show that recruiting and retaining a diverse student body, especially in engineering programs, is difficult. Students of color, women, and students who are Pell-eligible tend to avoid and drop out of engineering and other STEM workforce pathways. There are many issues with a mismatch of expectations and a lack of a supportive culture that figure into the common problems of recruiting and training a diverse student body in engineering. This paper examines the recruitment and retention strategies of a program, embedded within the Electrical and Computer Engineering Department at Texas Tech University, that aims to recruit and retain a diverse scholar cohort. The project entitled "*Tech Intrapreneurs Program*" is funded by the National Science Foundation with additional scholarship funding from a prominent semiconductor company. This program recruits a diverse student body through the departmental advisor, outreach to diversity-focused organizations, and through faculty mentoring connections. Additionally, the program retains students by leveraging practices that have been shown, in the literature, to support a diverse student body. Namely, the program provides individual mentoring from faculty and industry experts, financial support through scholarships, and intentional community-building activities. The program provides help for students through a strategic review of the student's academic progress and grades. This paper highlights specific examples of all these strategies in action and discusses both successes and challenges in this area.

introduction

This paper examines the recruitment and retention strategies of a scholarship program in the Electrical and Computer Engineering Department (ECE) at Texas Tech University (TTU). TTU is a public university in Lubbock, TX which has a total enrollment of ~40,000 students. ECE has approximately 600 undergraduate students classified as either Electrical Engineering or Computer Engineering majors. Table I lists the ethnicity for the Fall 2022 semester in ECE. Female students are ~ 15% of the ECE undergraduate enrollment. Funding from the National Science Foundation Scholarships in STEM (S-STEM) program and financial gifts from a semiconductor company funded the student scholarships and other project costs.

TABLE I. Ethnicity of ECE Students (Fall 2022)

Ethnicity	Count	%
White	253	43.2
Hispanic	124	21.2
Black or African American	39	6.7
Non-Resident International	105	17.9
Two or more races	26	4.4
Asian	33	5.6
Other	6	1.0
	586	100

Recruiting and retaining a diverse student body in engineering [1], [2] can be difficult because there are a number of systemic issues that can hinder students from underrepresented backgrounds from entering the field. These issues include:

1. Lack of access to engineering education and resources in traditionally underserved communities [3], [4].
2. Preconceived notions about the field and the ability to succeed in it [5], [6].
3. Financial barriers such as tuition costs, lack of family support, *etc.* [7].
4. Lack of mentorship and networking opportunities for minority students [8].
5. Different cultural norms and expectations for success [9].
6. Limited representation and role models in the field [10].
7. Lack of Engineering-Focused Self-Efficacy [9].

In order to address these systemic issues, universities and engineering programs must take a proactive approach to improving access to and support for underrepresented students. This can include providing financial aid and scholarships, creating mentorship and networking programs, offering additional resources for underrepresented students, and actively recruiting diverse students. It is also important to create an inclusive environment that celebrates and supports the diversity of students, and to create a culture of belonging to the engineering field.

overview of the program and its strategies

The S-STEM program was designed to produce intrapreneurial students, primarily from traditionally underrepresented groups, who are poised to be innovators and managers in industry. The combination of faculty and industry mentorship, workforce development seminars, international experience, an industrial internship, entrepreneurship programs, and scholarships are producing graduates sought after in the workforce. Industrial partners provide mentorship, guidance, and positions to the scholars. By working with faculty and industry mentors, students are able to develop their skills and knowledge of industry. The project is embedded in evidence-based practices and previous research showing that:

1. Mentoring is vital to foster underrepresented groups' retention in undergrad courses, graduate school, and the professional workforce [11]. [12]
2. Student persistence is facilitated by mentors [13], [14], [15], [16], rigorous curriculum, and multiple opportunities to engage in real-world work contexts.
3. STEM identity is created through real-world experience in and connections to the STEM workforce; STEM identity is a strong and leading indicator of retention and advancement in the STEM workforce [17].
4. Experience with STEM innovation as an undergrad fosters entrepreneurship and innovation after graduation [18].
5. International experience as an undergrad facilitates preparation for the global STEM workforce [19].

recruiting a diverse student body

a. role of departmental advisor

The department academic advisor was the primary recruiter of the students. The advisor reached out to all potential students through emails, and then during one-on-one advising sessions

provided them with detailed information about the program, discussed the educational and career benefits of the program, and helped potential students to understand the academic requirements, course offerings, and selection criteria.

b. outreach to diversity-focused organizations

After the first year, presentations about the program were made by current scholars in the program to the engineering focused diversity organizations including NSBE, SHPE, and WIE. Through four cohorts, 33/68 (49%) program participants are from ethnic/racial minorities and 28/68 (41%) are women. These numbers indicate that recruitment efforts have been successful in reaching a diverse group when compared to the department as a whole.

c. faculty mentoring connections

Faculty helped to recruit students by providing information about the program. This was in the form of faculty-led information sessions, one-on-one meetings, and informal networking events. By providing students with an opportunity to speak with faculty members, they learned more about the program components offered, which ultimately helped them make an informed decision. Additionally, faculty members provided mentorship to students in the program and helped them to succeed in their academic pursuits.

retaining a diverse student body

a. mentoring from faculty and industry experts

By engaging in one-on-one mentoring relationships with students, faculty helped them build meaningful connections to their academic experiences and to the university. This kind of relationship fostered a sense of belonging, which is key in helping students stay in school and persist to graduation. Faculty mentors provided guidance and support with academic, career, and personal issues, helped students stay on track and proactively address any challenges or issues that arose. They also provided information about academic and career opportunities, helped students develop networks, and provided resources to help them succeed. Mentoring proved to be a key motivator of retention and graduation for our students. This aligns with the literature on mentoring. For example, Elliott *et al.* found that mentoring proved to be vital for women and underrepresented minorities in STEM fields and Engineering coursework that had a focus on entrepreneurship [20] Additionally, Blaique *et al*. found that mentoring was a key predictor of women and underrepresented groups in STEM fields going into and staying in the STEM workforce [21].

b. financial support through scholarships

Scholarships helped retain the students by providing them with financial resources to continue their studies and reduce their financial burden and need to work extended hours. Scholarships provided students with motivation and recognition for their achievements, which encouraged them to stay in school and continue their studies. Additionally, scholarships provided students with more time to pursue resources, such as mentorships and internships, which helped them develop their skills and provided them with networking opportunities.

c. intentional community-building activities

Intentional community-building activities can help retain undergraduate students by creating a sense of belonging and connectedness among students. The program accomplishes this through a weekly 1-hour seminar that includes various activities including resume critiques, mock interviews, discussions with engineering professionals, and a book report assignment. In addition, students participate in an annual 3-Day start-up weekend hosted by the university's innovation hub. The students form teams with others from across the university system to develop an idea for commercialization. Although not suggested or mandated, typically, the program students tend to cluster into teams which allows them to get to know each other better as they work towards a common goal.

strategic review of the student's academic progress and grades

A strategic review of a student's academic progress and grades helped retain undergraduate students by providing an opportunity for early intervention in areas where a student was struggling. The review identifies areas for improvement and provides guidance for the student on how to better manage their workload and focus on areas of strength. It also provides the student with an understanding of expectations and strategies for success. Additionally, students were given opportunities for "mastery experiences" where they were able to try out some of the key-competencies of intrapreneurship by engaging in projects that focused on entrepreneurial pathways. By providing timely and individualized support, students were more likely to remain enrolled and persist to graduation.

results

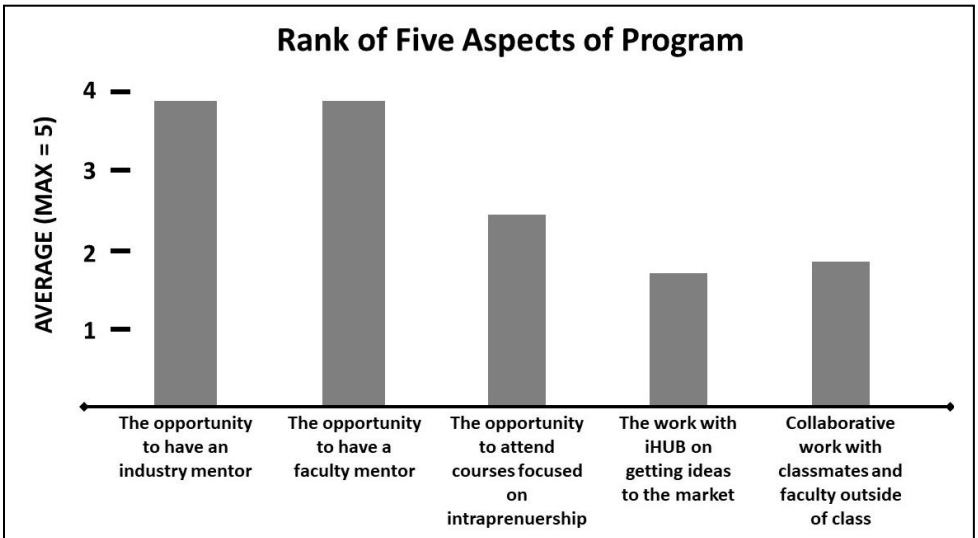

Figure 1. Rank of five aspects of program (Scale: 1-5)

Graduates of the program were asked to complete a survey that asks them to indicate which aspects of the program were most beneficial to them, provide open-ended responses to how the program benefitted them, and suggested areas to be improved or enhanced. 15 students responded to the survey. Graduates were asked to rank five aspects of the program. As shown in Figure 1, having an industry and faculty member were noted as the most important aspect of the program. Collaborative work with classmates and working with the university's innovation hub were deemed the least important with courses focused on intrapreneurship falling in the middle.

Figure 2 shows the extent graduates agreed that various aspects of the program were beneficial. All agreed that the scholarship was beneficial, which is of course no surprise. Many were in

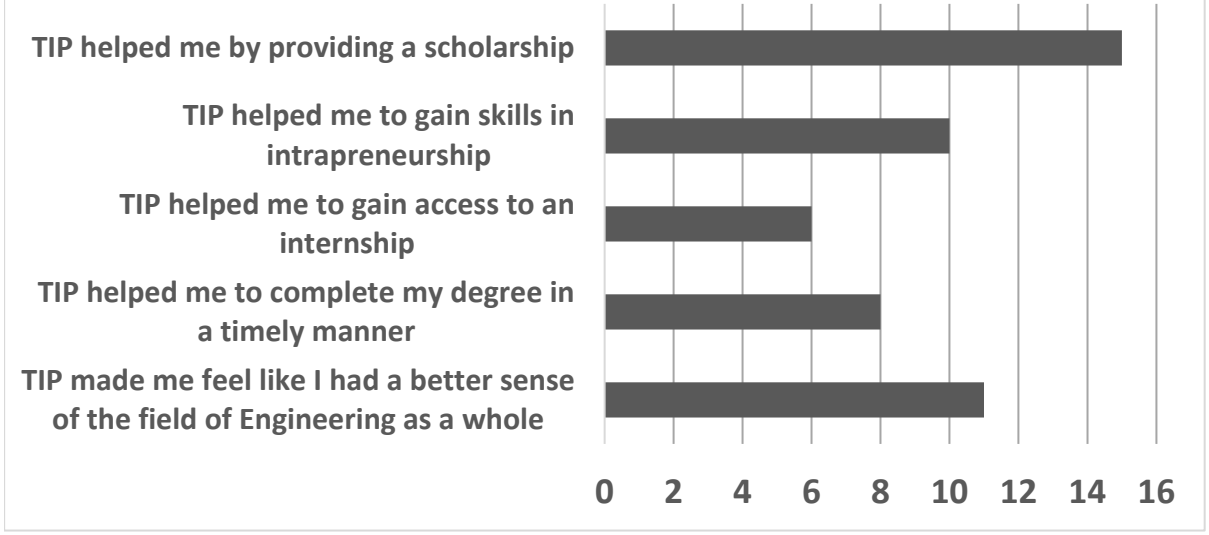

Figure 2. Number of graduates agreeing with program benefits.

agreement with the other statements. Fewer than half of the graduates attained an internship, with COVID being a principal reason why there were limited internship opportunities. Most students believed that they had a better sense of the field of engineering as a whole as a result of the program. The majority noted that the program helped them complete the degree in a timely manner.

Figure 3 shows the responses of the graduates when asked to rank the importance of aspects of the program including engagement with the field of engineering, timely progression towards degree, access to internships, and gain intrapreneurial skills. Overall, engagement and connection was deemed the most important. Timely completion of degree varied in importance.

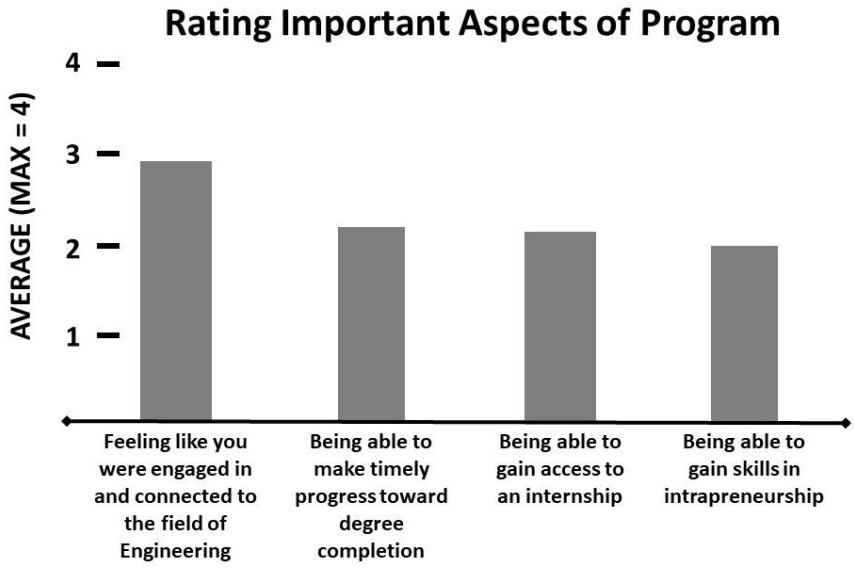

Figure 3. Important aspects of program (MAX = 4)

Students were given the opportunity to provide open-ended responses to the benefits and areas for improvement in the program. Table II provides these responses. The insight and suggestions from these responses is being used to refine the students' experiences and activities.

Table II. Open-ended responses regarding program

I think the industry mentors were very valuable and should be continued. To improve the course I think field trips to business should be considered.
I think the resume reviews, leadership talks, company insights, and creative thinking at the iHUB were all things that went very well. More discussions on talking to managers about innovations
Enjoyed all of the guest speakers that were brought in.
Exposure to main topics like intrapreneurship went well but could be further explored in the curriculum
I think the program would benefit more through having professors come in and discuss their research more or even their higher level courses.
The guest speakers went well throughout this class. Connecting us to industry mentors did not go well and was an overall challenge.
Enjoyed having weekly classes to meet as a group and learn something new.
The program helped me prepare for my internship.
I believe it gave me the skills needed to participate in meaningful communications once in my internship and also give me ideas as to what I should be getting out of it.

conclusion

The recruitment of a diverse group of students came about through a concerted effort by a number of staff, faculty, and students. Given the overall ethnic/racial and gender demographics of the electrical and computer engineering department and the field, the percentage of women and under-represented minorities in the program was very good. The responses of the students demonstrate that the program is worthwhile and makes significant contributions to their college career and beyond. Mentorship by faculty and industry personnel were deemed as the most important aspect of the program, not including the scholarship. There are still areas of the program that can be enhanced, but overall the program is meeting goals and objectives.

references

[1] L. Calian, R. M. Marra, L. R. Lattuca, K. L. Piacentini, and D. B. Knight, *"*Programs and Practices Making a Difference: A Cross-Case Analysis Identifying Programs and Factors that Influence Recruitment and Retention of Women Engineering Students*,"* 2011 ASEE Annual Conference & Exposition. https://peer.asee.org/18954

[2] L. C. Trautvetter, "Institutional Practices and Policies for Recruiting and Supporting Undergraduate Women in Engineering Across Four-Year Institutions," *New Directions for Institutional Research 2018* (179), pp. 91-114 (2019). https://doi.org/10.1002/ir.20277

[3] Darling-Hammond, Linda, Molly B. Zielezinski, and Shelley Goldman. Using technology to support at-risk students' learning. Washington, DC: Alliance for Excellent Education, 2014.

[4] Owens, Michael, and Natasha Ramsay-Jordan. "Diversity in STEM: A Look at STEM Choices Amongst Black and Latinx High School Students." *Journal of Underrepresented & Minority Progress* 5.1 (2021).

[5] S. Cheryan, *et al*. "Do female and male role models who embody STEM stereotypes hinder women's anticipated success in STEM?." *Social psychological and personality science* 2.6 (2011): 656-664.

[6] J. M. Grossman, and M. V. Porche. "Perceived gender and racial/ethnic barriers to STEM success." *Urban Education* 49.6 (2014): 698-727.

[7] M. Banerjee, "An exploratory study of online equity: Differential levels of technological access and technological efficacy among underserved and underrepresented student populations in higher education." *Interdisciplinary Journal of e-Skills and Lifelong Learning* 16 (2020): 93-121.

[8] A. G. Marshall, *et al*. "The importance of mentors and how to handle more than one mentor." *Pathogens and Disease* 80.1 (2022): ftac011.

[9] L. Andersen, and T. J. Ward. "Expectancy-value models for the STEM persistence plans of ninth-grade, high-ability students: A comparison between Black, Hispanic, and White students." *Science Education* 98.2 (2014): 216-242.

[10] J. E. L. Shin, S. R. Levy, and B. London. "Effects of role model exposure on STEM and non-STEM student engagement." *Journal of Applied Social Psychology* 46.7 (2016): 410-427.

[11] Z. S. Wilson, *et al*. "Hierarchical mentoring: A transformative strategy for improving diversity and retention in undergraduate STEM disciplines." *Journal of Science Education and Technology* 21 (2012): 148-156.

[12] R. L. Stelter, J. B. Kupersmidt, and K. N. Stump, "Establishing effective STEM mentoring relationships through mentor training," *Annals of the New York Academy of Sciences* 1483.1 (2021): 224-243.

[13] C. Poor and S. Brown, "Increasing Retention of Women in Engineering at WSU: A Model for a Women's Mentoring Program," *College Student Journal* 47 (3), pp. 421-428 (2013).

[14] K. A. Griffin, D. Pérez II, A. P. E. Holmes, C. E. P. Mayo, "Investing in the future: The importance of faculty mentoring in the development of students of color in STEM*," New Directions for Institutional Research 2010* (148) pp. 95-103 (2010). https://doi.org/10.1002/ir.365

[15] B. Bilgin, A. E. Felder, H. Darbi, R. Nazempour, S. Reckinger, R. A. Revelo, and D. Ozevin, "Looking Ahead: Structure of an Industry Mentorship Program for Undergraduate Engineering Students," *Advances in Engineering Education* 10 (3), (2022). DOI: 10.18260/3-1-1153-36031

[16] L. Guessous, B. Sangeorzan, Q. Zou, and X. Wang, *"*Industrial Mentors: An Often Untapped Resource in Undergraduate Research Programs*,"* IMECE 2008-66063, pp. 19-24 (2009). https://doi.org/10.1115/IMECE2008-66063

[17] Pascale, Amanda Blakewood, Dan Richard, and Karthikeyan Umapathy. "Am I STEM? Broadening Participation by Transforming Students' Perceptions of Self and Others as STEM-Capable," *Journal of Higher Education Theory & Practice* 21.7 (2021).

[18] D. Rae and D. E. Melton. "Developing an entrepreneurial mindset in US engineering education: an international view of the KEEN project." *The Journal of Engineering Entrepreneurship* 7.3 (2017).

[19] O. Ugweje, and H. Tritico, "Preparing Students for the Global Engineering Workforce: A Case Study of International Engineering Field Experience at the University of Mount Union." *Proceedings of the Future Technologies Conference (FTC) 2021, Volume 3*. Springer International Publishing, 2022.

[20] C. Elliott, C. Mavriplis, and H. Anis, "An entrepreneurship education and peer mentoring program for women in STEM: mentors' experiences and perceptions of entrepreneurial self-efficacy and intent." *International Entrepreneurship and Management Journal* 16 (2020): pp. 43-67.

[21] L. Blaique, A. Pinnington, and H. Aldabbas. "Mentoring and coping self-efficacy as predictors of affective occupational commitment for women in STEM." Personnel Review (2022).