

Understanding Diverse and Atypical Engineering Students: Lessons Learned From Community College Transfer Scholarship Recipients

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Abstract

With funding from the National Science Foundation's S-STEM grant program, the ECASE (Engaging the Community to Achieve Success in Engineering) Scholarship at Seattle Pacific University (SPU) has targeted transfer students from urban and rural community colleges in the region. For the past nine years, this program has provided scholarship and other support funds to assist these transfer students in obtaining a Bachelor of Science degree in Electrical Engineering. The goal of the ECASE Scholarship is to provide pathways for financially needy, academically talented transfer students to thrive in the university environment, enter the workforce as well-trained engineers, and engage the community as service-minded leaders. Generally, these students came to SPU from low-income households, underrepresented populations, and atypical backgrounds. By examining our body of ECASE scholars in this paper, we aim to expand perceptions about who could, who would, and who does succeed in earning the rigorous undergraduate electrical engineering degree.

This paper includes a discussion of the lessons learned from interacting closely with 49 ECASE scholarship recipients and supporting them in an adaptive manner to address their individual needs. The paper provides composite illustrations of the range of their backgrounds and unique situations. It highlights the challenges faced by these students during matriculation at SPU and details the interventions and support provided to these students, according to their distinct needs as engineering students from diverse and non-traditional backgrounds. Specifically, this paper includes examples of such supports, including: individual tutoring, individual mentoring, advising by an assigned faculty member, and delayed due dates when necessary, among others. While some students have personal obstacles or lack preparation for university education that prevented them from continuing even with extensive support, most (89%) recipients of the ECASE scholarship have succeeded with the appropriate academic, social, emotional, and professional supports. This paper will present composite narratives representing student uniquenesses, challenges, commonalities and supports. It will discuss the scenarios in which supports have facilitated the successful matriculation and graduation of diverse, underrepresented, and atypical engineering students, as well as when the supports have fallen short. Finally, it will describe the challenges for providing such supports, such as faculty time, student availability, community acceptance/integration, and student preparedness. This paper will also include suggested strategies for overcoming these challenges.

Introduction

Helping minority, underrepresented and low income engineering students succeed is a topic of great interest to engineering educators today both to fill a societal need for more engineers and to facilitate larger participation from these groups into this meaningful field of work. Researchers and engineering faculty have made efforts in recent years toward this goal. Early interventions at

the high school level, community college support, college learning communities*, and both faculty and peer to peer mentoring have shown themselves to have significant effect in assisting underrepresented engineering students to persist.

Researchers have found that socioeconomically disadvantaged high school students encountered complex and diverse barriers to engineering studies and concluded that access to engineering programs requires better undergraduate college prep programs¹. Similarly, Menifield² found that lottery funded scholarships alone were inadequate for African American students to achieve success in college. Thus, in the absence of improved college prep programs, colleges need to bridge the gap.

For minority students who achieve high school graduation, community college is often the next step. Packard³ concluded that community colleges often provide an entry point for first generation, low income, racial/ethnic minority or non-traditional college students. Increasing the numbers of successfully graduating minority students in Science, Technology, Engineering and Math (STEM) is known to be achieved by intentional strategies to recruit students to and retain students at community colleges: emphasizing dual credit classes in high school, providing opportunity for career related experiences and providing community-related support⁴. Other research showed that financial difficulties and math deficiencies, in addition to a lack of belonging to the engineering communities, were barriers to success⁵. Similarly, Soria⁶ determined that socioeconomically disadvantaged students struggled more with integration on campus compared to their middle and upper class peers. However, Ricks et al.⁵ found that learning communities can address each of these obstacles.

Almost ubiquitous among studies at both community colleges and four year institutions was the finding that minority students of any race or gender required community to survive and thrive to through to graduation. Corroborating the findings of Ricks et al.⁵, learning communities have been commonly identified as a strategy to provide tools for these populations^{2, 7, 8, 9, 10}. Coston et al.¹⁰ determined that students “solved problems, studied together, shared texts and called each other for support in many areas of their lives”, and thus managed to overcome multiple “stressors” that effect the success of underrepresented students in transferring from a two-year community college and subsequently completing a four-year degree.

Peer to peer and student to faculty mentoring are also commonly found to enable a sense of belonging and contribute to persistence^{2, 4, 8, 11}. Litzler and Samuelson¹¹ found that support from older peers helped boost student confidence. For instance, they found that with support, some students would frame negative experiences in a positive way that helped to insulate them from the discouragement of racism and discrimination. Litzler and Samuelson’s research¹¹ also identified how a sense of belonging was furthered by faculty/student relationships. Faculty interaction with minority students in a variety of social and academic contexts improved retention: being approachable, giving guidance, providing opportunity to work together on research projects and showing dedication. Plett et al.¹³ quoted student reports that faculty behaviors can lead students to engage or disengage and reported that there are many ways in which faculty can enhance a student’s sense of belonging and sense of faculty support. They

* The term ‘learning communities’ is generally used to describe a group of students who study, learn, live and/or socialize together who also take one or more of the same classes.

also found that a student's classroom engagement is correlated to both a student's sense of belonging and sense of faculty support. Packard³ found that success of minority STEM women was helped with faculty acknowledgement that their lives are more complicated than an average dorm student. Reyes⁴ found that faculty/student mentoring sessions that addressed institutional culture, academic expectations, isolation and invisibility helped abate considerations of leaving. Lower working class students benefitted by developing important networks with faculty who could provide letters of recommendation, research opportunities and mentorships. These connections with faculty are vital since students in this group often lack "social capital" (i.e. assistance from knowledgeable and available family and friends) needed to connect them with important academic and professional opportunities⁶. Instead of faculty, it has been shown that the support could be from a nurturing staff person who would serve as counselor and mentor¹².

Thus, while community, peer and faculty supports are important for retention and persistence through to graduation for all students, the literature indicates that these are more critical for underrepresented and minority engineering students. The same is true for this population in the engineering programs at SPU. Like other students who transfer from community colleges to a small, private, four-year university, many of our transfer students find themselves in the minority in numerous ways: ethnic/racial background, financial status, age, family background, life experience, and housing situation. Unlike the majority of undergraduates in the private university setting, these community college transfer students frequently come from very low-income backgrounds. Many are first generation university students, are older than their undergraduate peers, and have to work many hours in order to generate income while attending school full-time. These transfer students include military veterans, married students, and parents of young children. Some come with still other significant life experiences that are atypical for undergraduate university students.

This paper details the specifics of the community, peer and faculty support that we offer at SPU to engineering student recipients of our S-STEM scholarship program funded by the National Science Foundation (NSF). This paper contributes to the literature by providing insights into the lived experiences of engineering transfer students. As engineering faculty and staff, we have gleaned these insights by working more closely with this group of students than we often are able to with non-S-STEM students. We are writing to share these insights to other faculty who, like us, do not typically have the opportunity to get to know student stories this closely. This paper also contributes to the literature by detailing the impact of various supports and the effectiveness of individualization for specific students in specific situations. The paper concludes with descriptions of the lessons learned so far from our efforts.

Methods

Since 2007, our ECASE* scholarship program^{14, 15} funded by the NSF's S-STEM grant has provided \$5,000 or \$10,000 annually to 49 incoming transfer students pursuing electrical engineering degrees. Roughly half of these students are ethnic minorities, roughly one third were older than our typical student, and all had significant financial need. In addition to the scholarships, our ECASE program intentionally supports our ECASE students both academically, socially and professionally. Our ECASE student support services are focused on

* ECASE stands for Engaging the Community to Achieve Success in Engineering

building connections with their peers (through social functions and ECASE study tables), with the faculty (through faculty advisors), and with the profession (through an industrial mentoring opportunity). Our ECASE program also provides funds for individual tutoring when necessary and funds for each ECASE scholar to attend one engineering conference in order to expose him or her further to a sub-discipline of interest as well as to the engineers actively doing research in that area.

Engineering faculty get to know our ECASE students rather well since they take multiple classes from each engineering faculty member. They also interact regularly with the ECASE program coordinator and director through social events and the various ECASE support structures. In writing this paper we, as engineering faculty and ECASE staff, have considered the various stories of the challenges and struggles of our ECASE students as we have come to know them from our interactions with these students as part of their education and the scholarship program. In the Results section we provide composite vignettes representing the characteristics of the ECASE students. We use composites so that no student is identifiable, but their stories can be told. We use the narrative approach rather than demographics to illustrate the multiple challenges that can be faced simultaneously by any one ECASE student and the individualized efforts to support each student situation. The engineering faculty and ECASE staff have been struck by the contexts in which our ECASE students pursue their degrees. The vignettes are intended to convey these contexts to the reader. The Discussion section summarizes the various supports that we have provided and distills lessons learned from this scholarship program effort.

Results

Since 2007 there have been 49 engineering ECASE scholars, 44 of whom are either still at SPU pursuing engineering (11) or have graduated in engineering/computer science (33) and are pursuing STEM careers.

Since many of these students are bucking the trend of the typical engineering student, we want to share their stories from a faculty or staff perspective. However, we want to protect their identities and personal details. So, to share their situations and accomplishments, we have created nine vignettes describing our students from details that we, engineering faculty and ECASE staff, have learned about our ECASE students as we've interacted with them through their education and the ECASE program. Eight of the nine vignettes describe students who persisted, and one provides a view of a student who did not persist. In the vignettes, we have changed the details slightly, used pseudonyms and mixed up the characteristics among the vignettes so that none of the vignettes describes any specific student. However, the characteristics and experiences mentioned in the vignettes are collectively true of our 49 ECASE students. Some of the included characteristics and experiences have been common to multiple ECASE students. Others are unique enough to warrant inclusion to raise awareness among engineering educators so that together we can appreciate the depth of the challenges that some of our students face.

Pat... is a Native American, first generation college student. He comes from a large family and needed to work many hours while attending school. The transition to our four year university was challenging for him, and not just due to the long hours. We soon found that he lacked

effective study skills, resulting in his need to repeat a couple of classes. To assist him, we directed him to the Center for Learning where he sought study skills help. We also connected him with an ECASE tutor for individual help with the concepts in some of his math and engineering classes. The fact that he lived in an apartment near campus enabled him to find the time to access these supports. Pat also took full advantage of the ECASE mentoring opportunity with an engineer from industry, with whom he continues to interact occasionally. Pat successfully graduated and is now working in engineering at an aerospace company.

Chris... is a married veteran who transferred to SPU from another four-year university, seeking smaller classes and more individual attention. He has a passion for audio production. Prior to his college studies he was on active duty with the Marine Corps and served a tour in Iraq. He worked half time while pursuing his engineering degree to support himself and his wife, as well as a daughter who was born while he was studying at our school. As a head of household, he juggled household responsibilities along with his work and college activities. As a commuter student with a family at home, he was only able to attend social functions that fit into his commuting schedule. While in our program he led a group of ECASE students through some study skills activities. He also used ECASE funds to attend a conference on audio engineering. It was exciting for him to interact with researchers in audio engineering due to his long-term music interests. Chris completed an internship before his final year of school and went on to work for that same company upon graduation.

Jamie... came to SPU having been a fireman. His dad is an engineer, though, and Jamie is interested in computers. So, Jamie decided to change course from fighting fires to engineering and joined our engineering and ECASE programs. Jamie found the engineering coursework doable but challenging. We saw his potential and provided regular encouragement that he was capable and that the hard work would pay off. He responded well to this by renewing his effort and persisting when concepts and assignments seemed overwhelming. Jamie also gained leadership experience by organizing ECASE social events, which also helped him to connect further with the other students. Jamie was especially challenged by learning a foreign language, which is a requirement for graduation. We connected him with one of the other ECASE students, a native speaker of the language, who tutored Jamie to help him pass the language courses. Jamie did persist through to graduation and is now thriving working at a computer company.

Cary... is a husband and a father who returned to college at the same time as his daughter started college. Since he was supporting a family, he was working nearly full time while attending school full time. Cary was no stranger to adversity: his father died when Cary was a teenager. Cary once worked in the Army, but had an interest in prosthetics, so he decided to pursue engineering. He found the math courses especially challenging, but he regularly attended the related study sessions and found study groups to make it through them. His undergraduate engineering research under the direction of an engineering faculty member provided the motivation to put in that extra effort to succeed in these classes. Cary is now gainfully employed as an engineer at a biomedical company.

Leslie... came to engineering as the first woman in her family to pursue a male-dominated career. She came to the United States as a refugee when she was very young. Soon after that her mother

died. When she came to SPU, she still struggled with language and cultural barriers. Leslie was further challenged by the fact that she was a care-giver for her disabled father. Caring for his health needs required her to occasionally miss school and frequently lose sleep. We encouraged her to explain her situation to her professors, but she was reluctant to do so. When she did alert them, they allowed her alternate due dates as needed. Despite the time commitment of being a care-giver, Leslie found time to earn some extra income by tutoring her fellow ECASE students in math. Thus, her strong math skills were an asset for her engineering courses and also to her finances and social connections. Leslie succeeded in graduating and is now working in engineering at an aerospace firm.

Peyton... came to our ECASE program from an inner city neighborhood, not having known anyone else from her neighborhood who went to college. She began pursuing engineering in hopes of using her engineering degree and interest in physics to work in renewable energies. Her mixed-race family, however, discouraged her from pursuing an engineering degree. After several years at a community college, Peyton took several years off of school to work full time to save money. She returned to school by joining our ECASE program. While in our program, she served as a study table tutor and also as the chair of our student branch of the Institute of Electrical and Electronics Engineers (IEEE). This provided leadership experience, social connections and career networking. Peyton had the benefit of living in on-campus apartments to facilitate her connection with her fellow students and free up time (not commuting) to serve as a tutor and in leadership. Peyton has now graduated and is working at a local energy company.

John... is the son of migrant workers with a mother who has significant health issues. This led him to pursue engineering with a goal of improving the quality of life for the poor. While in our ECASE program, he found the classes very challenging and did not have enough time to devote to them. We encouraged him to take advantage of study tables and services provided by the Center for Learning, but he deemed that he could not afford the time that it would take for these. When his GPA became quite low, he did make the time for one-on-one tutoring for chemistry and to meet with a faculty member regularly (briefly) for encouragement and accountability. Despite all of these efforts, however, John eventually left school altogether.

Kelsie... is African American and grew up in a Seattle suburb with a high percentage of ethnic minorities and lower incomes. He had struggled academically at first at a technical school, so he came to the ECASE program expecting to work hard and take advantage of the supports available. His interest in learning how things work sustained him through the challenge. While in the ECASE program he attended an engineering conference focused on energy soon after the topic had been addressed in one of his classes. He returned from the conference convinced that what he was learning was valuable, which provided additional motivation for his studies. As a senior, Kelsie participated in our school's Social Ventures Competition with a team of both engineering and business majors – and they won. This boosted Kelsie's confidence and aided him in landing an engineering position in industry upon graduation.

Tracey... has had a lifelong interest in electronics which led him to study engineering and to eventually be a lead participant in SPU's robotics club. Tracey has a learning disability which is an impediment and necessitates that he set aside more time for assignments than his peers. He has learned to compensate, however, and is making solid progress toward his engineering degree.

He plans to attend an engineering conference this year or next to make more connections with other engineers in robotics. His path has been a bit jagged, but he expects to graduate a year from now.

Discussion – lessons learned

As the vignettes illustrate, ECASE students can have significant financial need, significant family responsibilities, limited effective study habits, and limited pre-requisites understanding. However, most respond favorably to efforts to get to know them and assist them.

We have learned many things about how to assist our ECASE students, and others like them, in succeeding through to graduation and into a technical career. The following is a short list of some challenges that we have discovered and the corresponding approach that we use to mitigate the challenges. Many of these are corroborated in the literature as discussed in the Introduction section of this paper. Here we consider them collectively and concretely.

- 1) *Challenge:* Students have varying needs for encouragement and prodding. Some have low confidence. Others do not yet recognize the significance of poor study habits.

Support: Students with low confidence are boosted by regular words of encouragement. Sometimes an encouraging written note or a brief hallway conversation can make a big difference for a student. Also, students with poor study habits need regular, firm accountability to take steps to improve these skills.

- 2) *Challenge:* Students who live on or near campus are often most available on the evenings and weekends, unless they are working. Commuter students, however, are generally unavailable on evenings and weekends since some have long commutes each way.

Support: Social events can be scheduled at various times to accommodate the different student availability. Study tables and tutoring can be offered on evenings and weekends to supplement faculty office hours which are typically during the day to collectively provide academic support at a broad range of days and times.

- 3) *Challenge:* Struggling students are often reluctant to ask for additional academic help and won't necessarily alert any faculty or staff members to their struggles. To them it is an embarrassment to admit these struggles. One frequent mode of response is to not attend class and often not return e-mail messages from concerned faculty or staff, thus cutting off vital communication.

Support: Persistent, proactive engagement by faculty and staff can bring them back into a positive problem solving mode. This kind of extra effort can make the difference in saving a potential failed academic trajectory.

- 4) *Challenge:* Very low income students often need to work during the school year to earn income, sometimes working full time while also a full time student.

Support: Employment provided on campus can eliminate commuting time. Supports can also be provided at a wide range of days and times to accommodate student work schedules.

- 5) *Challenge:* Low-income students do not typically have family and friend networks that provide guidance on navigating college or job searching.

Support: Faculty, staff, student mentors and industrial mentors can provide this guidance. Sometimes students need a lot of encouragement to take advantage of these since they may not readily see their value.

- 6) *Challenge:* There is a period of adjustment for students transferring in from community colleges. The pace and requirements of our courses are overwhelming for some students, and their grades drop as a result. Also, our student body is not as diverse as the typical community college in our region, and the vast majority of our undergraduate students are in the typical 18 to 23 year old age range. Therefore, for some transfer students, it takes a while to find a place to fit in socially.

Support: Students can be offered extra encouragement after they first transfer to seek out social support and to take advantage of academic supports. If the first quarter does not go well academically, students need additional care and accountability the subsequent term.

Aside from these specific observations, these lessons learned collectively suggest the need for an approach that is both comprehensive and individualized for supporting financially-needy students. The support set provided must be comprehensive in that it needs to support students emotionally, academically, and socially in addition to financially.

Emotional support can take the form of mentoring, flexibility in due dates, careful advising, and a staff or faculty member offering encouragement and/or accountability as necessary. For students with significant emotional or mental health challenges, referral to the college's counseling center can be helpful.

Academic support can take the traditional forms of study tables, individual tutoring, and additional office hours. Supplementing these, though, with proactive faculty involvement can be vital: a faculty or staff member speaks up when it is apparent that a student is struggling by specifically checking in with a student periodically, pointedly asking the student about his or her academic standing in each of his or her classes.

Social support needs can be met with social events, peer mentoring, encouragement for study groups, encouragement for involvement in campus clubs, and carefully formed teams in courses. When possible, students can be grouped intentionally so that each team member has something in common with other team members, such as gender, ethnicity, age, or commuter status.

In addition to scholarships, *financial support* can take the form of paid on-campus jobs relevant for engineering such as lab manager, tutor, lab assistant, study table host, grader or undergraduate research assistant. This ideally would eliminate the need for off-campus jobs which limit their time availability for studying, socializing, tutoring and mentoring. (Unfortunately, however, this requires additional funding.) Sometimes, though, the needed financial support is simpler, such as loaning a student a textbook for a week or two until they have the funds to purchase the text. Further, to accommodate the transition period that many incoming ECASE students experience during the first year at our university, incoming ECASE students are guaranteed the scholarship for the entire first year regardless of their grades. After the first year, ECASE students must maintain a minimum GPA to continue to receive scholarship funds.

Individualized support involves developing relationships with our students, tracking and interacting with them sufficiently to know when the above supports are needed. Many students will not seek out these supports, for various reasons, some of which may be related to the culture in which they were raised. Sometimes a faculty or staff member's efforts to provide either encouragement to seek out specific supports or to match the student with a specific form of support can make a tremendous difference in a student's success. We have found that students perceive this as being cared for, and this can lead the student to work harder, persist and care more themselves. [These findings from our S-STEM experience corroborate the research that we have done regarding the role of a student's connection to community¹³.]

Having interacted with ECASE students over so many years, an unexpected outcome has arisen: the faculty in our department has embraced a culture of supporting this student group. That is, as the faculty have seen students from disadvantaged backgrounds succeed, motivation for supporting them and 'going the extra mile' for them has increased. These students have been teaching the faculty by providing up close examples of the extra barriers they face to succeeding and also illustrating that given the right support they can go on to graduate and have successful professional careers. Their positive impact extends beyond themselves to include their immediate families and others in their social network. This means that their success has a ripple effect, producing a positive impact on parents, siblings and friends. Having witnessed these successes and impacts repeatedly, a culture is forming among the faculty and staff within our department and sister departments that seeks to reach out to lower income students. This culture aims to provide them the extra guidance that their more traditional or higher income counterparts might receive from their family and peers.

One primary motivation for providing the comprehensive set of supports has been the accountability of having an S-STEM grant. As our grant comes to an end, we face the question of how to sustain the needed supports without funding. While the scholarship funding will cease, other supports need not end. The emotional supports, some of the academic supports listed above, and the individualized support are more dependent on faculty/staff motivation than on financial backing. Thus, the long-term sustainability of these supports is primarily dependent on the departmental culture, as well as having a faculty or staff member to champion the needs of this group of students. Further, some academic and social supports, such as study tables and social events, are often regularly provided by the university at large and by student clubs. By

paying attention to student needs, faculty and staff can help to guide university and student club offerings to best meet the needs of students. Some academic supports and financial supports, however, do require specific funding which would require seeking external or internal funding sources.

Conclusion

Low income students bring varying, valuable experiences with them, and they also bring varying needs. These needs can be met by connecting with them in a community through empathy and understanding, accompanied by a comprehensive set of supports that can be tailored to each student individually. Aside from scholarship funds, most of these supports can be accomplished with a faculty or staff champion and a departmental culture aimed at providing such supports.

The current ECASE supports are effective, as demonstrated by the high persistence and graduation rates (89%). We are continually looking, though, for additional ways to support these students and will continue to learn from the experiences of other universities. Hopefully the experiences described here will aid other universities in supporting diverse and atypical engineering students. The goal is that these students obtain meaningful employment and bring value to society through their engineering competence and diverse experiences.

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