Enduring Commitment: Exploring Why Low-Income and First-Generation Students Choose to Stay in Engineering

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Abstract

Given the intense challenge of engineering schooling, gatekeeping capabilities of the courses, and the high dropout level of engineering students, this study aims to uncover what factors fuel students to show enduring commitment throughout the course of their engineering education. An abundant number of studies focus on student persistence; however, this study focuses on students with minoritized identities who may face additional challenges because of financial stress and lack of experienced familial support. This study uses 11 interviews from undergraduate engineering students who are either first-generation students, low-income students, or both. During these interviews, participants were asked why they chose engineering as their major and if they had ever thought about leaving engineering. The answers to these questions were then thematically analyzed and analyzed using existing motivation frameworks. Our findings show that low-income and first-generation students share intrinsic as well as extrinsic motivations for choosing engineering. Moreover, despite their financial disadvantages, low-income and first-generation students are more likely to choose their engineering majors due to an intrinsic motivation factor.

Keywords

Persistence, engineering, motivation, first-generation, low-income

Introduction

The path to obtaining an engineering degree can have many ups and downs. Nearly 25% of engineering students leave engineering by the end of the year, and another 25% leave by the end of their senior year [1]. The challenges that lead to leaving include difficult of content, lack of passion, and lack of sense of belonging and resources. In addition to understanding why students leave, it is important understand why students stay. Seymour & Hunter discuss the differences between "persisters" and "leavers" within STEM fields [2]. They highlight the importance of differences in identities between students who wish to leave and those who wish to stay. For example, sense of belonging, influences from professors and parents, and confidence in math and science skills have been shown to impact students decisions to stay [2], [3].

Students from low-income and first-generation backgrounds face additional barriers to staying in engineering and may have setbacks due to financial stress and constraints [4]. Moreover, engineering college classes are notorious for their gatekeeping capabilities and high dropout level [2], [1]. For low-income and first-generations students in engineering, combining the struggles of financial difficulties, a lack of guidance, and the gatekeeping tendencies of engineering courses makes obtaining an engineering degree more challenging for these students. Given the persistent retention challenges in engineering for all students [5], it begs the question,

why and how do low-income and first-generations students persevere through these intense challenges. This study focuses on the enduring commitment of both low-income and first-generation engineering students after they contemplate leaving their engineering studies.

The goal of this study is to utilize interviews of first-generation and low-income engineering students to understand what drives them to choose engineering, what drives them away, and, most importantly, why they choose to persist. This study draws on 11 interviews with engineering students that identify as either first-generation or low-income to investigate the research question:

> Why do low-income and first-generation engineering undergraduate students at a large, public, land-grant university in the Midwest choose to stay in engineering after considering leaving?

This study is significant because it provides a nuanced understanding of why low-income and first-generations students persevere within engineering, along with the main reason they want to leave.

Literature Review

Understanding the motivations behind choosing an engineering major is essential to creating a nuanced understanding of why low-income and first-generation students persist through an engineering major. Most engineering students have a love for math, science, and problem solving which may help lead them to an engineering career choice [2], [6], [7]. An interest in math and recognizing its importance at an early age positively influences later math achievement skills [7]. which fosters an interest to pursue a STEM field. Most STEM students benefit from parental support as they encourage them to pursue their passions [2]. Along with this, some parents of STEM students may encourage their child to pursue and complete a four-year STEM degree to not only follow their passions but also to build a better foundation for their futures [7]. Some parents view a choice of a STEM degree as an investment towards the future of high financial success [2]. Low-income and first-generation students may lean into an engineering field to make their parents proud or to build a foundation for a financially stable future [2], [7]. Powell, Boyd and Wang claim that the reasoning for choosing a STEM major is largely dependent entirely on intrinsic attributes, such as a love for math, science, and problem solving [8], [7]. While intrinsic motivations may be important to choose an engineering major, there is little research focusing on the intrinsic versus extrinsic motivations of low-income and first-generation students choosing a high-paying engineering major, along with a focus on why they persist through their major choice. Despite the wide array of reasons for choosing an engineering career path, many engineering students contemplate dropping out or switching their major at some point in their collegiate career [1].

According to the American Society of Mechanical Engineers, roughly 50% of engineering students change majors or drop out before their graduations. Half of the switches and drop outs happen during their freshman year. Along with this, Seymour & Hunter found that given their lack of representation in STEM majors, more women are likely to switch out of STEM, even if their GPAs are relatively good [2]. A lack of sense of belonging as well as a negative self-assessment of their intellectual competence often leads women to switch out of STEM [2]. Along

with a lack of belonging, some students who contemplate leaving the STEM field become disappointed in the lack of passion, enthusiasm, and empathy that they received from the instructors of STEM courses [2]. Another reason for discontinuing an engineering career path could be a passion for another field. According to Seymour & Hunter [2], most switchers note a passion for a non-STEM field that competed for the student's interest before deciding to pursue a STEM field. Finally, another main factor for engineering dropout is the challenging course curriculum [9]. Low-income and first-generation students are more likely to switch to a non-STEM major after receiving only one poor grade or withdrawing from a foundational course [10]. Stress caused by financial difficulties could be an enhancing reason to drop out of their current engineering field [9]. Financial stress, a lack of passion or belonging, other career interests, and course challenge are all reasons that low-income and first-generation students could want to drop out of their engineering education; however, this study aims to understand why students choose to stay.

Theoretical Framework

The purpose of this research is to investigate the motivations for low-income and first-generation students to persist through their engineering degree. This work is framed by two conceptualizations of motivation: (1) intrinsic vs. extrinsic motivation and (2) expectancy-value theory. Intrinsic motivation is an individual's innate desire to perform a task for its own sake, based often on needs for competence or self-determination [11], [12]. Conversely, extrinsic motivation reflects factors external to an individual, often rewards or a desired outcome [11]. Expectancy-value theory posits that competence beliefs and task value beliefs factor into an individual's choice to engage in actions [13], [14]. Specifically, we draw on Matusovich et al.'s operationalization of the subjective task value that students use to make decisions about whether to persist in engineering: attainment, cost, interest, and utility [6], [14]. *Attainment* value indicates that a student pursues (or does not pursue) engineering because of a reason related to "being the type of person who is an engineer" [6]. *Cost* value refers to the "price of success or failure in terms of effort, time, and/or psychological impacts of pursuing engineering or another career"[6]. *Interest* value refers to the "enjoyment (or lack of enjoyment) experienced in doing engineering activities and/or being or becoming an engineer in the future" [6]. *Utility* value refers to the "perceived usefulness (or lack of usefulness) of becoming an engineer and/or earning an engineering degree" [6].

Methods

To answer the research question, we draw on qualitative data analysis methods [15]. This study draws from a broader study, which aimed to explore underrepresented undergraduate engineering students' perspectives on mental health. The site for this study is a large, public, research-intensive university in the Midwest region of the U.S. The data for this study are hour-long, semi-structured interviews conducted for this broader project. Specifically, we analyze responses to two questions: (1) "what made you decide to pursue engineering degree?" and (2) "have you ever thought about leaving engineering?" These questions aimed to uncover what motivations underrepresented students had for choosing engineering, why they debated leaving, and what drives their persistence.

Participants

The original study consisted of 21 undergraduate engineering students at a large, public, land-grant university in the Midwest. In this paper, only participants who identified as first-generation, low-income, or both are included for analysis. Participants were recruited via flyers posted around engineering buildings and recruitment email distributed by different engineering departments. Participants were compensated with a $30 Visa gift card for taking part in the study. We define low-income as self-reporting a family income of under $70,000 annually, which was recorded during the interviews. The demographics of the participants are shown below in Table 1.

Table 1. Participant Profile

Demographic Category		Number of Participants (n = 11)
First-Generation / Low-Income Status	First-Generation Only	4
	Low-Income Only	4
	First-Generation & Low-Income	3
Gender	Female	6
	Male	4
	Non-Binary	1
Race	White or European American	7
	Asian or Asian American	1
	Black or African American	1
	Middle Eastern or North African	1
	Native American & White	1
Major	Mechanical Engineering	6
	Civil Engineering	2
	Biological Systems Engineering	1
	Chemical Engineering	1
	Unspecified	1
Year	1st Year	2
	2nd Year	4
	3rd Year	3
	4th Year	2

Data Collection & Analysis

The interviews took place either in person or over Zoom and were audio recorded. The audio recordings were transcribed and the responses to the questions asking the participants about why they chose engineering and if they ever thought about leaving engineering were extracted. These responses were then independently coded using Thematic Analysis by Authors 1 and 2 [17]. Each author identified themes for each question independently, and then met to establish the refined themes by using Braun & Clarke's suggested steps for reflexive thematic analysis [17]. Lastly, the author team deductively coded the transcripts using the theoretical framework (i.e., intrinsic motivation, extrinsic motivation, and value codes). During this deductive coding phase, any discrepancies between authors were discussed to consensus.

Positionality of Authors

Mann and Fitzpatrick are undergraduate student researchers, advised by Deters. Mann is a sophomore civil engineering student with 7 months of research experience, and Fitzpatrick is a junior mechanical engineering student with almost 2 years of research experience. Deters is an Assistant Professor of Mechanical Engineering, received her Ph.D. in Engineering Education, and conducts engineering education research. All authors identify as white women. Mann, who is a first-generation student, is currently undergoing the same educational experiences as the participants chosen for the research study. Using the authors' positionality as current and former engineering students, they can use their different perspectives to understand and interpret the interview data. Mann and Fitzpatrick performed most of the data analysis and met regularly with Deters to discuss their progress and findings.

Findings

We organize our findings into three categories: (1) Choosing Engineering, (2) Debating Leaving, and (3) Enduring Commitment. Within each category, the themes that were developed through the thematic analysis process are presented alongside the deductive codes that align with the theoretical framework.

Choosing Engineering

Two themes shown in Table 2 describe why participants chose engineering: extrinsic motivation and intrinsic motivation.

Table 2. Themes for Choosing Engineering

Theme	Definition	Occurrence
Extrinsic Motivation (Outcome)	Student who chose an engineering major because of the anticipated outcome of the degree. This could be to make their parents/family proud, or to obtain a high paying job post-grad.	18%
Intrinsic Motivation	Students who chose an engineering major due to personal reasons such as a passion for engineering, being interested in engineering, good at math and science, or yearning to make an impact on society.	82%

Participants who fell under the extrinsic motivation theme described choosing their engineering major because they were focused on the outcome, describing how they were focused on the high-paying aspect of an engineering career or focused on making their parents proud. For example, Participant 12 said:

> I decided to pursue an engineering degree, honestly, the biggest thing for me would be the money. but that came about recently, because I went through kind of a financial burden where I came into UNL and I made sure I had enough resources and I had enough funds to support me, since I came from a low-income family and I'm a first-generation student. And there's been like some financial trouble that happened with my financial aid and my FAFSA, and my parents' financial situation too. So, I wasn't able to get funding this past semester. And it was just it was a really, I would say it was kind of my lowest period. So, it was really hard as a student who was like a refugee to come here and just be really excited for everything and then things just kind of not work out. So, I said, well, my parents made the sacrifice to come here and they left everything

and so it's not like, I put my dream all the way aside. My number one goal is to become a dentist. But as of right now, I would say my goal is to be financially stable. My parents made this big sacrifice to come here and leave everything they have. So I feel like I can make a little sacrifice to just pursue a career where I can get on my feet and make a little bit. Have a job that's guaranteed right after college. And then from there, I don't mind working on what I want to pursue.

Participant 12's story reflects external, *Utility*-based factors for choosing engineering. They are focused on the financial stability and career prospects immediately following graduation that an engineering degree can provide and has decided to put her dream of being a dentist on hold.

Participants who fell under the 'intrinsic motivation' theme chose their major because of an intrinsic drive or passion. These personal choices can range from a passion for engineering, to enjoying tinkering and building things, to enjoying problem solving, or wanting to make an impact on society. We found that 82% of low-income and first-generations students chose their engineering major because of intrinsic motivation factors. Participant 11 shared their experience:

> I've always been really passionate about like math and science, and I've always really liked to like build things. Those are kind of like the toys as a kid I even gravitated to. So really, I've just been passionate about the subject and like, wanting to improve different systems and stuff.

Participant 11's story reflects *Attainment* value – she sees being an engineer as aligned with the type of person that she is and the type of things that she is interested in.

Debating Leaving

Of the students who discussed their internal discourse about leaving engineering, three themes arose: lack of passion, other career interest, and course challenge, as shown in Table 3.

Table 3. Themes for Debating Leaving

Theme	Definition	Occurrence
Lack of Passion	Students who debated leaving engineering because of a lack of passion for the curricula or a future career in engineering.	18%
Other Career Interest	Students who debated leaving engineering because of another career interest that was more appealing to them.	45%
Course Challenge	Students who debated leaving because of the intense course challenge	36%

Participants who showed a lack of passion spoke of their disinterest in a future career in engineering. Participant 6 shared their feelings about contemplating leaving engineering:

> I'm so disillusioned or disenchanted with a couple of facets. Sometimes it feels like I'm doing this, essentially to purchase that job security. […] So, I started questioning why am I here? Like if that's what we're doing here, do I need to be doing something else?

Participant 6 describes their internal conflict between choosing a career path. They feel that they have pursued an engineering education with the intention of securing a stable career. However, this dichotomy between choosing a college major that supports their financial needs versus their personal interests can present unique challenges. The 'lack of passion' theme reflects *Interest* value as Participant 6 and others note the lack of enjoyment doing engineering.

The second theme that emerged from participant discussions about considering leaving engineering is 'other career interests.' Among the 11 participants, 5 participants expressed a strong interest in pursuing careers outside of engineering. Several participants believed they would find more satisfaction in other professions, such as law, dentistry, or teaching. Despite these interests, many noted that engineering remained attractive due to the relatively short degree completion time and its reputation for providing a financially stable career. Participant 1 shared their other career interest:

> For my work study for the past three years, I've gone to [name] Elementary School. I worked with the fifth-grade teachers, and I formed relationships with the fifth-grade students. And then I went to the after-school program, and I helped the kids with homework. It was very rewarding. At the time, when I was really struggling with engineering, I was looking at this different side of like, what I was doing at the elementary school, and it was really fulfilling, and I really thought about changing majors.

Participant 1's story highlights their interest in teaching. They share that their experience during a work-study opportunity with elementary school students left them fulfilled. When they were faced with adversity in engineering, they considered switching to a major that would be more aligned with their passion for teaching. The theme of 'other career interest' also reflects *Interest* value as it depicts a distaste in anticipation for a future career in engineering.

Lastly, participants expressed an interest in leaving engineering due to the challenge and intensity of the courses. Among the 11 participants, 36% attributed the rigor of engineering coursework to their reasoning for considering leaving. Participant 7 shared their experience with a challenging course:

> Someone I know told me to switch professors. So, I have the top professor for math this summer – everyone I've ever met says that he's the best. But then, someone told me, if you fail with Dr. [name], you maybe should not be in engineering. So, I was like, what if I do fail? What's going to happen?

Participant 7 describes their worries about a challenging course they have endured. Their peer explained that if someone can't pass a particular class with a certain professor, they shouldn't continue in engineering. This pressure was daunting for Participant 7 and contributed to their consideration for leaving engineering as they were worried that they 'wouldn't make it.' The 'course challenge' theme aligns with *Cost* value. This is because participants who fell under this theme expressed a fear of failure in terms of effort, time, or mental impacts of their engineering education.

Enduring Commitment

As participants explained their decision to persist in engineering, three themes arose: total investment, original reasons for choosing engineering, and growing to love engineering, as depicted in Table 4. Many participants responses co-aligned with more than one theme and were marked as such. Participants who chose to stay in engineering due to what they had already invested in their education/career fall under the 'total investment' theme. This theme encompasses all investment towards engineering, including time spent on degree requirements, energy spent towards their classes, extracurriculars, and/or internships, and money invested into their schooling.

Table 4. Themes for Enduring Commitment

Theme	Definition	Occurrence
Total Investment	Students who choose to stay in engineering because they are 'in too deep.' These students feel it is too late to switch because of the time, energy, and monetary investments they have put into pursuing an engineering degree.	27%
Growing to Love Engineering	Students who choose to stay in engineering because of making connections, enjoying the challenge, or discovering a passion for engineering.	55%
Original Reasons for Choosing Engineering	Students who choose to stay in engineering because they remember their original extrinsic and intrinsic motivation factors for choosing an engineering major.	82%

Several participants noted that they have scholarships that would not cover the cost of switching majors and taking additional courses. Participant 2 talks about their motivation to stay in an engineering major:

> I thought about it before, but after thinking about it, I'm pretty sure my parents would kill me if I did change my major just because it would cost a lot more money to do something else. When I've already spent two years into this already. So that's one thing that's stopping me from you know, changing majors.

Participant 2's story encompasses *Cost* value. Their story shows that the price of success in terms of time and phycological impacts of pursuing engineering are important them. They emphasize how they have come too far and do not have the time or money to waste on starting a new education.

Next, participants who fell under the theme of 'growing to love engineering' shared their experiences of developing a sense of appreciation and pride for the subject. Participants expressed pride in the effort they put into building their networks, succeeding in challenging courses, and discovering a passion for their engineering. Participant 12 described how their relationship with engineering evolved:

> I decided on civil engineering because it was close to architecture. I didn't want to do architecture specifically because it was more art heavy. And I think my best subjects are like math and physics. So, I thought that would be my best option for now. And I would say, I kind of had it like temporarily at first, but now it's something that I just grew to love.

The theme of 'growing to love engineering' reflect *Interest* and *Utility* value. As they grew an enjoyment for the experience of doing engineering activities as well as found a perceived usefulness of becoming an engineer.

Lastly, 82% of participants shared their choice to stay in engineering related back to one of their original reasons for choosing engineering. This could be because of extrinsic or intrinsic motivation. Table 5, shown below, shows the prominence of extrinsic vs intrinsic motivation factors when it comes to choosing to persist in the pursuit of an engineering major.

Original Reasons for Choosing Engineering

Table 5 shows the themes for participants' original reasons for choosing engineering.

Table 5. Themes for Original Reasons for Choosing Engineering

Theme	Definition	Occurrence
Extrinsic Motivation	Students who choose to stay in engineering because	18%
Intrinsic Motivation	of their original motivators for choosing engineering.	64%

Among the participants of this study, 82% noted that their original reasons for choosing engineering impacted their decision to stay in engineering. Participants shared they chose engineering for a multitude of reasons, both intrinsic and extrinsic, including financial stability, passion for engineering, making their family proud, and desire to positively impact the world. Participant 19 explains their thoughts about persisting in engineering and how it relates to their original reasons for choosing engineering:

> I feel like just every once in a while, it's kind of like, 'Is engineering what I want to do?' But there's never something else that comes to my mind of anything else that I would want to do. It's usually pretty quickly that I'm kind of back to like, no, this is cool.

Participant 19 occasionally doubts their motivation for pursuing engineering. However, they always conclude that they cannot envision another desirable career path and find engineering to be an interesting field. This internal discourse ties back to their original decision to choose engineering which aligns with their interest in the subject.

Conclusion

This study aimed to explore why low-income and first-generation undergraduate engineering students at a large, public, land-grant university in the Midwest choose to persist in engineering after considering leaving. Our findings indicate that the interviewed participants are primarily drawn to engineering by intrinsic motivators such as a passion for engineering, a love for problem-solving, and a desire to make a societal impact. While financial stability and parental expectations influence their decision to pursue engineering, intrinsic motivators are the primary drivers sustaining their commitment. Moreover, students who consider leaving often cite a lack of passion for engineering, interest in other careers, or the challenging nature of the coursework. However, those who persist do so due to their initial motivations, the investments they have made, and a growing appreciation for the field. Our research underscores the need for engineering educators to recognize and support the unique experiences and perspectives of these students. By providing financial support, mentorship, and fostering a sense of belonging, educators can help reduce dropout rates and create a more inclusive learning environment. Additionally, future work in this area can further strengthen our understanding of student motivators for persisting in engineering. Addressing the specific needs of low-income and first-generation students can enhance their retention and success, contributing to a more diverse and robust engineering workforce.

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