When Life Gives you Lemons, Make Lemonade: The Unique Challenges and Strengths of Low-Income Transfer Students Pursuing an Engineering Degree (Research)

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Introduction

Given the diverse socio-demographic backgrounds of transfer students, supporting the success of transfer students provides a unique opportunity to accomplish the desired diversification of the engineering workforce [1]. However, the transition from community colleges to four-year bachelor-degree awarding institutions often comes with a "transfer shock" and unique challenges leading to undesired academic outcomes [2,3,4]. More effective support is needed to ensure their success [5].

More specifically, previous research has shown that transfer students can experience unique challenges in their engineering journey, particularly after their transfer to a four-year institution. They can be faced with a lack of guidance as they navigate a new educational environment along with a lack of social integration as they enter this new social space [6,7,8]. In addition, financial costs often present a major obstacle for transfer students throughout their engineering journey in general [9]. At the same time, there are challenges that any new undergraduate student might face, including transfer students. For instance, undergraduate engineering students in an interview study expressed that they experienced the academic rigor as challenging and feeling isolated at the beginning of their engineering studies [10].

However, transfer students have unique and valuable lived experiences that provide them with valuable skills and knowledge that can act as important personal assets in their engineering journey. Following this more asset-based approach in designing education for minority students [11,12], a better understanding of the strengths that transfer students bring to engineering will allow us to empower students in meaningful ways in their undergraduate education. For instance, in a qualitative study transfer students' cultural capital in terms of their demographic, cultural and familial background were seen as strong assets by experts working with and researching transfer students [9]. These findings are also in line with the cultural wealth model that highlights the cultural knowledge from within their homes and communities that socially marginalized groups possess, but which are often not recognized appropriately [13]. Furthermore, research on the assets of first-generation students has pointed out their optimism, academic resilience, goal-orientation, civic-mindedness and proactive attitudes along with a sense of self-awareness as important traits that support their success [14]. Given the socio-demographic characteristics of the majority of transfer students, these assets are likely to play a role for engineering transfer students as well. Research on undergraduate engineering students' motivation to engage in engineering studies provides a further insight into some important assets engineering students possess. Apart from their talent and academic abilities [10,15], findings of a qualitative interview study also highlighted that enjoyment of the subject matter plays a big role for students. In addition, students choosing to enroll in engineering also reported having an inclination towards engineering in the way they tackle problems they encounter along with a tendency to engage in engineering-like tasks from an early age [10]. These attitudes are likely to positively affect

students' engagement with their engineering studies. More research is needed to better understand whether these factors play a similar role for transfer students and which other assets and challenges are relevant to their unique engineering journeys.

Thus, the current study aims to explore the challenges and obstacles along with the invaluable personal assets of engineering transfer students enrolled in an NSF S-STEM scholarship program for academically talented, community college transfer students with unmet financial needs from diverse backgrounds. More specifically, we analyzed essays from 122 engineering transfer students enrolled in the scholarship program that explored their engineering career aspirations and their motivation for joining the scholarship program to answer the following research questions:

> R1. What challenges have engineering transfer students enrolling in an NSF funded S-STEM scholarship program encountered in their career path?

> R2. What personal assets do engineering transfer students enrolling in an NSF funded S-STEM scholarship program possess that have supported them in their career path?

Methods

Sample and Setting

The data used in the current study stems from 122 engineering transfer students (27% Female, 48% Hispanic, 26% Asian, 18% White, 8% Other/Declined to report, 55% First-generation college-going). All participants were recipients of an NSF funded S-STEM scholarship at a 4-year Hispanic serving university in the Southwest of the U.S. Scholarship recipients transferred from 49 different community colleges and were an average of 22.6 years old with 7% of students above the age of 30 years when they transferred. They enrolled in a variety of engineering majors at the 4-year university: 10% Aerospace Engineering, 11% Biomedical Engineering, 11% Chemical Engineering, 8% Civil Engineering, 10% Computer Engineering, 13% Electrical Engineering, 2% Environmental Engineering, 1% Material Science and Engineering, 34% Mechanical Engineering.

The goal of the scholarship program is to improve the transfer student experience in engineering by providing co-curriculum cohort activities to prepare for STEM careers or graduate studies. Co-curricular activities include a mentoring program as well as academic advising, tutoring, summer bridge programs, academic and career workshops, and industry and research internships. The scholarship program targets students who have the ambition to pursue engineering degrees, but often lack the resources or exposure to engineering opportunities. Transfer students join the scholarship program after their transition and stay enrolled throughout their tenure at the university [16].

Measures

To assess students' perceived challenges and assets on their engineering journey, students' essays submitted as part of the scholarship program application process were analyzed. Students discussed their career goals and their motivation for joining the scholarship program by answering the following essay prompts: a.) *Provide a brief summary of your career goals, your interest in engineering.*, b.) *The S-STEM program provides low-income students from various*

backgrounds a cohort experience with scholarships, support, and resources to help them thrive in engineering. Why are you interested in the S-STEM Program and why would you like to participate?. Students were expected to write responses of about 250 words for each of the essay prompts. Essays were then coded and analyzed as described in the data analysis section.

Data analysis

Data was analyzed using the qualitative coding program Dedoose [17]. Given the focus of the current study, a deductive approach was used in the first step, in which the data was coded for two themes: perceived challenges and perceived assets [18]. In the second step, coded excerpts were then coded inductively by determining sub themes that emerged naturally from the data. A description of the sub themes can be found in Table 1 for perceived challenges and Table 2 for perceived assets.

Table 1. Overview of coding categories for perceived challenges

Categories	Description	% of students
Financial need	Discussion of financial challenges or hardship	53
Academic concerns	Discussion of concerns regarding the academic demands and/or their academic abilities/preparedness	31
Competing responsibilities	Discussion of concerns about existing responsibilities that might be impeding their academic journey	23
Lack of resources/guidance	Discussion of a lack of guidance/resources to help inform their academic journey	20
Lack of social support/representation	Discussion of a lack of social support in going through their academic journey or feeling not represented	17
Immigration/language barriers	Discussion of a lack of cultural knowledge and language barriers impeding their academic journey due to immigration	16
Lack of opportunities/ experience/knowledge	Discussion of a lack of prior professional experience or educational opportunities	13
Challenging life circumstances	Discussion of general challenging life circumstances that impede(d) their academic journey	12
(Mental) health concerns	Discussion of (mental) health concerns or issues experienced personally or by close family	7
Cultural/societal/familial expectations	Discussion of a need to overcome cultural/societal (familial) expectations to be able to follow their academic journey	6

Note: % of students = percent of students that mentioned respective theme at least once

For the first step of coding, coders received initial training on the themes to be coded. For the second step of coding, coders read coded excerpts for each of the two themes to determine subthemes. Emerging sub themes were discussed amongst coders before coding. To ensure consistency in coding, subsets of essays and identified excerpts were coded by all three coders throughout the coding process. In a reiterative process, any inconsistencies in coding were discussed amongst the coders and agreed upon changes were implemented. Average interrater reliability amongst coders across all coding rounds showed good agreement ($\kappa = .81$, [19]). In addition to a qualitative description of the identified subthemes, findings were further quantified by investigating the frequency with which students mentioned coded subthemes using IBM SPSS [20]. To this end, the percentage of students that mentioned individual subthemes at least once were calculated.

Table 2. Overview of coding categories for perceived assets

Categories	Description	% of students
Commitment	Discussion of commitment/drive/persistence	31
Learning orientation	Discussion of having a drive and commitment to learn	28
Purposeful engagement	Discussion of interest and purposeful engagement with tasks to foster their career	27
(Inter)personal skills	Discussions of having (inter)personal skills	21
Social orientation	Discussion of excelling in social interaction or valuing receiving and providing support	18
Confidence in STEM ability	Discussion of intellectual abilities and/or academic/ engineering-related talents	14
Life lesson learned	Discussion of reflective attitude towards life based on life experiences	12
Creativity	Discussion of being creative/inventive	10
Confidence in practical abilities	Discussion of practical knowledge/practical abilities/having the ability to apply knowledge hands-on	8
Cultural capital	Discussion of cultural capital in the sense of having a strong cultural/familial background	4

Note: % of students = percent of students that mentioned respective theme at least once

Positionality statement

Three coders with different training and backgrounds were involved in the coding of the essays. The first coder was a white female educational psychologist with graduate training in education

research. Given her research interest in studying the motivation and career choices of undergraduate students from diverse socio-demographic backgrounds, she approached the research as an opportunity to understand the unique and complex lived experiences of a diverse student population. The second coder was a white male engineering professor with graduate training in engineering research. As a STEM educator, he approached the research as an opportunity to identify structural barriers that the university can address and to recognize students' strengths that can be amplified in supportive learning environments to promote persistence and students' success. The third coder was a female undergraduate engineering student. As a transfer student herself, her own lived experiences informed her research approach.

Results

R1. What challenges have engineering transfer students enrolling in an NSF funded S-STEM scholarship program encountered in their career path?

As can be seen in Table 1, we identified ten subthemes of perceived challenges mentioned by participants in their essays. The frequency at which the identified subthemes were mentioned varied between 53% to 6% of the students, with the most common challenge identified by more than half of the participants being financial need. In the following, identified sub themes will be discussed in detail from most common to least common.

Financial need. The most common challenge faced by students is financial need. A number of students expressed that they were used to having little financial resources (*I have experienced what it means to not have much….. I have always had to maintain a job to pay for things school related and to maintain myself.*) and could not expect to receive financial support from their family: *Being in school is my priority at this time but it is an independent venture for which I cannot expect my family to help with financially speaking.* In addition, some students actually had to carry financial responsibility within their family such as mentioned by one student: *In the last six months my savings have been cut by half from supporting my family with paying off major financial obligations. These first two quarters have reoriented my mindset which is constantly counting the several fees and paying off daily expenses of living on-campus.*

Academic concerns. The second most common challenge identified is students' academic concerns. On the one hand, students had concerns about having to adapt to a new educational environment (*I admit that the idea of transferring from a community college to a university can be frightening)* and its new features (*I know that it will be difficult to adapt to the shorter quarter system and in addition to the rigorous upper division classes.).* On the other hand, they were concerned about their academic ability (e.g., *I have not always been the smartest or the fastest)* and the difficulty of the subject they chose to study (e.g., *It is common knowledge that engineering is one of the most difficult majors one can take in university. Engineering is rigorous due to the fact that it requires a strong background in math and physics. Most engineering majors need help along the way with their studies, including me.)*

Competing responsibilities. Almost a quarter of the students expressed that they felt challenged by competing responsibilities. As a result of the financial need they experienced, students reflected on their need to work and provide for themselves while balancing an academic career: *I*

had to work part-time while balancing my schoolwork. I had difficulty balancing my responsibilities and managing my time, so I had to make tough decisions where I needed to choose between taking less classes or working less hours. Other students mentioned a plethora of different responsibilities they need to manage, including work, and familial responsibility: *I have experience with working while being a full time student and a student athlete. I work part time at Walgreens, a pharmacy and retail store, as a customer service associate and as an IHSS provider, taking care of my grandmother.* One student with a family of their own described their struggle to maintain work-life balance: *I'm head of household with a family of three. I have a beautiful three-year-old boy that I must support. Because of this, I must work full time to cover all the family expenses: rent, vehicles, insurances, utility bills, etc. The other half of my time is used to go to school and do school-related activities such as homework, reading, and studying. What little time I have left it's used spending quality time with my son and my wife. Because of these reasons, I sometimes feel like I don't have enough time, nor energies left for any more activities.*

Lack of resources/guidance. A fifth of the students mentioned that they were lacking resources and guidance throughout their academic journey. In particular, students reported that they did not have anyone in their close family that was familiar with engineering, which made navigating their studies harder (*Since I do not have anyone in my family that is an engineer, it can be hard to navigate this field of study.* In addition, first-generation college-going students felt further disadvantaged due to the fact that they had no family support in navigating the educational system in general: *Most students here in my age have their parents support and help in their education. For example, they get help about how to enroll in different programs or what opportunities exist for them, but for me, I had to figure out everything on my own.*

Lack of social support/representation. Students discussed their lack of social support in different ways. On the one hand, they described that a missing social network led to negative experiences for them. For instance, one student expressed that "*I often found myself frustrated and discouraged, both of which I feel could have been mitigated and managed better had I had regular access to a community of people who were also going through the same things as me.* On the other hand, some students felt like they did not feel themselves represented in the engineering community given their background, which led to feelings of alienation: *Being a woman of color in the STEM field, I always tried to keep up with my classmates, but I still felt like I did not belong or that I was not smart enough to take on such a challenging major as engineering.*

Immigration/language barriers. Students described the barriers they experienced due to their immigration background in detailed ways. Students felt a struggle to navigate the education system due to a lack of language as well as cultural knowledge. For instance, one student described that their lack of English proficiency had a profound impact on their educational journey (*When I started elementary school, I struggled to learn English since it was not really spoken at home. Therefore, in the following years, I would also struggle with different subjects because I was not able to comprehend the material the same way as the other students*), while another student expressed their struggles with understanding the cultural norms and system in the U.S. (*One of the primary challenges I have as a first-generation immigrant is the need to adapt to the cultural norms in the US and navigate the complicated education system.*).

Lack of opportunities/ experience/knowledge. Some students mentioned that they felt that throughout their academic journey circumstances led to them having a lack of opportunities, experience or knowledge compared to other students. For instance, one student mentioned that *[b]eing a first-gen student, it is very difficult to fulfill these steps for internships since I don't have much experience on doing it,* while another worried about a lack of background knowledge for navigating a career in the workforce *There is a lot from college and the workforce that I do not know about. Entering the workforce is very intimidating for someone with no background or knowledge.* In addition, one student mentioned that they "*[were] unable to participate or engage in any student groups or organizations due to my limited availability",* while another student mentioned that they had "*very little access to STEM programs"* throughout their early academic journey.

Challenging life circumstances. A subset of students described general challenging life circumstances within the communities they grew up in that created obstacles that ultimately likely also impacted their academic journey. As one student stated: *Why don't kids from my community go to college? They worry about rent, healthcare, immigration, discrimination, gangs, and safety. Above all those obstacles, the pandemic killed many in my community due to the less accessible vaccines, misinformation, and healthcare access.* Apart from the wider community, other students reflected on their immediate community, such as their family situation: *For my entire life I have only lived with my mother. I have never met my father once, in my 22 years of living. He has never paid a visit—or a childcare payment. Throughout my life, I have seen my mom stress out about whether or not she will be able to pay the bills for that month—whether or not we will have a roof over our heads. I have seen her worried about where our next meal will come from.*

(Mental) health concerns. A few students mentioned health struggles as well as mental health-related concerns as challenges within their lives. For instance, one student stated that "*due to personal struggles, I would find myself in the hospital persistently",* while another experienced struggles due to the COVID-19 pandemic: *The covid-19 pandemic would take the world by storm. Making me lose my job as well as causing many mental issues.*

Cultural/societal/familial expectations. Lastly, a few students expressed that cultural, societal and/or familial expectations made their academic journey more difficult. Some students were actively discouraged by their family to pursue an academic career (e.g., *When I initially told my parents I wanted to become a civil engineer, they were doubtful and were not supportive. They even tried to persuade me to seek a different career path.)*, while other, particularly female, students were confronted with societal role expectations that clashed with a career in STEM (e.g., *My parents always believed " Females shouldn't study Engineering, there is no point because you will get married".).*

R2. What personal assets do engineering transfer students enrolling in an NSF funded S-STEM scholarship program possess that have supported them in their career path?

A total of ten subthemes of perceived assets were mentioned by participants in their essays (see Table 2). The frequency at which the identified subthemes were mentioned varied between 31% to 4% of the students, with the four most common assets being identified by more than 20% of

the participants. In the following, identified sub themes will be discussed in detail from most common to least common.

Commitment. The most common asset expressed by a third of the students in their essays was their willingness to commit and persist despite potential obstacles. As one student stated: *Being dedicated to achieving these goals requires discipline, perseverance, and hard work. It is important for people to have a clear understanding of what they want to achieve and to develop a plan for how to get there. I need to make sure I stay motivated and to continue to work towards my goals, even when faced with challenges or obstacles!* Some students expressed that being able face challenges and persist is something they actually enjoy (e.g., *Engineering is not easy but that is why I like it, it's about perseverance and persistence*) or value about themselves (e.g., *I have always been someone that likes to explore and go out of my comfort zone. If I make a decision it's because I will always follow through with it.*)

Learning orientation. Students willingness and desire to learn was mentioned as an asset almost as frequently as their willingness to commitment. Students commonly described themselves to have a mindset of lifelong learning and a general curiosity about understanding the world in general (e.g., *I was always a very curious kid and I asked a lot about why things were the way they were and how things worked.*), and engineering in particular (e.g., *The journey of exploration, innovation, and problem-solving in electrical engineering is what truly excites me and I am working towards it both in and out of my classes every day.*).

Purposeful engagement. The third most common asset that emerged in students' writing is their purposeful engagement with opportunities to further their academic journey. This included students taking advantage of opportunities provided to them, such as involvement in programs provided to them. For instance, one student elaborated that "*[a]ctively participating in STEM-based clubs like cybersecurity, robotics, and computer machinery associations were very exciting and beneficial for me; I got to network with professors and career professionals and interact with other students that have similar career goals. Thanks to this, I both created and joined communities as well as narrowed down what I'd like to focus the rest of my undergraduate studies on. Moreover, I've been able to interact with mentors and upperclassmen that also belonged to these organizations. As a result, I gained a stronger understanding of what career pathways I'm able to take and how to apply the skills I'm learning in class in the workplace.* Other students purposefully sought out or created opportunities for them to engage in activities relevant to their academic journey (e.g., *I have invested time researching modern techniques in power systems control and grid reliability. To ensure I am positioned to keep up with digital transformation going on across the grid. I have taken courses in Python and C programing as well.*)

(Inter)personal skills. A fifth of the students expressed that they developed certain (inter)personal skills valuable to the academic and work environment they aspire to be in. The skills mentioned by students ranged from time management skills (e.g., *Learning how to juggle my classes, homework, work schedule and tennis matches has made me a strong student and worker*), organizational and decision-making skills (*In my internship I have developed communication, organization, and decision-making skills that could not have been learned in the*

classroom.) to communication skills (e.g., *Throughout this project, I learned to work cooperatively in the context of a team and I further improved my researching skills.)*

Social orientation. Almost a fifth of the students wrote about their social orientation as a personal asset. This included their possession of social skills (e.g., *I'm a very sociable person)* and their orientation towards helping others (e.g., *if I help my community do well, we all end up doing well*) and their ability to thrive in community (e.g., *The ones who I hope will bring me up and push me because I am more than willing to do the same for them.).*

Confidence in STEM ability. A further personal asset discussed by students was their confidence in their STEM academic ability. Students expressed that they felt confident that they could do well academically (e.g., *I have solid skills and am confident of my ability to succeed in upper-division courses)* and that they had developed their academic ability sufficiently to succeed on their academic path (e.g., *By taking fundamental classes for the engineering field, such as math, physics, computer science, and chemistry, I have developed my skills for this academic branch.).*

Life lesson learned. A subset of students also shared important life lessons they learned that they feel are important assets determining their decision making and choices. For instance, one student expressed an important life motto they learned through their experiences: *Growing up as a child who went through this, you have two options: you could either be upset and blame others or you could do something that will change this situation and use it as motivation. That is how I learned to live my life, by taking every opportunity and maximizing it.* Another student reflected on how their parents' struggles taught them an important lesson: *Although these were unfortunate times my parents always found a way to keep us smiling. From these experiences I have grown to appreciate the little things we experience everyday. An understanding of how happiness does not dictate wealth or privilege but admiration for wanting to do and be better.*

Creativity. Ten percent of the students wrote about their creativity. They either mentioned that creativity is an important outlet for them (e.g., *Even as a young child, I have always enjoyed creating things and solving problems in a creative fashion.*) or gave specific examples for their creativity within the realm of engineering (e.g., *However, my father likes to say that necessity is the mother of invention and with ingenuity and will, we can make the most of what we have. And so, I often found myself incorporating design strategies to improve our small team's coordination as well as tinkering with parts to optimize and automate our equipment. I used basic mathematical models to design tactics that we could seamlessly implement at events when working together and crafted my own camera rigs to capture unique shots single-handedly when operating alone.).*

Confidence in practical abilities. Some students emphasized their confidence in their practical abilities in terms of their affinity for learning by doing (e.g., *I love being able to design and build things by hand.)* and the practical skills they acquired (e.g., *I began to build project devices like a robot arm, an electric shock machine, a solar panel, and a complex fan, to mention a few. While at home, I started by fixing simple home issues like repairing remote controls, vacuums, and electrical problems.).*

Cultural capital. Lastly, a few students wrote about how their culture and family empowered them in their choices (e.g., *Currently being the first generation within my family to be attending a university is an achievement I am very proud about. This was not done on my own but with a vast amount of support from both my parents)* and provided them with positive encouragement (e.g., *My family is very supportive of me going into the engineering field so that boost my interest even more because now I can do what I like to do with full support of my loved ones).*

Discussion and Future Work

Our findings highlight the breadth of experiences, including significant assets, that these students possess and challenges that engineering transfer students have to continuously face and overcome. By better understanding these assets and challenges, we can improve and create better support programs to help engineering students from diverse backgrounds persist in their degree programs and future advanced study and engineering careers. Our findings corroborate and extend previous findings in meaningful ways.

A lot of the challenges identified in our study complemented previous research. In accordance with previous findings on the challenges faced by transfer students, one of the main concerns mentioned was the financial needs students experienced. Interestingly, the financial need experienced by students was closely connected to their experience of competing responsibilities that impeded their progression in their academic career; a factor that has been discussed less often in literature. Students also expressed academic concerns in line with previous research. Our findings highlighted how at least some of these concerns appeared to be connected to students not experiencing the level of support needed during their academic journey. Students spoke about lack of support in intricate ways: In addition to the lack of resources and guidance commonly discussed in relation to transfer students' transition to four-year-institutions, students also expressed that they experienced a lack of opportunities that would have set them up for success along their academic journey. Furthermore, a lack of social support and representation further compounded students' feelings of not belonging. Lastly, given the diverse racial background of our sample, challenges related to immigration and language barriers along with the challenge of meeting cultural expectations also played an important role in some students' academic journeys.

Importantly, students possess essential strengths that help them combat the challenges they face. In line with previous research, students have confidence in their abilities and possess a general orientation towards wanting to learn and wanting to actively and purposefully engage in engineering-related tasks and being creative in their pursuits. They aspire to do challenging things and reported a strong sense of commitment and drive to persist in the face of challenges; an orientation also found to be important in previous research on first-generation students. This type of commitment likely also helped students develop a myriad of important (inter)personal skills ranging from time management to organizational skills based on the life lessons they learned and the challenges they faced. In line with a civic-mindedness found in previous research, students expressed a strong social orientation, not only in terms of wanting to connect themselves, but also wanting to contribute positively to the communities they were in. The cultural identity of the students, while being reported as posing challenges on the one hand, on the other hand were seen as important assets that helped them persist and succeed on their

academic journeys. The assets identified in this study are essential strengths needed for having a successful career, particularly in engineering, and make these students valuable members of the engineering community. These incredible assets should be further cultivated and celebrated in engineering.

To help support transfer students in their endeavors, findings highlight the need to create systemic solutions to some of the main challenges they are faced with. Firstly, this includes the creation of more opportunities of financial support for transfer students that are clearly advertised within low-income communities. At the same time, students' lack of resources could be further systematically addressed in manifold ways. This could include extensifying existing initiatives to bring more STEM-related opportunities to students from low-income diverse communities early on during their schooling as well as support programs at the high school and college level that provide not only systematic access to resources about how to navigate college and university, but also mentoring programs that provide access to role models and can help students learn about graduate school and career options, and how to make connections and get started on a particular career path. More importantly, these types of opportunities would not only meet their challenges, but also support and amplify the assets students possess. To further cultivate and celebrate these assets, systemic mechanisms could be developed and improved to more quickly get transfer students exposed to and involved in activities such as undergraduate research and extracurricular student projects, where they can further demonstrate their motivation, confidence, skills, and creativity.

Acknowledgment

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