

“The Change:”

A Narrative-Informed Case Study Exploring the Tension between
Structures and Agency in the Educational Trajectories of Engineering
Students from Underserved Backgrounds

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Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in
partial fulfillment of the requirements for the degree of:

Doctor of Philosophy
In
Engineering Education

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December 11, 2019
Blacksburg, VA

Keywords: engineering education, underserved, low income, first generation, access, equity

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Abstract

In the United States context, there is a particularly prevalent dialogue about the transformative power of an engineering degree for underserved students. Long positioned as a mechanism for moving up the social ladder, engineering education is often discussed as a mechanism for upward mobility, promising underserved students the opportunity to climb. However, a critical examination of *who* enrolls and persists in engineering degree programs suggests not everyone can equitably leverage the transformative power of an engineering degree, with persistent inequities for underserved students. Though literature highlights systemic barriers faced by underserved engineering students, much less is known about how underserved students navigate barriers to pursue an engineering bachelor’s degree. Accordingly, the purpose of my study was to explore how students from underserved backgrounds navigate their educational trajectories, focusing on the interplay between structures and agency. Using a Bourdieusian lens, my study was guided by the overarching research question: *In their narratives, how do students from underserved backgrounds describe navigating their educational trajectories towards a bachelor’s engineering degree?* I used a single case study methodology with embedded units of analysis to explore this research question. My primary data sources included narrative interviews with 32 underserved engineering students and geospatial community-level data extrapolated from students’ home zip codes. My results indicate that underserved engineering students describe a variety of strategies to enact agency by planning, optimizing, and, at times, redirecting their educational trajectories. This study also highlights the influence of family, community, economic, and political environments on the educational journeys of underserved engineering students, as students described navigating and adapting to these various social environments. Students also describe their environments as dynamic, with trajectories changing based on critical incidents such as a parent illness or loss of work. Lastly, students’ narratives highlight a diverse range of reasons for pursuing engineering,

which often extended beyond private goods approaches to engineering education. My results present implications for engineering education, the most notable of which is that underserved students are not a monolithic group and represent a diverse range of lived experiences. My results also highlight agency as a collective endeavor, challenging popular notions that agency is operationalized at the level of a single individual. Lastly, students' lived experiences with material hardship highlight the dynamic and multidimensional nature of economic disadvantage. Such insights compel engineering educators to reexamine how we conceptualize and measure economic disadvantage in higher education. Ultimately, this research highlights opportunities to increase access and equity in engineering education for underserved students.

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Ashley Rae Taylor

General Audience Abstract

In the United States, engineering is often viewed as a transformative career for underserved students. Long positioned as a mechanism for moving up the social ladder, engineering education is positioned to underserved students as an opportunity to climb. However, inequities in engineering education persist, with low income and first generation students underrepresented in engineering. The purpose of my study was to explore how students from underserved backgrounds navigate their educational trajectories, focusing on the interplay between societal forces (i.e., structures) and individual decision-making (i.e., agency). My study was guided by the overarching research question: *In their narratives, how do students from underserved backgrounds describe navigating their educational trajectories towards a bachelor’s engineering degree?* My primary data sources included narrative interviews with 32 underserved engineering students and geospatial community-level data. My results indicate that underserved engineering students describe a variety of strategies to plan, optimize, and, at times, redirect their educational trajectories. This study highlights the influence of family, community, economic, and political environments on the educational journeys of underserved engineering students. Additionally, students describe their environments as dynamic, with trajectories changing based on critical incidents such as a parent illness or loss of work. Lastly, students’ narratives highlight a diverse range of reasons for pursuing engineering, which often extended beyond private goods approaches to engineering education. My results highlight agency as a collective family endeavor, challenging popular notions that agency is operationalized at the level of a single individual. Lastly, students’ lived experiences with material hardship highlight the dynamic and multidimensional nature of economic disadvantage. Such insights compel engineering educators to reexamine how we conceptualize and measure economic disadvantage in higher education. Ultimately, this research highlights opportunities to increase access and equity in engineering education for underserved students.

Dedication

To my family, by blood and beyond: I am because we are.

And to the enduring legacy of change-chasers, past, present and future, remaining ever expectant
that change will come.

Acknowledgements

It is strange to type only my name on the title page of this document, for truly the transformative process of my doctoral education has been a collective endeavor. Through each step of my journey, good people have surrounded me with encouragement and wisdom. This page cannot hold the depths of my gratitude.

Students

To the students I have had the privilege of working with over the past four years, who generously shared their stories and time with me: you are the heartbeat of this work. My gratitude is eternal to each of you. Know that I will always carry your stories with me, for they have transformed the depths of me. My unwavering hope rests in you, the change-chasers and world-changers. I will always be behind and beside you.

Committee

To my advisor, Dr. Walter Lee: There are not enough words to express the overwhelming gratitude I hold for every moment you have encouraged me along this journey. I am certain that I would never have finished this journey without your mentoring. You are the most persistent force for change I have ever witnessed, and it is a great honor of my life to have been so closely mentored by you through this process. Thank you for believing in me when I didn't believe in me. Thank you for helping me find my voice and live into my authentic self. And perhaps most of all, thank you for never asking me to justify or defend my worth, as a scholar and beyond. This is a uniquely powerful gift- to let go of the chains of having to prove oneself and instead get on with the process of doing good work. May the goodness you put into the world be returned to you tenfold.

To Dr. Bevelee Watford: You are where this journey began for me, as I started the doctoral journey in large part work alongside your leadership and learn from you in CEED. You are a warrior for good. Over the past four years, it has been transformative to witness the way you advocate for every single student. You leave no one behind. You are so deeply courageous and so deeply compassionate. Thank you for trusting me in leadership roles I would have never trusted for myself. Thank you for pouring your courage into me. I will carry it always. Wherever the journey leads, I will hold onto your spirit of courageous, compassionate leadership. From the bottom of my heart, thank you.

To Dr. David Knight: There is so much that I deeply respect about you, your leadership, and your approach to life. Thank you for treating me with such sincere respect as your colleague. Thank you for never straying away from the hard conversations, about balance, family, and all things in between. Your ability to have the hard conversations with a sprinkle of humor along the way—never taking yourself or life too seriously—is something I aspire to. Your authenticity inspires me.

To Dr. Jenni Case: Thank you for never letting me shrink back into smallness. You have continuously reminded me, even through my stubbornness, to grow into confidence while holding on to humility. This is no small thing. I thank you, for the generosity of your time to pour energy into me along this journey and for reminding me to never dim my light in smallness.

To Dr. Khaled Hassouna: It is a transformative thing to be understood, and more than any other mentor in my journey, I felt deeply understood by you from the moment your mentoring began. Thank you for your selfless mentoring. You daily renew my hope in the powerful force of good in the world. Thank you for “swimming beside” me in every step of this journey, and thank you for teaching me to swim beside my brothers and sisters in this world. I will always carry your teachings with me.

Family, By Blood and By Choice

To my partner in life and love, Philip: you are my joy, the other half of my soul. You remain so steadfast in every journey, including this dissertation. Thank you for never letting me quit and for your enduring patience.

To my Momma and Daddy: everything I am is because of you. This belongs to all of us. From the bottom of my heart, thank you for walking alongside me on the mountaintops and in the valleys. Thank you for fighting for me through prayer, through love, through encouragement. Thank you for reminding me every night since I was born that I can do anything, through Him. I love you. I will never take your sacrifices and your encouragement for granted.

To my Sister: you are strength and wisdom, humor and humility. You embody so much of the good in the world, and I am overwhelmingly proud to share your DNA. Thank you for encouraging me to persist in every step of this race. Thank you for having my back. I will always have yours. I love you so endlessly.

To my Granny: you are the strongest woman I have ever known. You built us, you built me. We grow as a strong tree from your roots. Thank you for all that you have sacrificed and endured to provide a better life for our family. I love you.

To Sissy, Roger, Gary, Debbie, Kenneth, Lindsay, Eric, Jess, Elliott, Matthew, Christy, Johnny, Caleb, Tyler, Zane: you’ve walked with me every step of this journey. Thank you. I would not have made this journey without you. We cross into whatever lies ahead together. I love each of you so much.

To my Warminster family: thank you for celebrating this milestone with me, and thank you for taking an interest in understanding my heart’s work in this dissertation.

To Drs. Andy and Penny Muelenaer: you are mentors for life. You have shown me the world, and helped me find my place in it. You have embodied hope for me, showing me that a small seed of a dream can grow into a something powerful with the proper nurturing. With all that I am, I thank you for your goodness and for the way you strive daily to make the world a better place. Love to both of you, always.

To Karis Boyd-Sinkler: what a gift meeting you on the first day of this journey was. You are so full of goodness and light. Thank you for the light you’ve poured into my journey. It remains an honor to walk alongside you as you change the world for good.

To Cynthia Hampton: you are the most selfless person I have ever known. You make the world better in every moment, and you are a force to be reckoned with. Thank you for your unwavering strength and hope, and thank you for sharing it with me. You are truly a remarkable person. Know that I will always stand behind you as you continue in your amazing work.

To David Reeping: thank you for being my writing partner and dear friend through this journey. Journeying with you is an honor.

To the students in the Center for the Enhancement of Engineering Diversity: you have been my home and anchor during this process. Thank you.

To Dr. Theresa Mkandawire, Faith Mzandu, Dumisani Kaliati, and my brothers and sisters in Malawi: thank you for your leadership. I stand behind you, grateful for the journey we've shared and hopeful for whatever is to come.

To the GUIDE Research Group, Teirra, Janice, Karis, Cynthia, Adam, Taylor, Crystal, Raeven, and Yasmine: thank you for being more than colleagues through this process. I celebrate with each of you on your journeys.

To my sisters and brothers by choice: Carley, Corin, Danielle, Andrew, and Michael: your strength encourages my soul. I write this remembering distinct moments when you pulled me up and kept me going. Thanks for walking with me through this. We will walk together always.

To Appalachia, the people and place that built me: my deepest gratitude. I draw strength from your mountains. May you ever endure and thrive.

And above all, to the One who made a way when there was no way: this journey has never been about me. To Him be the Glory.

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Foreword: About the Title

“I’ll tell you what the change was...*the change* came from just being fed up...” These words were shared by Rita in her narrative interview for this study. Rita was fed up with her high school teacher who “straight up made me feel like I was stupid,” systematically patronizing students of color in her classes. She was fed up with not seeing “people who look like me” in engineering and instead having to navigate micro-aggressions from her “so privileged peers” who “don’t realize how their behaviors and actions affect the people around them.” Rita got fed up, she said, and the change came.

The change.

Rita spoke of changing her GPA, changing her networking strategies, changing her perspectives to develop self-confidence. But Rita’s quote seems, to me, to encompass so much more in the context of this larger study. Rita spoke of the change—moments of agency amidst barriers, re-humanizing micro- and macro-level barriers that low income students encounter in the pursuit of a bachelor’s degree in engineering.

The change.

Rita’s words also summarize my personal transformation through this dissertation process. When I set out to understand the journeys of low income students, I had a firm grasp of the literature and what I thought was a firm grasp of the barriers students face in the pursuit of higher education. However, the truth is nothing could have prepared me for the intense empathy that has connected me to my research participants and that has *demand*ed that I lean in and give space to truly *hear* students’ stories.

The change.

Most importantly, Rita’s words summarize the need for structural change in engineering education, particularly as we wrestle with questions concerning equity and access. In engineering, the structural change has not come, as at the time of this writing students from households earning less than \$40,000 represent only 3.5% of engineering students (Major et. al, 2018).

The change.

In one of my final dissertation review meetings with my advisor, I presented some student quotes for tentative titles. He circled “The Change Came” and asked me if I knew the lyrics to the song “A Change is Gonna Come” by Sam Cooke. I’d heard the song before, knowing the classic melody by heart. However, in my white privilege I had never before examined the history of the song, which served as an anthem of hope and revolution during the United States Civil Rights Movement. In this moment, even nearing the end of my dissertation journey, I realized I was again changing. This song resonated with my work, as well, with its focus on structural change, beyond the level of individuals. Though my work considers the individual experiences of underserved engineering students, the heartbeat of this work is rooted in structural change.

The change.

I write, then, with the spirit of the anthem of change shared by participants' narratives, the anthem of change reflected in my own life through this process, and a call for structural change in engineering education.

*I was born by the river in a little tent
Oh and just like the river I've been running ev'r since
It's been a long time, a long time coming
But I know a change gonna come, oh yes it will*

*It's been too hard living, but I'm afraid to die
'Cause I don't know what's up there, beyond the sky
It's been a long, a long time coming
But I know a change gonna come, oh yes it will*

*I go to the movie and I go downtown
Somebody keep tellin' me don't hang around
It's been a long, a long time coming
But I know a change gonna come, oh yes it will*

*Then I go to my brother
And I say brother help me please
But he winds up knockin' me
Back down on my knees, oh*

*There have been times that I thought I couldn't last for long
But now I think I'm able to carry on
It's been a long, a long time coming
But I know a change is gonna come, oh yes it will*

.

-A Change in Gonna Come

Sam Cooke

.

Chapter 1

“If the ladder of educational opportunity rises high at the doors of some youth and scarcely rises at the doors of others, while at the same time formal education is made a prerequisite to occupational and social advance, then education may become the means, not of eliminating race and class distinctions, but of deepening and solidifying them.”

-Foreword, Truman’s 1947 Commission on Higher Education, 1947

1.1 Motivation: The Engineering Profession as Transformational

Though originally perceived as a blue-collar profession (Florman, 1996), engineering is contemporarily viewed as one of the most admired and respected professions in the United States (Cunningham, 2014). The “Golden Age for Engineering” began sometime between 1850 and 1950 (Florman, 1996), birthing a distinct rhetoric positioning engineers as positive transformers of society (Constable & Somerville, 2003; Florman, 1996). Throughout the last century, this winding yet consistent narrative has put forth grand claims about the transformative power of the profession, declaring engineering as mankind’s “redeemer from despairing drudgery and burdensome labor” (Hermany, 1904, p. 464) and, most recently and prevalently, the world’s “problem solver” (Jonassen, 2014). As one engineering professor summarized, “engineers can be proud to say that ours is a profession with a great history of transforming lives” (Hancock, 2017; *Institution of Civil Engineers (ICE) opens its Malaysian chapter in Bangsar*, 2018). The perception that the engineering profession transforms society is thoroughly chronicled (see Constable & Somerville, 2003), with the ideas of engineering as transformative embedded deep within the culture of engineering departments across the United States.

In the U.S. context, there is a particularly prevalent dialogue about the transformative power of an engineering degree for low income students. What we refer to as *broadening participation in engineering* efforts often directs recruitment toward low income students, pointing to engineering degrees as a certain way to secure a lucrative career. Long positioned as a mechanism for moving up the social ladder, the engineering profession is often discussed as a mechanism for *upward mobility*—a discipline “that [offers] the best opportunities for economic independence and social mobility” (Catsambis, 2002, p. 349). Some have gone as far as to argue that “engineering ... [is] a key to socioeconomic mobility” (Morrow, 1994, p. 16). Put simply,

engineering degrees are pitched to low income students as an opportunity to “climb” (Valerie C. Lundy-Wagner, 2013; Riley, 2008).

1.1.1 Transformational for Whom?

Given the widely held public beliefs that engineering is a promoter of upward mobility for low income students, most would suppose “engineering should be an equal opportunity profession” (Hersh, 2015, p. 5). However, the global history of engineering is, sadly, rather exclusionary, with well-chronicled marginalization of not only low income students, but also racial and ethnic minorities and white women (G. Lichtenstein et al., 2014; Mambo et al., 2016). A critical examination of *who* enrolls and persists in engineering degree programs raises troubling questions about equity and access. Data suggests not everyone can equitably leverage the transformative power of an engineering degree, with students from low income backgrounds remaining underrepresented in engineering while middle class students account for the largest proportion of engineering majors (Xianglei Chen, 2009; McIlwee & Robinson, 1992). Some scholars posit that engineering education is systematically excluding students from low income backgrounds (Strutz, Orr, & Ohland, 2012).

1.1.2 Calls for Expanded Access in Engineering

Recognizing the persistent equity gaps in engineering degree attainment for low income students, scholars and policy-makers alike have put forth a number of strategies to increase access. Broadly, these strategies include calls to reduce financial barriers, reduce non-financial barriers (e.g., aspirations, academic preparation), and support students after they arrive “at the door” of higher education (Chien et al., 2017). In the United States, the arguments to increase access are often rationalized by two distinct arguments, which I will refer to as the *diversity* and *social justice* arguments. In engineering, calls for change underpinned by the diversity argument suggest that increasing access for low income students will lead to increased diversity in engineering. Such arguments acknowledge and celebrate low income students as important contributors to engineering diversity (Baillie et al., 2012; Xianglei Chen, 2009; Valerie C. Lundy-Wagner, 2013; Valerie C. Lundy-Wagner et al., 2013; Smith & Lucena, 2016a; M. Strutz et al., 2012). The main premise of the diversity argument is to include low income students in our definition of a “diverse” engineering profession (M. Strutz et al., 2012). Proponents of the diversity argument contend that low income students bring a unique and important perspective to

engineering education (Xianglei Chen, 2009; Smith & Lucena, 2016a), and thus increasing access for underserved students (i.e., increasing workforce diversity) enhances the “likelihood of developing the best ideas” (Geller, 2003, p. C8).

The second branch of calls for change leans more heavily on principles of social justice, arguing that the “issue for people who have been historically excluded from various professions is about having options to live life more fully on their terms” (Case, 2017). These calls for change sometimes take issue with arguments that hinge on diversity, arguing that reducing people to a kernel of their identity (even if well-intentioned towards diversification of the engineering profession) is fundamentally problematic (Case, 2017). Instead, calls for change underpinned by principles of social justice rebuke “playing the diversity card” (Strutz et al., 2012, p. 152), advocating instead for ensuring underserved students can fully access and succeed in the engineering profession as a means to transform *their own lives*, not just the engineering profession (Case, 2017; M. Strutz et al., 2012). Proponents of workforce diversity and social justice alike often take up the banner of increasing access to engineering education; however, much work in both research and practice remains.

1.1.3 Expanding Our Knowledge of Underserved Engineering Students’ Journeys

Despite ongoing contemporary conversations about underserved students in the engineering profession, underserved students’ educational journeys in engineering are critically underexplored (M. Strutz et al., 2012). As I will expand upon in Chapter 2, most research on low income students in engineering focuses on the “deficit” narrative (Smith & Lucena, 2016a), focusing on the barriers that low income students face in pursuit of an engineering degree. As a research community, we know little about how low income students use agency to navigate educational journeys. From a sociological perspective, zooming out from the deficit (barrier-centered) narrative is imperative to understand both structures *and* agency in the educational journeys of underserved students. Recognizing this gap in literature, my work aims to examine the interplay between structures and agency in the educational journeys of underserved engineering students. In this chapter, I begin by outlining the purpose of my study and my research questions. Next, I introduce the terminology of *underserved students* that will be used throughout my dissertation. I then discuss the contemporary relevance of this study, highlighting not only why this study is important but why it is important *now* in the context of mounting inequities in the United States. I then discuss sociological framings of educational journeys,

delineating what we know about education broadly and what makes engineering unique. Lastly, I introduce the theoretical framework for my study and my overarching research strategy. I conclude this chapter with a discussion on the significance of this work in the broader engineering education community.

1.2 Purpose and Research Questions

The purpose of this study is to explore how students from underserved backgrounds navigate their educational trajectories, focusing on the interplay between structures and agency. Accordingly, the overarching research question guiding this study is:

In their narratives, how do students from underserved backgrounds describe navigating their educational trajectories towards a bachelor's engineering degree?

The sub-questions guiding this inquiry are:

- RQ1: What strategies do underserved students use in pursuit of an engineering degree?
- RQ2: How do social environments (e.g., community, family, economic, political) shape the educational trajectories of underserved engineering students?
- RQ3: What critical incidents do underserved engineering students perceive to alter their educational trajectories?
- RQ4: What agency do underserved engineering students believe a bachelor's engineering degree will provide?

This research is exploratory in nature as it aims to interrogate the interplay between structure and agency in the educational journeys of underserved engineering students. Through student narratives, this research aims to understand the barriers that engineering students encounter and the various agentic strategies that students use to negotiate barriers. Through a richer understanding of student experiences—including barriers and strategies to overcome barriers—this research aims to contribute to efforts aiming to increase access to engineering for future engineering students from underserved backgrounds.

1.3 Introduction to Terminology

Throughout my dissertation, I will use the term *underserved students* to refer to students who are A) from a low income background and/or B) the first in their immediate family to attend college (i.e., first generation). In Chapter 3, I discuss the inclusion criteria for my study. Notably, I use a broader definition of underserved to intentionally problematize the way economic disadvantage is viewed in higher education. In university settings, we tend to operationalize

underserved status in two ways: parental educational attainment and Pell-Grant eligibility. However, such proxies for economic disadvantage are ridden with measurement error (Delisle, 2017; Neckerman et al., 2016). For example, when we operationalize economic disadvantage through Pell Grant eligibility, we exclude students who are at the margins of the “cut-off” for Pell-Grant eligibility. Similarly, parental educational attainment may speak to a family’s familiarity with higher education contexts, but it does not inherently speak to a student’s lived experiences with economic disadvantage.

Still, it is worth noting that literature often discusses first generation college (FG) student status and low income background together, though these factors do not always intersect. In reality, these two demographics are identifiers of two different types of disadvantage: academic and economic. One clear justification for this approach to operationalizing underserved status is that both low income backgrounds and FG status significantly impact access to higher education (Chetty et al., 2014; Terenzini et al., 1996a; Thayer, 2000). Furthermore, studies strongly suggest that low income backgrounds and FG status are often—though not always—interrelated; as a result, FG status is sometimes used as a proxy for low income (M. Strutz et al., 2012). Several longitudinal studies have reported that FG students are more likely to be from lower income communities/households than non-FG students (Nunez & Cuccaro-Alamin, 1998; Pascarella et al., 2004; Terenzini & And Others, 1996). For instance, a 1996 study found that only 5% of persons from families in the bottom income quartile complete a baccalaureate degree, compared to 74% of persons from families in the top income quartile (Mortenson, 1998). This example, however, confirms the issues raised about how we operationalize economic disadvantage, as evidence shows that students in the bottom income quartile (i.e., low income) are not always first generation.

Therefore, I use the term *underserved students* in a liberal way, including students who are first generation, Pell-eligible, or who self-identify as experiencing material hardship (e.g., housing or food insecurity). My intention with this broad definition is to critically examine our measurement of economic disadvantage while exploring students’ lived experiences. Put simply, my conceptualization of underserved students avoids missing students “at the margin” of the measurement boundaries we have perhaps arbitrarily or bureaucratically drawn.

1.4 Contemporary Relevance of This Study

My exploration of underserved engineering students must be embedded within the contemporary conversation on broader inequity in the United States. As Goldrick-Rab (2016, p. 11) succinctly states, “a public debate is raging” on these topics; therefore, my study is timely. In the following sections, I briefly situate my study of the educational journeys of underserved students within two related contemporary conversations: 1) troubling trends in economic inequality in the United States, and 2) mounting inequities in U.S. education.

1.4.1 Troubling Trends in Wealth Income Inequality in the United States

To get right to the point, poverty is on the rise in the United States. A 2017 investigation by the United Nations found that more than one in eight Americans—over 40 million people—are living in poverty (Alston, 2017). Over half of these Americans live in deep poverty (Alston, 2017), and 1.5 million U.S. households live on less than \$2 per person per day (Edin & Shaefer, 2015). The latter measure reflects *extreme poverty*, a characterization that indicates severe deprivation in a combination of income poverty, human development poverty, and social exclusion (Sengupta, 2010). Nearly 15 million children in the United States live below the federal poverty line. These children represent over 22% of all children living in the United States (O’Brien & Pedulla, 2010; Porter, 2013). The percentage of students eligible for free and reduced lunch rose to 58% in 2018, up from 31% in 1989 (Calahan and Perna, 2019). The growing number of low income students extends from K-12 education to higher education, with 42% of students eligible for Federal Grants in 2019. Perhaps most alarmingly, researchers believe our current data grossly underestimates the number of children and college students experiencing significant material hardship (O’Brien & Pedulla, 2010; Porter, 2013).

Comparative analyses of other developed nations reveal alarming inequality trends that in many ways are unique to the U.S. context. Compared to trends from other developed countries, inequality is alarmingly high and intergenerational mobility in the United States is strikingly low (Jacobs & Hipple, 2018; Jäntti et al., 2006). For example, a recent study found that children born in 1940 had a 90% chance of earning more than their parents whereas children born in 1984, however, have only a 54% chance they will earn more than their families (Chetty, 2019). These trends hold steady over time, with analyses showing that mobility has declined for every birth cohort since 1940 (Chetty et al., 2017). In addition, wealth concentration in the U.S. is at its

highest since the 1920s, with the top 1% holding 40% of all of the nation's wealth. In contrast, the bottom 90% hold only 21% of the nation's wealth (Calahan et al., 2019). The Gini Index—an international measure of income inequality—is rising in the United States, with a higher Gini Index indicating higher income inequality. At the time of this writing, the United States has the highest Gini Index of any Western nation (Alston, 2017). Combined, these data tell the story of a shifting landscape in the United States, where the land of plenty is not equitably plentiful for everyone.

1.4.2 Global Contextualization of Disadvantage

While my research is focused in the United States, it is appropriate to briefly clarify the *disadvantage* I refer to throughout this research in the context of global disadvantage. The fundamental issue here is the inherent complexity of measuring poverty, a topic which is the subject of much debate in both the United States (Blank, 2008) and across national boundaries. The debate is warranted because current measurements of poverty are widely recognized as flawed (Cauthen & Fass, 2008) and ripe for reconceptualization (Blank, 2008).

In this ongoing debate about how to best measure poverty, it is particularly imperative to directly address the notion that disadvantage in America is *relative*—or, in other words, “America’s poor” cannot be compared to the “world’s poor” (Shaefer et al., 2016). Even within the U.S., Americans are divided regarding their beliefs about the lived experiences of disadvantage, with persons from high income backgrounds in the U.S. believing “poor people today have it easy because they can get government benefits without doing anything in return” (Krogstad & Parker, 2014). Perceptions from within and outside national boundaries often assert that disadvantage in America is *relative* compared with the world.

First and foremost, I emphasize that comparing disadvantage across contexts should be handled with discretion. Disadvantage and notions of poverty are not merely technical measures of income, but rather carry social and political ideas that are always context-specific. While it is beyond the scope of this dissertation to fully address the assertion that disadvantage in the U.S. is relative on the global scale, I will highlight here recent work that suggests poor individuals in America experience wellbeing levels similar to people living in the world's poorest nations (Shaefer et. al, 2016). Using measures of wellbeing that include life expectancy, infant mortality, homicide rates, and incarceration rates, Shaefer et. al (2016) conclude that low income

Americans have higher homicide rates than Rwanda. Additionally, their comparative analysis finds that African American low income infants have a mortality rate similar to Grenada, a country whose GDP is only a fraction (0.0062%, to be exact) of the United States' GDP. These recent comparative analyses suggest that low income individuals in America are not, in fact, well off by international standards (Shaefer et. al, 2016). In any case, we should proceed with extreme caution when comparing poverty across national contexts, because poverty is not merely a technical issue of income—rather, poverty is always embedded within social and political contexts (Niemietz, 2010).

To conclude this brief global contextualization, I note three philosophical underpinnings of my research on disadvantage in U.S. educational contexts. First, it is unquestionably beyond the scope of this work to rank or tabulate disadvantage within the United States and across other nations. I do not focus on measuring disadvantage directly; rather I explore students' lived experiences with disadvantage and the role of disadvantage in educational trajectories. As I explain in section 1.3, I use an exploratory conceptualization of economic disadvantage in this study, defining disadvantage as students who are Pell-eligible, first generation, and/or experiencing material hardship. By using this exploratory definition of disadvantage, I conceptualize poverty as a social construct and not merely as a technical measure of income.

Second, in alignment with current literature (e.g., [Niemietz, 2010](#)), I assert that disadvantage (i.e., poverty) is context specific but not relative. There is undoubtedly a geographic element to poverty, whereby poverty looks different in different contexts. This is evidenced in the complex and nuanced recounts of poverty in the student narratives shared in this study. For example, as shared in their narratives, students from rural locations experienced disadvantage differently than students in urban settings. Similarly, domestic students shared different experiences with disadvantage than first generation immigrants. Recognizing the context-specific nature of poverty, different for each student represented in this study, I implore readers to abandon their prior conceptualizations of poverty in the United States at the national level. Ideas that poverty in America is “relative” on the global scale remain unsupported by literature and by the lived experiences of students in this study. Such ideas effectively render invisible the lived experiences of students in this study.

Third, my case study research is bounded at engineering degree programs at an institution of higher education in the United States. Therefore, I somberly acknowledge that my case boundary excludes many students experiencing disadvantage who did not make it to the door of the university in my research context. Though in earnestness I have attempted to avoid leaving students at the margins of our conceptualizations of disadvantage, the very nature of the case study boundary causes some students to be systematically missing from this research. I acknowledge the relative privilege of students who attend institutions of higher education in the United States, and I soberly recognize the voices that remain missing in this study on disadvantage in educational systems.

I will now turn to a brief overview of the United States' higher education landscape for higher education for underserved students.

1.4.3 Growing Inequities for Underserved Students in Higher Education

In recent years, U.S. policy makers have pointed to increasing access to higher education as “the single most important means of improving mobility and leveling social and economic differences” (Haveman & Smeeding, 2006, p. 126). In fact, expanded access to higher education is a tremendous national achievement of the 21st century, driven by demands at the societal and individual levels (Chien et al., 2017). In the U.S., 31% of adults held a bachelor's degree in 2016, up from 29% in 2015 (Calahan et al., 2019). In some palpable ways, the U.S. has opened the door wider to higher education.

However, opening higher education's door wider does not diminish inequities (Reisburg & Watson, 2010). Rosy numbers of expanded access to higher education hide mounting concerns of equity, as the two do not always grow in parallel. Indeed, a closer examination suggests that inequities are rising in higher education in the United States, particularly for underserved students. Much public attention currently focuses on the rising costs of higher education in the United States, which remains a significant barrier for underserved students. Averaged across all institutions, the cost of higher education doubled between 1990 and 2013 (Chien et al., 2017). With the exception of students from the top income quartile, students have greater unmet financial need in higher education than ever before (Chien et al., 2017). Pell Grants, designed in their inception to alleviate financial burden for underserved students, cover less of college costs with current skyrocketed tuition prices. In 1976, Pell Grants covered, on average, 67% of costs at

four year institutions (Calahan et al., 2019; Goldrick-Rab, 2016). Flash forward to 2017, however, and the maximum awarded Pell Grant now covers only 25% of college costs (Calahan et al., 2019). In 1990, the net price of college was 45% of family income for students in the lowest income quartile. Nearly three decades later, net college costs, on average, constitute 94% of family income for families in the lowest income quartile (Calahan et al., 2019). This striking difference reflects more tuition cost shifting to families due to roll backs in state funding for higher education and increasing tuition prices, among other factors (Goldrick-Rab, 2016). Ultimately, equity gaps persist in access and persistence in higher education. Regarding access, a 37% gap in participation exists between the top income quartile and bottom income quartile (Cahalan & Perna, 2015). In addition, the data are clear that inequities persist even once underserved students reach the door of higher education. Students who are underserved in multiple ways (i.e., low income and first generation) have a 21% chance of completing their bachelor's degree in six years, compared to 57% for non-underserved peers (Calahan et al., 2019).

1.5 Underserved Students in Engineering

Most of our knowledge about underserved students' experiences is in the broader higher education literature, with a dearth of work focused specifically on engineering education. Because my research questions focus specifically on the engineering context, I will turn to the scholarship—albeit limited—that has examined underserved student experiences in engineering. Most of our knowledge in the U.S. about underserved students has focused on understanding student barriers to persistence in undergraduate engineering programs. We recognize that diminishing inequities in higher education is not the same as “opening the door wider” (Reisburg & Watson, 2010, p. 7) because even after barriers to access are reduced, barriers to persisting may still exist. At an overarching level, studies show that underserved status is negatively related to overall satisfaction with undergraduate engineering programs, confidence in technical skills, and involvement in extracurricular activities (Donaldson et al., 2008a). Across disciplines, including engineering education, underserved students perceive college faculty to be less interested in their development than their non-underserved peers (Terenzini et al., 1996a). Perhaps most importantly, underserved students may face psychological barriers adapting to the culture of higher education (Jury et al., 2017), which has strong roots in high socioeconomic

status (SES) cultural norms that are “taken for granted... rules of the game” (Stephens, Fryberg, Markus, Johnson, & Covarrubias, 2012, p. 1178). With the exception of a few notable studies, underserved students’ experiences in engineering are critically underexplored. In particular, work exploring the interplay between students’ agency and the barriers they face is nearly nonexistent. This work aims to fill that gap.

1.6 Bourdieusian Lens for This Study

To explore my research questions, I leverage a Bourdieusian (1977, 1986) lens to frame the relationship between structure and agency in the educational journeys of underserved engineering students. Although perhaps oversimplified, to briefly introduce Bourdieu’s broader framework, Figure 1 visually summarizes Bourdieu’s concepts of *agents*, *fields*, and *habitus* as they relate to *capital*. The visualization is inspired by lectures on Bourdieu’s work (e.g., Cheryl Reynolds, 2013; Simon, 2010) and has been modified to more closely relate to the focus of my study.

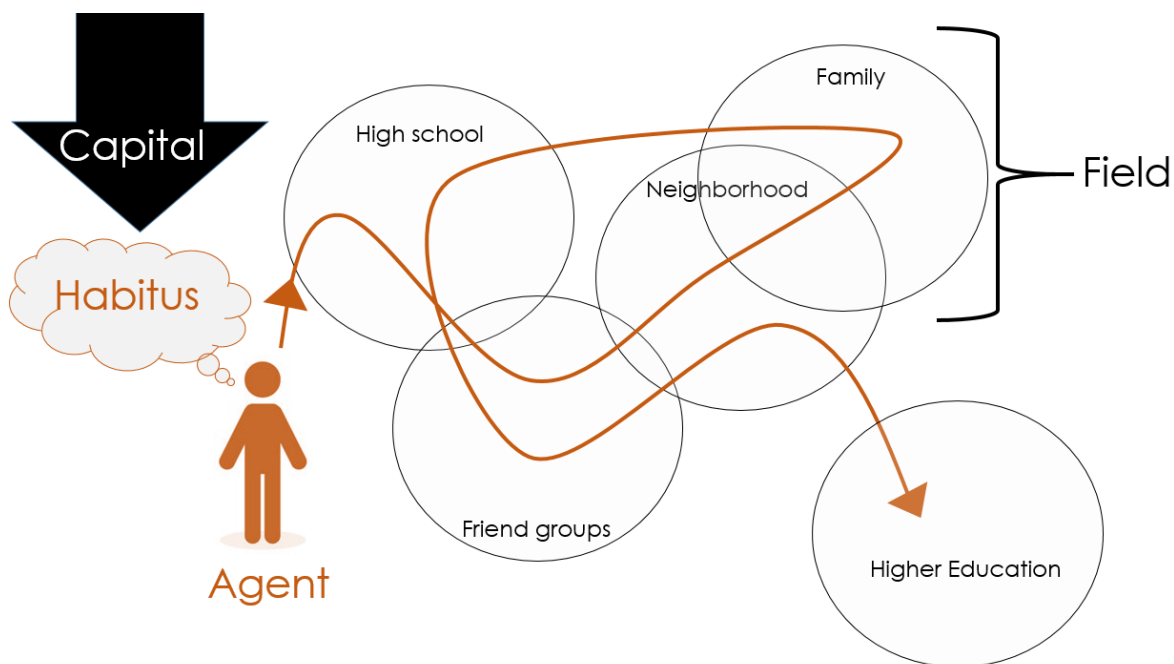


Figure 1. An overview of Bourdieu's conceptualizations of fields, habitus, and capital.

Bourdieu conceptualized the social world as consisting of *fields*, or social circles of sort. As shown in Figure 1, fields such as a high school environment, friend groups, neighborhoods,

and families can overlap but are largely autonomous (Davey, 2009; Reynolds, 2013; Routledge, 2016). Agents, or individuals, enter into various fields carrying their *habitus*, or their collection of identity, choices, and actions shaped by their experiences (Davey, 2009; Reynolds, 2013). *Capital* feeds into the habitus; in fact, Bourdieu refers to habitus as the embodiment of cultural capital, or a “feel for the game”, where the game might refer to navigating a particular field or social circle (Routledge, 2016). In addition, the currency of *capital* varies within each *field*; in other words, *capital* that carries high value in one *field* may not hold the same value in another *field*.

I use a Bourdieusian lens augmented with Yosso’s (2005) Community Cultural Wealth to conceptualize the broader sociological framing of the relationship between structure (i.e., societal forces, barriers) and agency. Using Bourdieu’s framework, I conceptualize the relationship between structure and agency to be mediated by habitus, or the embodiment of an individual’s capital. The concept of habitus suggests that the structures of the social world—such as access to financial resources—impact human behavior; however, as a transformative mechanism, habitus suggests that human behavior also impacts the social world. Peters (2014) summarizes the idea using the Latin phrase *summa summarum*—“sum of sums”—meaning agents have agency and shape society, and society reproduces structures to shape agents in a continuous, circular process.

Applied to my study, the Bourdieusian framework suggests that the agency of underserved engineering students is shaped by the structures of the social world, such as their national context, political context, and the context of higher education. Reciprocally, the Bourdieusian framework also asserts that structures (e.g., structures of higher education) may be transformed by the agency of underserved engineering students. Ultimately, using the Bourdieusian framework in this light suggests that agency of underserved engineering students—even if limited by structures—are mechanisms for social change (Murphy & Costa, 2016). I therefore use a Bourdieusian lens to examine how underserved students navigate engineering degree programs of higher education.

1.7 Overview of Research Design

Educational journeys of underserved students are heavily influenced context and demand consideration of both societal barriers and individual agency. Therefore, to explore my research questions, I use a single instrumental case study design (Yin, 2009) with embedded units of

analysis. My case study uses a Bourdieusian theoretical lens to critically examine the interplay between structure and agency in underserved students' educational journeys. As summarized below in Figure 2, my research design bounds the case as the engineering bachelor's program at a large public research institution in the Southeastern United States. This case is situated within broader contexts, including the broader institutional, political, and economic contexts. I discuss each of these in Chapter 3 to enable transferability of my results by richly describing the case context (Borrego et al., 2009; Golafshani, 2003). My embedded single case study design permits two sub-units of analysis: 1) individual engineering students and 2) narrative storyline elements, which I operationalize as critical incidents in each student's narrative. Examination of the data at each level is imperative to capture the diverse experiences of individual underserved students, who are not a monolithic group and whose experiences are not homogenous.

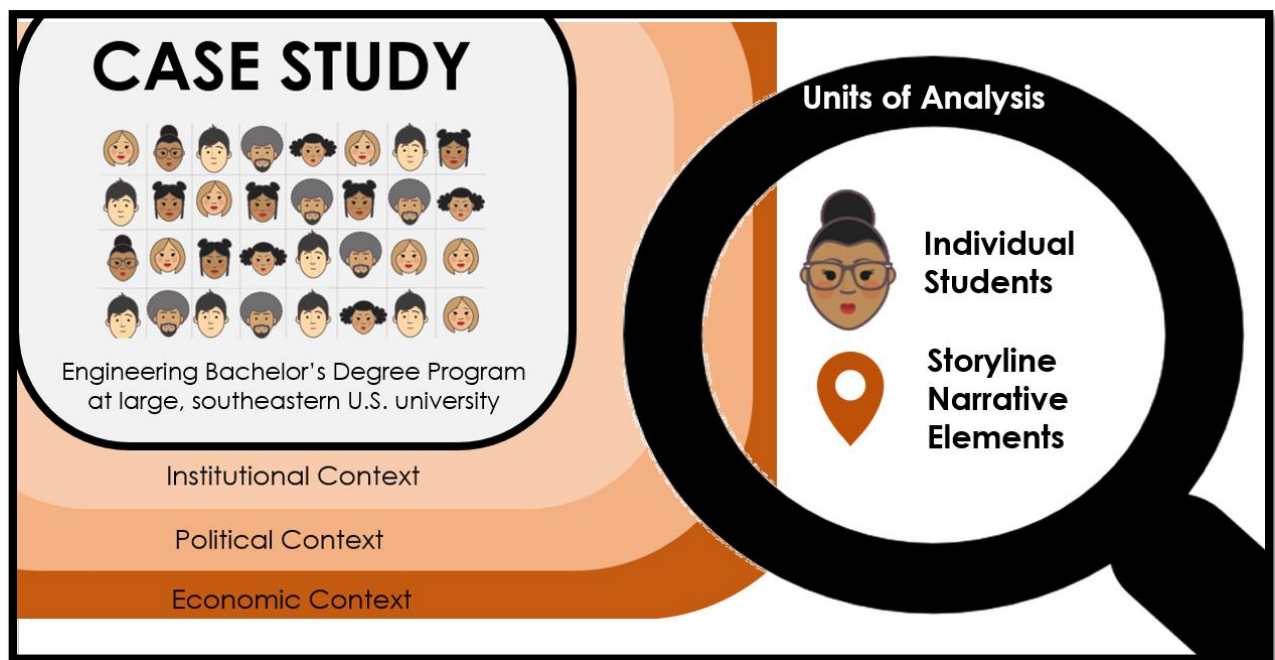


Figure 2. Summary of single case study design with embedded units of analysis

For each individual student, data collection leveraged mixed methods and occurred in four phases as shown in Table 1. During Phase 1, screening surveys were used to recruit and select interview participants. During Phase 2 of data collection, narrative interviews were conducted with 32 engineering students from underserved backgrounds. Importantly, these students represent a variety of academic, geographic, and demographic backgrounds. At the

conclusion of each interview, students completed an exit survey aimed at understanding lived experiences with material hardship, including questions about access to healthcare, food insecurity, and housing issues. During Phase 3, I integrated community-level data with each student’s narrative profile to provide a complimentary view of each student’s community context.

Table 1. Summary of Data Collection

Phase	Data Source	Description
1	Screening surveys <i>(Mixed Methods)</i>	In addition to serving as a source of data, surveys were used to recruit and select interview participants
2	Interviews <i>(Qualitative)</i>	Conducted narrative interviews with 32 engineering students from underserved backgrounds to understand how students negotiate barriers and navigate the pursuit of an engineering bachelor’s degree
	Exit Survey <i>(Qualitative)</i>	Students completed a voluntary exit survey with information about lived experiences with material hardship, including housing insecurity, food insecurity, access to healthcare, etc.
3	Integrating Community-Level Data for Each Student	Created a database of geospatial data for each student, examining poverty rates and college graduation rates for each student’s self-identified home zip code.

1.8 Outcomes of Study

The outcomes of this study enlighten our understanding of the interplay between structures and agency in underserved engineering students’ educational journeys. To elaborate on the outcomes defined in Table 2, this single case study design with embedded units of analysis study weighs equally the analysis of each student’s experiences (embedded units of analysis) with an analysis that looks for themes across students (within-case analysis).

Table 2. Outcomes of Study

Unit of Analysis	Outcome
Individual Student	Narrative Portraits with Emphasis on Storyline Elements
Case	Thematic Narratives
	Joint Displays (Mixed Methods)
	Case Report for Institutional Partner

Because this case is contextually influenced, the end product of this research includes a rich description of the case, provided in Chapter 3. Through the embedded case study design, rich descriptions of each level of context is included in Chapter 3, thereby enabling researchers to make connections to their own research contexts (Borrego et al., 2009). In addition to the outcomes provided in Table 2, I will work with institutional partners to determine how research can be best disseminated to contribute to institutional goals and priorities and support underserved students.

1.9 Significance of Study

This research contributes to the engineering education research literature in several ways. First, my study is focused on the educational journeys of underserved students, populations that remain critically underexplored in engineering education research. While few studies have examined underserved students' experiences in engineering, most focus on the barriers that students face along their educational journeys. My study explores the *agency* of underserved engineering students, who—against all odds—have navigated to an engineering degree program. A deeper understanding of the agentic beliefs and perspectives that underserved students enact has important implications for practice. For instance, insights into student agency may support pre-college access initiatives and undergraduate student support programs as they strive to serve this population of students.

This research also contributes to Bourdieusian literature by: 1) exploring the experiences of underserved engineering students, 2) employing all three of Bourdieu's central thinking tools (i.e., *agent*, *field*, *capital*, and *habitus*), and 3) examining the capital of underserved students (i.e., a *non-dominant group*). By using all of Bourdieu's central thinking tools (i.e., *agent*, *field*, *capital*, and *habitus*), this study employs Bourdieu's lens in the context of engineering education

research and illuminates the interplay between structure and agency in the educational journeys of underserved students. My study also builds on our knowledge of underserved students, a non-dominant group. Most applications of Bourdieu's theoretical framework emphasize dominant-group capital, which can lead to a deficiency approach blaming underserved students for lacking capital that is valued in a particular setting. From a practice perspective, the deficiency approach can result in interventions designed to help non-dominant groups acquire capital of dominant groups, potentially reinforcing and legitimizing social reproduction. Augmenting Bourdieu's framework, I use Community Cultural Wealth (Yosso, 2005) to explore the capital of underserved students. Doing so acknowledges and explores the unique capital and agency of underserved students and moves the rhetoric away from the deficiency approach.

1.10 Summary

A gap in literature exists concerning the educational journeys of underserved students in engineering. Though access to higher education has increased in the United States, opportunities remain limited for underserved students amidst growing concerns about increasing poverty and inequity, including in higher education, nationwide. Systemic barriers often impede the journeys of underserved students. At the same time, students leverage agency to pursue and persist in engineering despite a journey laden with barriers. It is these journeys and—more specifically, the interplay between structures and agency in these journeys—that I aim to understand.

Towards this purpose, I use a single case study design with embedded units of analysis to explore the educational journeys of underserved engineering students. Through a deep contextual exploration using a Bourdieusian lens, I integrate narrative interviews with community-level data to explore the interplay between structures and agency in students' educational journeys. This work contributes to a deeper understanding of the barriers underserved students face and the agency they enact, which may enlighten future programs to support underserved engineering students.

Chapter 2: Educational Journeys of Underserved Students

2.1 Introduction

In Chapter 1, I put forth my overarching research question for this study: *In their narratives, how do students from underserved backgrounds describe navigating their educational trajectories towards a bachelor's engineering degree?* In order to explore this research question, I will first review literature on the educational journeys of underserved students. In this chapter, I first “zoom in” on the educational journeys of underserved students, focusing on critical segments along the journey. I will then introduce the Bourdieusian lens for this study, discussing my theoretical framing of students’ educational journeys.

My review of literature largely draws from higher education, as more work on underserved students is available in the broader higher education literature than in engineering education. However, where possible, I will discuss how these junctures contribute to inequities directly observed in engineering education, providing insights from engineering education literature. I will connect underserved students’ pre-college context, undergraduate experience, and career decision-making to engineering education. I will then discuss the college search process and summer melt phenomena in the broad context of higher education.

A final caveat on my discussion of underserved students’ journeys is that barriers at each juncture are largely entangled. By discussing the junctures over time, my intention is not to oversimplify these barriers or imply that these barriers are linear in nature. Rather, my intent in discussing these segments is to offer a framework for examining interwoven barriers that contribute to accumulated disadvantage along underserved students’ educational journeys.

2.2 Educational Journeys of Underserved Students

Underserved students traverse difficult journeys to a bachelor’s degree. In the following sections, I will outline five junctures along the engineering educational journeys of underserved students, as shown in Figure 3: 1) Educational Foundations (Pre-College); 2) The Search: College Application, Choice, and Enrollment; 3) Summer Melt: The Last Mile; 4) Transforming: The Bachelor’s Degree; and 5) The Decision. In each section, I will use literature to enlighten barriers that students face at each juncture, followed by a brief discussion of practice-based efforts that have targeted this juncture for underserved students.

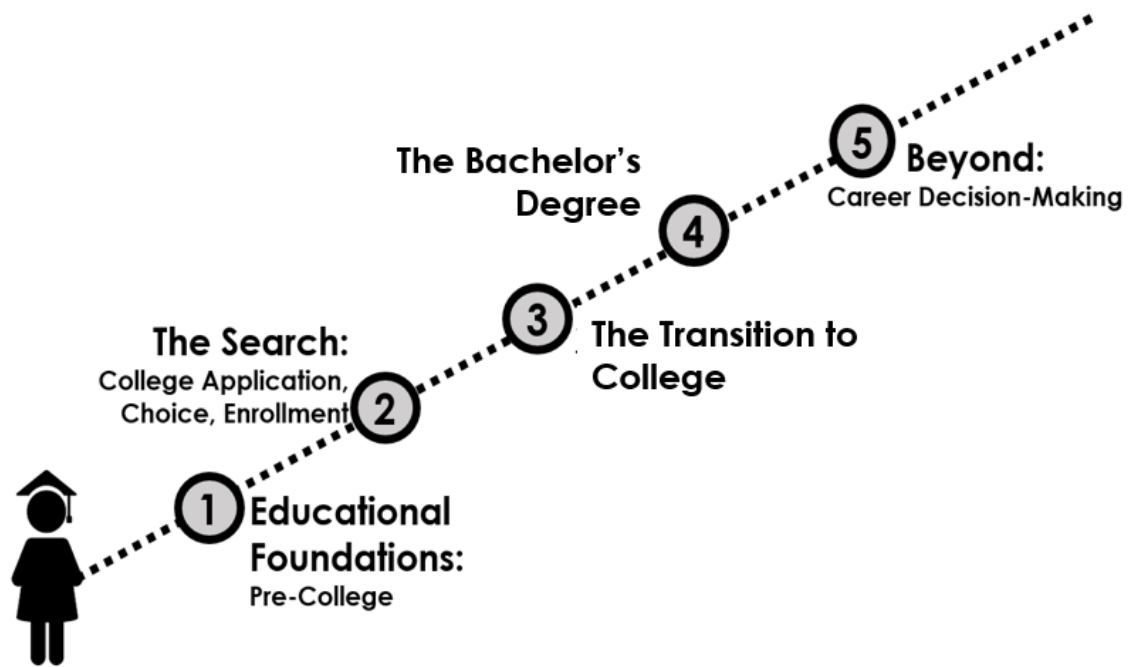


Figure 3. Critical segments during the educational journeys of underserved students

2.2.1 Educational Foundations: Pre-College (K-12)

An expansive body of scholarly work suggests that pre-college educational foundations vary widely within the United States, resulting in inequitable school outcomes and systematic disadvantage for underserved students' journeys to bachelor's degrees (Yun & Moreno, 2006). A host of factors contribute to inequitable educational foundations, including school segregation by socioeconomic status (Orfield & Yun, 1999) and level of academic preparation, the latter of which depends heavily on the available number of qualified teachers (Darling-Hammond, 2000). Below, I will discuss several factors that impact educational foundations for underserved students, including school segregation by class and race, academic preparation, support from significant others, and peer college aspirations.

School segregation by class and race. Underserved students are often embedded in areas of concentrated poverty, both at the school and neighborhood/regional levels. In the United

States, segregation in schools is increasing by both class and race, particularly in the American South (Orfield & Yun, 1999). In 2017, it was estimated that 40% of low-income students (approximately 10 million students) attend schools where the rate of students below the poverty line is above 75% (Jordan, 2015). Segregation in schools, particularly in areas of concentrated poverty, influences what courses are available to students, the number of credentialed teachers, and dropout rates (Orfield & Yun, 1999). Furthermore, students enrolled in high schools with concentrated poverty are often living in impoverished neighborhoods. Compounding school-level influences, data suggests growing up in an impoverished neighborhood negatively impacts students' psychological, physical, and cognitive health (Orfield & Yun, 1999; Owens, 2017).

It is important to note here that socioeconomic segregation in schools often coincides with racial segregation (Boser & Baffour, 2017). In California, a study found that a majority of African American and Latinx students attend schools where most students are non-white, while 63% of white students attend majority-white schools (Oakes et al., 2004). The study concluded that “the worst school conditions and fewest educational opportunities converge in the State’s racially isolated schools” (Oakes et. al, 2004, p. i). Racially segregated schools also are more likely to lack qualified teachers and offer fewer advanced placement (AP) courses, leading to overall lower college eligibility and participation rates (Oakes et al., 2004).

Academic Preparation. One of the most critical aspects of educational foundations is the academic preparation—or lack thereof—for college coursework. Underserved students are often embedded in high school contexts where International Baccalaureate (IB), Advanced Placement (AP), and other college preparatory courses are not available (Perna & Jones, 2013). It is imperative to distinguish here the difference between *access* to advanced courses and *practice* of taking advanced courses. Often, courses are technically available across high schools. However, in practice, students enroll in advanced courses differently within and across high school settings. Data suggests only 9% of first generation (FG) students enroll in rigorous courses in high school, compared to 20% of non-FG students (Warburton et al., 2001). Some underserved students intentionally abstain from rigorous high school courses, opting to take easier courses to maintain eligibility for merit-based aid (Perna & Steele, 2011).

Academic preparation in the area of mathematics is particularly important for access to engineering education. However, only 20% of FG students take calculus in high school,

compared to 34% of their non-FG peers (Warburton et al., 2001). The National Center for Education Statistics (NCES) highlights the relationship between poverty and math and science standardized tests, which begins as early as 4th grade; in 2009, the NCES found that students from low income backgrounds received lower average tests scores on the math and science portions of the National Assessment of Educational Progress than their middle- and high-income peers (Baillie et al., 2012). The data suggest that inequities in math and science education start in early education and proliferate throughout a students' educational journey.

More broadly speaking, insufficient academic preparation is an observable barrier for underserved students that results from a “network of barriers” (Kezar, 2010, p. 54) in educational foundations (i.e., pre-college contexts). Though underlying causal mechanisms are often unclear, we do know that academic preparation is a major barrier for underserved students accessing higher education. In 2011-2012, the NCES found that 36% of FG students were required to take remedial work upon entering higher education, compared to 28% of non-FG students. Similarly, 40% of low income students require remedial courses in higher education (*Improving College Access for Low Income and First Generation College Students*, 2015). Of students who enroll in remedial math courses, 70% will never move on to the next course in the sequence, which is particularly problematic for students wishing to enter engineering due to commonplace admission requirements (*Improving College Access for Low Income and First Generation College Students*, 2015). There are additional opportunity costs to students because remedial courses prevent progression in degree programs (Long & Boatman, 2013). In addition to placing significant financial burden on students, remedial courses also place financial strain on institutions. For example, the United States spends approximately \$1.4 billion delivering remediation courses each year. Recognizing these significant costs to both students and institutions, improving academic preparation—particularly for underserved students—has become a topic on the forefront of educational policy in the United States (see Congressional Hearing documented in *Improving College Access for Low Income and First Generation College Students*, 2015).

Support from Social Connections. Educational foundations for underserved students are also influenced by social connections, such as families, teachers, guidance counselors, neighbors, and other community relationships. Social connections, which are formed largely in a student's

pre-college context, impact students' access to higher education. In section 2.3, I will discuss this body of research from a theoretical construct of *social capital*, which, put simply, refers to "who you know." We know that families play an important role in underserved students' educational journeys, particularly in the pre-college context. Parental involvement directly impacts a student's college aspirations (Perna & Titus, 2005), which can pose a barrier for underserved students. For instance, parents of underserved students may be less involved in the college enrollment process for a host of reasons, most notable of which is their limited experience with higher education. Other documented reasons for decreased involvement include social, economic, and psychological barriers (Rowan-Kenyon et al., 2008; Wilder, 2014).

Peers' College Aspirations. Peers are another important set of social connections for underserved students that can help or hinder college access. For low-income students, particularly minority students in urban contexts, peers' college plans (or lack thereof) are key predictors of four year college enrollment (Sokatch, 2006). Even after controlling for students' academic preparation and demographic information, literature suggests that students' likelihood of enrolling in college increases with the proportion of their friends who also plan to attend college (Perna & Titus, 2005). This trend quickly becomes a barrier for underserved students in pre-college contexts where there is not a history of college enrollment. In everyday language, high school students are more likely to aim for college if their friends aim for college, and they want to attend the type of institution (2 or 4 year) that their friends want to attend (Melguizo et al., 2013).

Combined, school segregation, academic preparation, support from social connections, and peer college aspirations shape a student's educational foundations. For underserved students, pre-college school systems often result in accumulated layers of disadvantage, or barriers, that become particularly salient in the quest to access higher education.

2.2.2 The Search: College Application, Choice, Enrollment

Perhaps nowhere is the interaction between educational foundations (K-12 school systems) and higher education more acute than during a student's senior year of high school (Yun & Moreno, 2006). I refer to this juncture as "The Search," which encompasses the process of applying to college, choosing a college, and enrolling in college. "The Search is a pivotal time

in a student's journey. Below, I will discuss this juncture for underserved students in terms of overall college access pathways, college applications, college choice, and college enrollment.

Overall college access pathways. Underserved students often lack information aspects of college access pathways, such as college entrance exams, college application processes, and college preparatory classes. As mentioned before, underserved students are often enrolled at high schools where college enrollment is historically low and they may lack access to information about pathways to higher education (Grotsky & Jones, 2007; Kahlenberg & Century Foundation, 2004). We know that college access decreases as information about college access pathways decreases (Perna, 2005). Information about college access pathways might include available careers and college aspirations, how to prepare for college entrance exams and applications, and how to choose which type of institution might best suite a student's needs. Availability of such information—or the lack thereof—can pose a significant barrier to accessing higher education for underserved students.

Applying to College. For underserved students, applying to college may be particularly difficult due to a host of factors, including college entrance examinations and college application costs. College entrance exams can pose barriers for underserved students (Clark, 1960; Warburton et al., 2001). When compared to non-FG and higher income peers, underserved students are less likely to take college entrance exams and tend to receive lower scores when they do take such exams (Warburton et al., 2001). Combined, these issues contribute to barriers in the college application process because these exams are required by many institutions. The college application process is also difficult for underserved students due to a lack of mentors, family members, or significant others who have navigated college applications before. For instance, parents of underserved students may be less involved in the college application process (Rowan-Kenyon et al., 2008; Wilder, 2014).

College Choice. The type of college a student attends (*college choice*) is significantly shaped by family's income (Baum et al., 2010). Students' socioeconomic background may also intersect with other dimensions of identity that impact college choice. In addition to income, U.S. literature suggests that race shapes students' college choice process. A 2004 study found that no form of financial aid is associated with an increased likelihood of attending the first-choice institution for Hispanic or African American students, though grants are associated with an

increased likelihood of attending first-choice institution for white students (Kim, 2004). Furthermore, cultural context impacts college choice. Valadez (2008) studied the impact of cultural context on the college enrollment processes of high-achieving immigrant students from Mexico. Valadez's (2008) study revealed that cultural contexts (such as family norms) and structural contexts (such as high school norms) influenced the college enrollment process of immigrant students from Mexico. Valadez (2008) found that the students navigated the college choice process by weighing cultural and structural norms with personal agency and preferences. Other work has studied the college choice process of engineering students from Appalachia, revealing that Appalachian students prefer to attend college close to where they grew up (Carrico, 2013). For students from both Latinx and Appalachian cultural contexts, college enrollment is influenced by cultural norms of remaining in close geographical proximity to home (Carrico, 2013; Perez & Ceja, 2015).

College Enrollment. After students apply to college, the next step in the journey is enrolling in college. One of the most important influencers of college enrollment is financial resources, particularly for underserved students. As Perna and Kurban (2013) simply summarize, we know that “money matters” for accessing higher education (p. 15). A family's income significantly shapes a student's choice to attend college (Baum et al., 2010). Even after controlling for academic preparation and family support, we know from literature that college enrollment increases as family income increases and vice versa (Kane, 1999; Perna, 2000). Combined, the evidence clearly suggests that high costs of higher education diminish underserved students' access to higher education

Tuition prices for higher education have risen at astonishing rates—three times the national growth rates of inflation and family income (Heller, 2011). For underserved students, tuition increases are particularly problematic. Research shows that college enrollment for underserved students is more heavily impacted by increased tuition prices than their middle- and high-income peers (Heller, 1997). Even if grant aid increases alongside tuition prices, “sticker” prices often negatively impact underserved students' decisions to apply to and attend college (Heller, 1999). Data shows that when tuition prices increase, underserved students are less likely to enroll in college.

Supporting the notion that “money matters” (Perna & Kurban, 2013, p. 15), numerous studies have concluded that financial aid—more specifically, grant aid—increases a student’s chances of enrolling in college (Avery & Hoxby, 2004; Heller, 1997; Kane, 1999; Mundel, 2008). However, the availability of financial aid does not inherently equate to increased access to higher education for underserved students. Regarding the cost barrier for college enrollment for underserved students, there are two factors at play: (1) the availability of financial aid and (2) student/family *perceptions* of availability of financial aid (Coles & Baum, 2005; Grodsky & Jones, 2007; Tierney & Venegas, 2009). Some research suggests underserved students do not aspire for college, perceiving higher education to be prohibitively expensive (Grodsky & Jones, 2007; Rosa, 2006; Tomas Rivera Policy Institute, 2004). Alarming, even students who are qualified for financial aid sometimes do not apply for it (Tierney & Venegas, 2009). As Coles and Baum (2005) summarize, “too many qualified low-income students do not go to college because they believe they cannot afford to, even though they may be eligible for sufficient financial aid” (p. 7). Actual costs of attending college may be difficult for underserved students and their families to anticipate. There is often a significant difference between the “ticket” price on a university’s website and the “net” price that a family would pay for their student to attend (Heller, 2013). This is compounded by a lack of standardization of institutional financial award letters, including significant differences in institutional definitions of attendance costs and descriptions of awards (Advisory Committee on Student Financial Assistance (ACSFA), 2008).

For underserved students who aim to apply for financial aid, the system can be daunting and confusing to navigate (Heller, 2013; *Improving College Access for Low Income and First Generation College Students*, 2015; Tierney & Venegas, 2009). In the United States, for example, the Free Application for Federal Student Aid (FAFSA), which includes over 100 questions, serves as a gatekeeper for all federal aid and most institutional aid (Heller, 2013). While some high schools have resources to assist students in navigating the FAFSA, many high schools lack resources, particularly in areas where the college-going rates are historically low. In such areas, high school counselors may not be able to provide guidance on the availability, eligibility criteria, and benefits/detriments of each type of financial aid (McDonough, 1997, 2005; Perna et al., 2008, 2007).

Combined, “The Search” senior year juncture is a critical period in the journeys of underserved students. Overall college access pathways, which include college applications, college choice, and college enrollment, can pose significant challenges for underserved students.

2.2.3: The Transition to College

Immediately following graduation from high school, students encounter the metaphorical last mile on the journey to the door of higher education. For underserved students, the last mile can be a particularly tumultuous period, resulting in failure to matriculate to college. The attrition has been coined *summer melt*, a term that is distinct of language used by admissions to refer to students who change college enrollment (to a different institution) during the summer before they matriculate (Castleman & Page, 2014). Summer melt refers to clearly observed phenomena that “admission to college is not equivalent to going to college” (Arnold, Fleming, DeAnda, Castleman, & Wartman, 2009, p. 23). In both rural and urban U.S. contexts, recent estimates conclude that nearly 20% of students who intend to attend college never actually make it to the door (Castleman & Page, 2014). This trend disproportionately impacts underserved students across multiple contexts (Arnold et al., 2009; Castleman & Page, 2014).

For underserved students, the *summer melt* phenomena can largely be summed up in one word: gaps. Students experience a gap in 1) financial resources and 2) access to college counselors and information resources. There is often a significant gap between the financial aid a student receives and the full cost of college attendance (Castleman & Page, 2014). Additionally, during the summer before college, students experience a gap in professional assistance, such as college access counselors, teachers, or other mentors who can assist in navigating the last leg of the journey to college (Castleman et al., 2014). Other barriers contributing to summer melt include family and/or work obligations, and a lack of enthusiasm from social connections about the geographical distance or financial investment that attending college demands (Castleman & Page, 2014). Combined, these factors make the last mile to the door of higher education a complex maze for underserved students to navigate, contributing ultimately to significant attrition.

2.2.4: The Bachelor's Degree

The next critical segment in a student's engineering educational journey is the bachelor's degree, which I am calling "The Bachelor's Degree." The bachelor's degree is at the heart of higher education (Palmer et al., 2010). It is outside the scope of this chapter to adequately discuss the transformative role of higher education in a student's life. For brevity's sake, I lean here on the *capabilities approach* offered by Amartya Sen (1989) to describe one way of thinking about the value of a bachelor's degree. Applying the capabilities approach to higher education suggests that an individual's journey in higher education should have two aims: to develop 1) *functionings* and 2) *capabilities* (Wilson-Strydom, 2011). In short, "a functioning is an achievement [outcome], whereas a capability is the ability to achieve [potential]" (Sen, 1989, p. 48). Fundamentally, the capabilities approach argues that higher education ought to "expand people's capabilities—their freedom to achieve what they value doing and being" (Wilson-Strydom, 2011, p. 411). At its best, higher education offers students a period of transformation to exercise such freedom and pursue life on their own terms.

In addition to higher education's promises of transformation, a bachelor's degree in engineering education makes some grand promises, particularly to students from underserved backgrounds. As discussed in Chapter 1, engineering is continually positioned as a discipline that is transformative, promising individuals a ticket to climb up the social-mobility ladder (Baillie et al., 2012; V.C. Lundy-Wagner, 2013). Despite transformative promises, there is evidence that not all students are able to leverage the transformative power of an engineering degree equally. Underserved students face distinct barriers to persisting towards the bachelor's degree. For instance, underserved students tend to hold multiple jobs to help finance school or support family obligations (Billson & Terry, 1982). Due to job and family responsibilities, underserved students spend more time at work and more time commuting to campus, resulting in less interaction with peers outside the classroom (Baillie et al., 2012). Furthermore, near-peers of underserved students are often unsupportive of college studies (Terenzini et al., 1996b), resulting in potential dissonance between students' college experience and home community. Despite being labeled as an "at academic risk" community (Terenzini et al., 1996, p. 17), there is some evidence that underserved students are more resilient than their high SES peers when faced with hurdles in

college (Cabrera et al., 2003). This evidence may suggest that, when confronted with barriers, underserved students exercise agency to navigate and persist.

2.2.5: Beyond: Career Decision-Making

Near completion of the bachelor’s engineering degree—and beyond—students are confronted with a series of choices. I refer to this period as “*Beyond: Career Decision-Making.*” As students make choices, they exercise agency and negotiate barriers to decide how—or importantly, if—they plan to use their engineering degree. During this period, students are confronted with two choices: 1) degree choice and 2) career decision-making. Literature enlightens our understanding of degree choice, or why students choose engineering degrees. For instance, Seymour and Hewitt (1997) explored degree choice in science, math, and engineering and concluded that students were more likely to choose and persist in these degrees based on intrinsic interest. Matusovich, Streveler, and Miller (2010) built on this work, suggesting that students’ engineering degree choices hinge largely on a *sense of self*, or how closely a perceived engineering identity aligns with their personal identity.

However, there appears to be a fragile link between undergraduate degree choice and career decision-making (Amelink & Creamer, 2010; Gary Lichtenstein et al., 2009). As Lichtenstein (2009) succinctly summarizes—“an engineering major does not (necessarily) an engineer make” (p. 227). Amelink & Creamer’s 2010 study corroborates Lichtenstein’s (2009) findings, suggesting plans to persist (i.e., graduate) in an engineering degree program do not always align with desires to be working in engineering ten years from now. Though the literature is sparse, a few studies suggest that career decision-making is largely impacted by students’ backgrounds. Some research suggests career decisions are shaped by “socializers” such as family, peers, and university and work connections (Abhyankar et al., 2018). Literature also suggests that engineering students from racial and ethnic minorities tend to articulate career decision-making in terms of helping their home communities or families, whereas students from majority groups tend to speak more broadly about using their engineering career to invent or improve things (Trenor et al., 2008). Another study suggests that many underserved students choose engineering careers because of a “sense of responsibility to give back to others” (Conrad, 2009, p. 1366). Broadly speaking, however, career decision-making is not well studied in the field of engineering (Gary Lichtenstein et al., 2009). Most of our work has emphasized guiding

students into engineering majors, with less work focused on what happens after they complete their major.

As discussed in this section, each of these segments is crucial to a student's educational journey. Rarely, however, are students' educational journeys explored longitudinally. Through students' narratives, my study explores each segment of underserved students' educational journeys. In the next section, I will discuss my application of a Bourdieusian lens to explore the longitudinal educational journeys of underserved engineering students.

2.3: Applying a Bourdieusian Lens to the Educational Journeys of Underserved Engineering Students

I am using a Bourdieusian framework to conceptualize the relationship between structure and agency in the educational journeys of underserved engineering students. Providing three central thinking tools of *capital*, *habitus*, and *fields*, the Bourdieusian framework provides a unique lens to view both structures and agency in the educational journeys of underserved students. Bourdieu's framework has been widely used in educational research to examine the role of educational systems in social reproduction (Burke, 2017).

To provide context for Bourdieu's work, I note here that Bourdieu's contributions were developed largely from his examination of educational systems (Burke, 2017; Robbins, 1993). The context in which Bourdieu's work was developed is imperative for understanding his conflicted views about the role of education in reducing inequities. His earlier work (e.g., *The Inheritors*, Bourdieu & Passeron, 1964/1979) advocated that educational systems could help reduce social inequities, despite systemic issues of access and disparate student experiences based on socioeconomic status (Burke, 2017; Robbins, 1993). However, his later work (e.g., *Reproduction*, Bourdieu & Passeron, 1970/1990) seems to accept social reproduction as an inevitable outcome of educational systems (Burke, 2017; Robbins, 1993). Because my research questions explore students' agency, my use of Bourdieu's framework is more in alignment with his earlier work, which suggests that despite deeply embedded issues of access and equity, educational systems can be a mechanism for reducing social inequities.

In the following sections, I will begin by drawing parallels between language commonly used in engineering education research and the "thinking tools" provided by the Bourdieusian framework. I will then introduce Bourdieu's framework and establish a shared vocabulary for the

remainder of the dissertation. Following, I will discuss Bourdieu’s conceptualization of the interplay between structures and agency, offering responses to critiques of Bourdieu’s framework. Additionally, I will provide an overview of previous applications of Bourdieu’s framework in engineering education research. To conclude this chapter, I will outline my study’s contribution to the theory and literature.

2.3.1 Language in Engineering Education: Pipelines and Pathways

Before diving into the Bourdieusian lens for my study, I begin by drawing attention to other shared ways of conceptualizing students’ journeys in engineering education. As Lee (2019) discusses, we often conceptualize and communicate about complex ideas (e.g., broadening participation in engineering) through *metaphors*, such as “pipelines”, “pathways”, and “ecosystems.” Lee (2019) argues that these metaphors are not only linguistic tools but instead reveal deep insights into our conceptual understanding of complex systems. Extending Lee’s (2019) arguments, I suggest that our shared metaphors of educational journeys in engineering are a useful starting point for communicating about the phenomenon of student journeys to and through engineering education. Therefore, I begin by briefly drawing comparisons between two common engineering education metaphors (i.e., pipelines and pathways) and the Bourdieusian lens I use for my study (Figure 4).

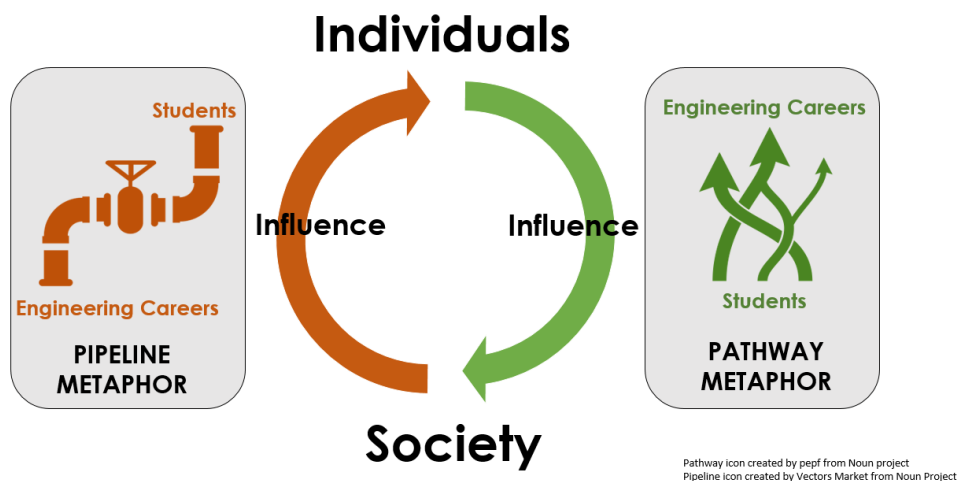


Figure 4. Comparison between engineering education metaphors and the Bourdieusian lens used for this study

In engineering education, the pipeline and pathways metaphors have often been at the core of our conversations on students' educational journeys. The pipeline metaphor is often used to examine how society (e.g., an educational system such as K-12 schooling in the U.S.) acts upon individuals in ways that either keep students in the pipeline to engineering or "leak" them out (Lee, 2019). This metaphor has largely focused on systemic barriers in educational system that perpetuate undesirable outcomes, such as attrition. Members of the engineering education community have also considered how to leverage the pipeline metaphor to *produce* desirable outcomes; such work rests on the notion that if we change the pipeline, we change outcomes. Whether to diminish undesired outcomes or increase desired outcomes, the pipeline metaphor emphasizes how society influences individuals, without much consideration of individual's agency (Lee, 2019). On the other hand, the pathways metaphor heavily values individual agency and emphasizes the process of individuals choosing to pursue engineering (Lee, 2019). Acknowledging that students may start at various points, the heart of the pathways metaphor is individual choice and agency. There is less consideration in the pathways metaphor of systemic or societal barriers that may impact an individual's educational journey (Lee, 2019).

Lee (2019) suggests that both metaphors could be leveraged to foster a more comprehensive examination of broadening participation in engineering. I argue the same for my study, which aims to explore access to engineering education for underserved students. I put forth that it is insufficient to only consider the ways that individuals make choices and shape society, because doing so fails to capture the authentic struggles students may face as they strive towards the bachelor's engineering degree. Conversely, it is also insufficient to solely explore how society influences individual students, as this notion deprives underserved students of their agency. It is useful to note here that the framing of the relationship between structure and agency is not a new debate; rather, the balance between structure and agency has been heavily debated in sociological literature (Alexander, 1988; Peters, 2014).

In some ways, Bourdieu's theoretical lens directly sprung from larger debates about the balance between societal structures and individual agency. In particular, his work was in direct response to critiques of two social views: structuralism and subjectivism. Bourdieu argued that structuralism generates and regenerates structures, robbing humans of their autonomy by creating "a priori" false dualisms between structure and agency (Hall, Grindstaff, & Lo, 2010, p. 101).

Bourdieu was equally critical of subjectivism, suggesting that a fatal flaw in subjectivism is its failure to acknowledge underlying processes that create societal structures (Hall et al., 2010). His framework, therefore, was born out of his critiques of the two flawed social views, asserting that structures exist only in the context of the social world (Hall et al., 2010). In response, he put forth a new set of theoretical suppositions—a framework to conceptualize both agency and structures in the social world.

Mills (1959) argued that both structure and agency are essential for an in-depth exploration of any social realm. Recognizing that structure and agency must be examined together, I employ a Bourdieusian lens for this study. The Bourdieusian lens is appropriate for this study because it considers individual agency, societal barriers, and the interplay between the two. Using the Bourdieusian lens, my study examines the relationship between societal barriers (i.e., *structures*) and a person's agentic beliefs and behaviors (i.e., *agency*) in the exploration of the pathways of underserved engineering students.

2.3.2 Establishing a Shared Vocabulary

Throughout the remainder of dissertation, I will use Bourdieusian constructs to discuss my study of the educational journeys of underserved engineering students. In order to first establish a common vocabulary, I offer Table 3, which matches language from the broader engineering education community to the Bourdieusian framework used for this study. I also provide a definition of each Bourdieusian construct as it applies to my study.

Table 3. Establishing a shared vocabulary for Bourdieusian Constructs

Bourdieusian Construct	How we might talk about the Bourdieusian Construct in engineering education	Definition applied to my study context
<i>Structures</i>	Systemic issues and barriers; reproductive forces	Barriers (societal, historical, financial, cultural, etc.) that underserved students encounter in the pursuit of a bachelor's engineering degree
<i>Agency</i>	Individual's ability to exercise choice; power of free will	Strategic actions or beliefs that underserved engineering students use to negotiate barriers in the pursuit of a bachelor's degree
<i>Agents</i>	Individual actors within a system	Underserved engineering students
<i>Fields</i>	Social circles	Social circles (e.g., university, peer groups, families, faith groups, etc.) that underserved students navigate in pursuit of a bachelor's engineering degree
<i>Capital</i>	Resources at an individual's disposal; "who you know", finances, family background, etc.	Resources leveraged by underserved engineering students in the pursuit of a bachelor's engineering degree.
<i>Habitus</i>	Combination of identity, actions, choices, beliefs, skills, preferences	Embodiment of capital; an underserved engineering student's "feel for the game" of navigating engineering education
<i>Non-dominant Group</i>	Students who are systemically disadvantaged or marginalized; "underrepresented" or "underserved"	Underserved students: students who are either a) from a low income background and/or b) the first in their immediate family to attend college
<i>Dominant Group</i>	Students who are not systemically disadvantaged or marginalized (e.g., in engineering, "white, upper-class, heterosexual men")	Engineering students who are not from underserved backgrounds

2.4 Introduction to Bourdieu's Framework

My study is grounded in Bourdieu's (1977, 1986) framework, with the construct of capital augmented by Yosso's (2005) Community Cultural Wealth. I offer a visual summary (inspired by lectures Cheryl Reynolds, 2013; Simon, 2010) of how I use Bourdieu's framework to study the educational pathways of underserved engineering students. In the image below, the individual carries with them the habitus, or embodied capital, as they navigate various fields, such as a school environment, neighborhood, or family circle.

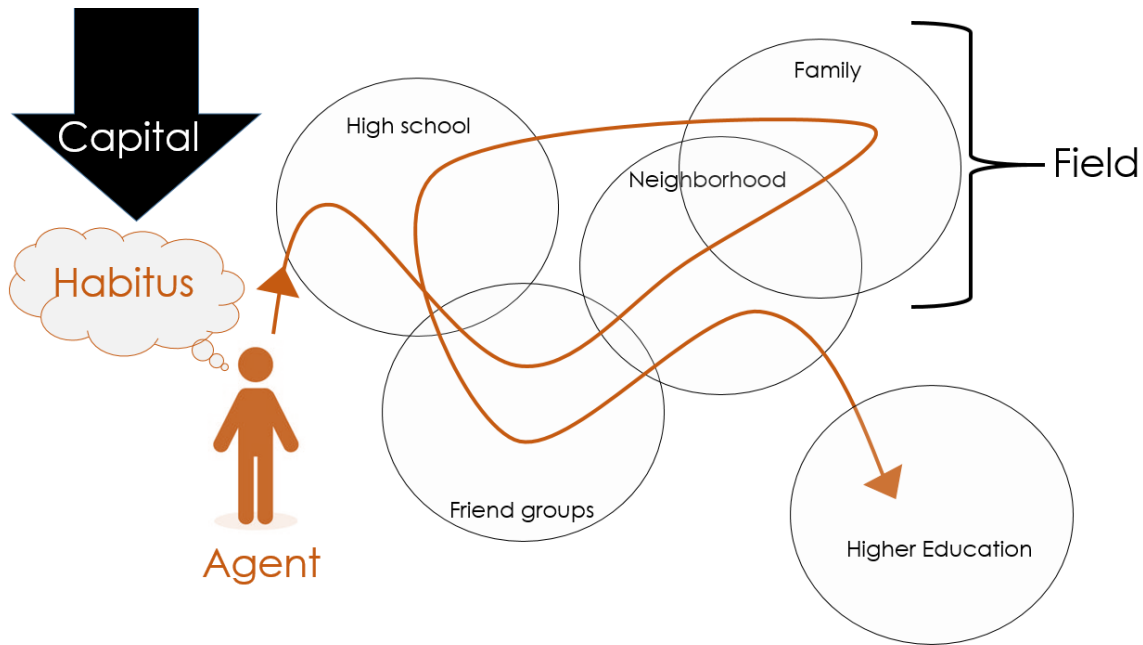


Figure 5. An overview of Bourdieu's conceptualizations of fields, habitus, and capital

In short, Bourdieu conceptualized the social world as consisting of *fields*, or social circles of sort. As shown in Figure 5, fields such as a high school, friend groups, neighborhoods, and families can overlap yet are largely autonomous (Davey, 2009; Reynolds, 2013; Routledge, 2016). Agents, or individuals, enter into various fields. Into every field they carry their *habitus*, or their collection of identity, choices, and actions shaped by their previous experiences and shaping their future experiences (Burke, 2017; Davey, 2009; Reynolds, 2013). *Capital* feeds into the habitus; in fact, Bourdieu refers to habitus as the embodiment of cultural capital, or a “feel for the game”, where the game might refer to navigating a particular field or social circle (Routledge, 2016). Although the visualization is perhaps oversimplified, it summarizes my understanding of the relationship between agents, field, habitus, and capital.

While Bourdieu expanded his framework throughout his career, his notions of *fields*, *capital*, and *habitus* are argued to be the “central thinking tools” of his theoretical contributions (Burke, 2017, p. 52). Burke (2017) argues that the combination of these thinking tools can be leveraged to examine “the genesis of action” (p. 52). I therefore focus my overview of Bourdieu’s framework to these central thinking tools. Before discussing these thinking tools, I will define my study’s conceptualization of the relationship between structure and agency in the educational journeys of underserved engineering students.

2.4.1 Structure and Agency

With my study's Bourdieusian lens, I view the relationship between structure and agency to be refereed by habitus, or the embodiment of an individual's capital. Bourdieu conceptualized habitus as comprised of both structural and agentic features (Burke, 2017). In alignment with this conceptualization, *habitus* suggests that structures in the social world—such as social connections or financial assets—influence human behavior; however, as a mechanism for transformation, habitus implies that human behavior also influences the social world. As visualized in Figure 6, this idea has been summarized by the Latin phrase *summa summarum*, or “sum of sums” (Peters, 2014). In this conceptualization, society reproduces structures and agents shape society in a circular process.

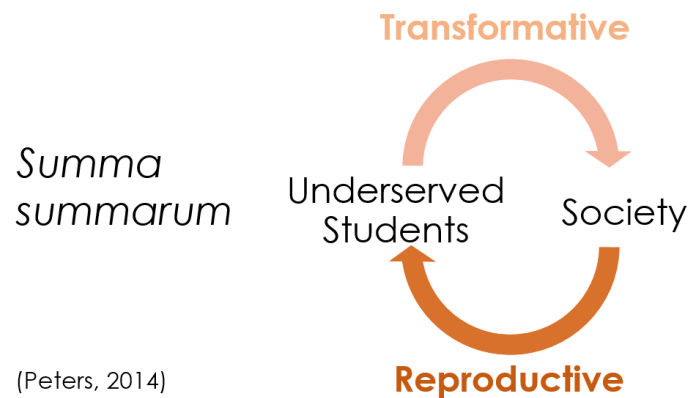


Figure 6. Visualization of Bourdieusian conceptualization of the interplay between structure and agency

Applied to my study context, the Bourdieusian framework suggests that agency of underserved engineering students is shaped by the structures of the social world, such as their national context, political context, institutional context, and cultural context. Reciprocally, the Bourdieusian framework also asserts that structures (e.g., structures of higher education) may be transformed by the agency of underserved engineering students. Ultimately, conceptualizing the Bourdieusian framework in this light suggests that agency of underserved engineering students—even if limited by structures—is a mechanism for social change (Murphy & Costa, 2016).

2.4.2 Fields

In Bourdieusian approaches, the social world is conceptualized as divided into circles, or *fields*, each of which values distinct forms of capital, ways of doing things, and knowledge (P.

Bourdieu, 1995). Marginson (2008) offers a useful definition of a field as “a social universe with its own laws of functioning” (p. 304). Though fields can overlap, Bourdieu asserts that each field is largely autonomous with its own set of rules and practices. Bourdieu’s later work suggests that the process of acquiring positions in fields can either reproduce or transform structures in the field (Peters, 2014; Reay, 2004).

2.4.3 Capital

One of the most widely used concepts in Bourdieu’s framework is *capital*. Bourdieu’s (1986) framework originally delineated three types of capital: (1) social, (2) economic, and (3) cultural. Social capital is used to conceptualize social connections and how such connections can be leveraged in a given social space (Burke, 2017). Cultural capital can be described as cultural beliefs, practices, and dispositions (Burke, 2017). And economic capital refers to financial resources, such as investments, money, or property (Burke, 2017). In the Bourdieusian framework, the combination of capitals determines one’s place (i.e., “rank”) in a social circle (*field*). In addition, capital can be exchanged for other valuables (e.g., services) within a social circle (Burke, 2017).

Bourdieu’s capital focuses largely on the capital of dominant groups, suggesting that non-dominant groups may not possess capital that is valued within a particular field, such as higher education. However, Yosso (2005) argues that non-dominant groups also have capital that should be acknowledged and valued. Though this non-dominant group capital may be different from that of dominant groups, it has inherent value that should be explored (Yosso, 2005). Because the population of interest in my work is a non-dominant group (underserved students), I augment Bourdieu’s definitions of capital with Yosso’s (2005) Community Cultural Wealth (CCW). Extending Bourdieu’s (1986) work, which focused on capital of dominant groups, CCW asserts that cultural resources of non-dominant students should be valued as capital. CCW (Yosso, 2005) provides a framework for exploring the unique and valuable capital of underserved students by delineating six types of capital as shown in Table 4: (1) aspirational, (2) familial, (3) navigational, (4) resistant, (5) social, and (6) linguistic. Originally developed to recognize the unique capital of communities of color in the U.S., CCW asserts that these six dynamic types of capital are interrelated, *not* mutually exclusive. For example, aspirational capital and familial

capital are reciprocally related; family history impacts one’s hopes and dreams for the future, and dreams for the future impact family culture.

Table 4. Community Cultural Wealth: Types of Capital (Yosso, 2005)

Type	Definition
Aspirational	Maintaining hopes and dreams for the future despite barriers, real or perceived
Linguistic	Social and/or intellectual skills built through communication experiences in multiple languages or styles
Familial	Knowledge of community history, memory, and cultural intuition nurtured by family
Social	Networks of resources, including people and community
Navigational	Skills of maneuvering through social institutions
Resistant	Knowledges and skills fostered through oppositional behavior that challenges inequality

Importantly, *CCW focuses on assets of individuals and communities instead of anchoring on deficits or disadvantages* (Samuelson & Litzler, 2016; T. Yosso, 2005), which has been a critique of Bourdieu’s framework (King, 2000; Varenne & McDermott, 1999). Ultimately, by supplementing Bourdieu’s notions of capital with Yosso’s Community Cultural Wealth of non-dominant groups, the unique capital of underserved students can be fully explored while still acknowledging the forms of capital that are particularly valued in engineering education.

2.4.4 *Habitus*

The habitus is heralded in literature as Bourdieu’s most influential yet ambiguous and widely contested concept (Davey, 2009; Lizardo, 2004; Reay, 2004) Bourdieu (1977) defines habitus as:

A system of lasting, transposable dispositions which, integrating past experiences, functions at every moment as a matrix of perceptions, appreciations and actions and makes possible the achievement of infinitely diversified tasks, thanks to analytical transfers of schemes permitting the solution of similarly shaped problems. (p. 95)

More simply, habitus can be described as the deeply embedded combination of our skills, habits, and temperaments resulting from our life experiences (Routledge, 2016). Habitus is the

embodiment of one's capital (Routledge, 2016) and, furthermore, the mechanism by which one's capital shapes their actions (Burke, 2017). When using sports analogies to describe his work, Bourdieu refers to habitus as a 'feel for the game' (P. Bourdieu, 1990), such as when an Olympic runner knows precisely when and how high to jump in the race to successfully clear the hurdle. In Bourdieu's reference, the "game" refers to social circles, or fields, we might encounter, while "feel for" refers to the subconscious set of knowledge, habits, and choices that guide our behavior in the field.

One of the advantages of Bourdieu's concept of habitus is the ability to analyze "how micro-practices are linked to broader social and cultural forces to reproduce inequalities" (Tierney, 1999). Bourdieu often lamented that the concept of habitus was wrongly assumed to be natural instead of socially developed. When habitus is viewed as naturally formed, it breeds justification for social inequality, allowing persons to believe that some are just naturally predestined to a better quality of life than others (Routledge, 2016). For Bourdieu, habitus is the mediator between structures and agency, serving as a "individual process involving choice but also influenced by structure" (Burke, 2017, p. 52), where structures might refer to educational environments, cultural expectations, peer groups, or family circles.

2.5 Previous Applications of Bourdieusian Framework in Engineering Education

As previously noted, Bourdieu's framework has been widely used in educational research. In the following sections, I scope my discussion to applications of Bourdieu's framework in engineering education research. To summarize the following sections, much of the engineering education research using a Bourdieusian lens has focused on Bourdieu's thinking tool of capital, largely to the exclusion of the broader framework. However, several exemplars have used all three of Bourdieu's central thinking tools (i.e., capital, habitus, and field), providing a mechanism to explore the relationship between structure and agency in various engineering education social spaces.

2.5.1 Capital

Similar to the broader set of literature using Bourdieu's theory, engineering education research (EER) informed by a Bourdieusian lens has largely focused on Bourdieu's notions of *capital*—more specifically, social capital. Previous work exploring social capital in engineering

education has explored the role of social capital in students' experiences. Typically augmenting Bourdieu's notion of social capital with Lin's network theory of social capital (1999), scholars have examined the social capital of Hispanic women (Martin et al., 2013), first generation college students (Martin, 2015; Martin et al., 2014), undergraduate researchers (Martin et al., 2012), and underrepresented students broadly (Trenor, 2011).

Other researchers have employed Bourdieu's *social capital* thinking tool to examine "instrumental relationships" between students and faculty (Brawner, Camacho, Lord, Long, & Ohland, 2012, p. 294); the use of social capital in navigation of undergraduate engineering laboratory courses (S. Brown et al., 2009); the assessment of construction engineering expertise (Poleacovschi Cristina & Javernick-Will Amy, 2017); and social systems of engineering projects (Lawson, 2006). Brown, Flick, and Williamson (2005) use Bourdieu's concept of social capital as a tool for moving towards curricular change in engineering, asserting that engineering programs should move beyond a sole focus on technical competencies and foster students' development of social capital. Most recently, the engineering education community has "pushed back" on Bourdieu's notions of capital, advocating for the recognition and valuation of capital of non-dominant groups (e.g., underrepresented students, underserved students). For instance, Samuelson and Litzler (2016) augment Bourdieu's notions of capital with Community Cultural Wealth (Yosso, 2005) to explore the experiences of underrepresented students, aiming to "focus on student strengths and reframe deficit perspectives" (p. 98). In a similar vein, Revelo and Baber (2018) use Bourdieu's notions of capital supplemented by Community Cultural Wealth to study how Latina/o undergraduate engineering students develop resistant capital. Combined, these studies reflect a prominence of Bourdieu's construct of *capital* in the engineering education research, with more recent work pushing the boundaries of Bourdieu's framework to explore distinctive capital of underrepresented students.

2.5.2 Broader Framework

While *capital* has been the emphasis of much Bourdieusian engineering education work, several notable studies have drawn from all three of Bourdieu's central thinking tools (i.e., capital, habitus, and fields) to examine social spaces in engineering education. One of the most notable contributions to this space is Foor, Walden, and Trytten's (2007) study of educational inequality through the in-depth narrative of Inez, a student from low socioeconomic status,

multi-minority, and first generation college backgrounds. Foor et al. (2007) refer to their methodology as “ethnography of the particular” (p. 104), which they use to compare Inez’s narrative to that of her middle- and upper-class peers. Using a Bourdieusian lens, Foor et al.’s (2007) findings demonstrate how advantage is accumulated in educational systems; by doing so, the authors draw heavily from Bourdieu’s supposition that capital significantly impacts educational success. Findings suggest multiple dimensions of marginalization (e.g., race, gender, socioeconomic status) influence Inez’s educational experience, with socioeconomic status carrying the strongest weight on her experience (Foor et al., 2007). Authors conclude that Inez’s family proved to be a critical mediator between structure and agency. Inez’s narrative shows that she is not a “passive victim of deterministic social structure” but instead is utilizing agency to achieve her goals, both educational and professional (Foor et al., 2007, p. 106).

Another exemplar of Bourdieu’s broader framework in engineering education is Mendoza, Kuntz, and Berger’s (2012) study of faculty in materials science engineering. Mendoza et al.’s (2012) study uses the Bourdieusian construct of *habitus* to explore the daily lives of faculty, with a particular emphasis on how habitus impacts strategies for maneuvering faculty roles. Their study suggests that symbolic capital plays a significant role in social reproduction, with more prestigious faculty members (i.e., those with more capital that is valued in the field) accumulating more economic capital (i.e., grants) (Mendoza et al., 2012).

A final exemplar is the work of Gopaul (2015), who used a Bourdieusian lens to study inequality in doctoral education. Focused in the Canadian context, Gopaul (2015) investigated the experiences of engineering and philosophy doctoral students. The study suggests distinctive “rules of the game” in doctoral education, which doctoral students learn as they navigate the social circle. Gopaul (2015) doctoral students rapidly begin to recognize “particular practices and achievements as emblematic of acquiring capital” (p. 81). Examples of such practices include attending conferences, publishing, reaching major program milestones, or securing funding (Gopaul, 2015).

Apart from these exemplary studies, minimal engineering education work with a Bourdieusian lens has drawn from all three central thinking tools (i.e., field, capital, and habitus). My study aims to contribute to this gap in literature by using all three of Bourdieu’s thinking tools as a lens for my research.

2.6 Critiques of Social Reproduction Theory and Responses

Literature also reveals vehement critiques of Bourdieu's work for limiting agency of individuals (King, 2000; Varenne & McDermott, 1999). Some argue that Bourdieu's work is overly deterministic, positioning individuals as helpless and without agency to create change (Varenne & McDermott, 1999). Tierney (1999) provides helpful imagery for this critique, suggesting that in Bourdieu's work:

... individuals are not seen as agents struggling within cultures but as mere actors trapped in modern day cages that encapsulate their experience and interpretation and lead to the reproduction of their social and economic conditions. (p. 82)

Lizardo (2004) echoes these sentiments, arguing, "[Bourdieu's] notion of habitus makes him fall into a determinist trap where individuals are construed as the 'puppets' of structure" (p. 379-380). Some critics even argue that Bourdieu's coupling of habitus and cultural capital suggest social change to be impossible (Tierney, 1999).

Responding to critiques that deem Bourdieu's framework overly deterministic, some scholars assert that it is not the framework itself that is inherently deterministic, but rather the way it is typically interpreted (Davey, 2009; Lizardo, 2004; Murphy & Costa, 2016; Peters, 2014). Critics are correct in pointing out the pessimistic determinism present in Bourdieu's notion of habitus, for the Bourdieusian framework indeed asserts that structures in the social world impact human behavior. However, as Lizardo (2004) notes, these critiques fall short when we acknowledge that the habitus is *active*. Of Bourdieu's work, Lizardo (2004) writes:

[deterministic critiques] can only be sustained when the habitus is seen simply as a passive perceptual and classificatory faculty or when the embodied habitus is simply seen as the docile clay where society leaves it stamp, and not as an *active* generative matrix of action. (p. 379-380, emphasis added)

An interpretation of Bourdieu that maintains agency is used by Murphy and Costa (2016), who interpret Bourdieu's perspective of human behavior as "directed but not determined" (p. 70). At the heart of the issue of whether Bourdieu's views are overly deterministic is the concept of habitus. Habitus is Bourdieu's mediator between structure and agency (King, 2000). Bourdieu and Nice (1994) are emphatic that an individual's habitus is not a schema that invokes involuntary actions, but rather that habitus is "something powerfully generative" (p. 87). Reay (2004) asserts that it is precisely the concept of habitus that "transcends dualisms of agency-

structures, objective-subjective, and the macro-micro” (p. 432). I relate most with Bourdieu’s conceptualization of habitus as a “transforming machine that leads us to reproduce the social conditions of our own production, but in a relatively unpredictable way” (Bourdieu, 1993, p. 87). By acknowledging the ability of human agency to be unpredictable *in spite of* social structures, this interpretation of Bourdieu avoids overly deterministic views of human behavior. Bourdieu concludes that the concept of habitus offers freedom from determinism by generating a wide range of possible actions, each of which have the ability to be transformative (Reay, 2004).

To summarize how I propose to balance agency and structure using the Bourdieusian framework, I offer two of Bourdieu’s counter arguments to the idea that his work is over-deterministic. First, Bourdieu asserts that habitus become active only in relation to a particular field. Again, these concepts cannot be viewed in isolation (P. Bourdieu, 1990). In my study context, the habitus of underserved students only becomes active in relation to various fields, such as home communities, pre-college environments, or higher education environments. Secondly, and perhaps most relevant to my research on access to higher education, Bourdieu asserts that the when an individual’s field and habitus are in tension, habitus can be transformative (Reay, 2004). When an individual’s field and habitus are in tension, social change can occur (Reay, 2004). Bourdieu conceptualizes habitus as constantly evolving due to social conditions, so interactions with a particular field—such as higher education—can potentially transform generative schemes instead of reinforce them.

2.7 Contributions to Literature

My study contributes to the literature on underserved students’ educational journeys in three ways. First, unlike much literature that focuses on one segment of educational journeys, my exploration spans multiple educational segments and junctures. As I will discuss in Chapter 4, the narrative interviews used in my study give participants the freedom to highlight whichever time periods are important in their journey. Rather than focus deeply on any particular educational segment, my study zooms out on the broader journey and asks participants to share their own stories, identifying segments that were important to them. Secondly, there is a gap in literature on the agency of underserved students along educational journeys. We know a lot about barriers that students face, but minimal work has explored how students navigate encountered barriers. My research questions emphasize agency in the journeys of underserved

students, which is an important contribution to a body of literature that has largely focused on barriers and deficits. Understanding how engineering students enact agency to navigate barriers has important implications for practice. By understanding agency in the journeys of underserved students, practitioners may be able to better foster agentic perspectives and beliefs in future underserved students.

Lastly, my examination specifically focuses on underserved students in the engineering context, a discipline that is currently understudied with regard to this population. While studies have examined underserved students in higher education, less work has examined their journeys in engineering. Within engineering, there are compelling questions about the journeys of underserved students to which this study aims to contribute. Underserved students are recently recognized as important contributors to engineering from both a standpoint of diversity and social justice (M. Strutz et al., 2012). Therefore, this work is timely.

I conclude Chapter 2 by outlining the ways that this study contributes to engineering education research literature and the broader literature employing Bourdieu's thinking tools. I argue that my study contributes to Bourdieusian literature in four distinct ways: 1) exploring the experiences of underserved engineering students, 2) employing all three of Bourdieu's central thinking tools, and 3) examining the capital of underserved students (i.e., a *non-dominant group*).

First, my study contributes to the engineering education literature by using Bourdieu's framework to explore the experiences of underserved students, groups critically underexplored in the literature. While subsets of Bourdieu's framework (i.e., capital) have been used to study the experiences of first generation students (e.g., Martin, 2015; Martin et al., 2014), minimal work has explored the experiences of students from low income backgrounds. In this way, my study aims to fill a gap in the engineering education research literature.

More broadly, my study contributes to literature on Bourdieu's framework by using all three of his central thinking tools (i.e., field, capital, and habitus). As noted previously, many studies have used Bourdieu's notions of capital. A systemic review of studies using cultural capital found that only 37% of studies mentioned even *one* of Bourdieu's other central thinking tools, which is a generous definition of using the broader framework (Winkle-Wagner, 2010). From a theoretical standpoint, using capital as a thinking tool removed from the broader framework is problematic because Bourdieu argues the concept of capital does not exist outside

of the concept of fields. More simply, capital only exists in relation to a particular field. Therefore, my study contributes to literature by employing all three of Bourdieu's central thinking tools to study the interplay between structure and agency in the educational journeys of underserved engineering students.

My study also expands the literature on underserved students, whom Bourdieu would refer to as a non-dominant group. Bourdieu's theoretical framework focuses primarily on dominant-group capital. This framing is problematic because it can lead to a deficiency approach, where students from low income backgrounds may be blamed for lacking cultural capital that is valued in a particular setting. From a practice perspective, the deficiency approach can result in interventions designed to help non-dominant groups acquire capital of dominant groups, potentially reinforcing and legitimizing social reproduction. Augmenting Bourdieu's framework, I use Community Cultural Wealth (Yosso, 2005) to explore the capital of underserved students. Doing so acknowledges and explores the unique capital and agency of underserved students and moves the rhetoric away from the deficiency approach.

2.8 Summary

To summarize, this chapter has provided a review of the literature on the educational journeys of underserved students. Critical segments in the educational journeys of underserved students include 1) Educational Foundations: Pre-College; 2) The Search: College Application, Choice, and Enrollment; 3) The Transition to College; 4) The Bachelor's Degree; and 5) Beyond: The Choice. My study uses a Bourdieusian lens, notably the central thinking tools of *field*, *capital*, and *habitus*, to explore the educational journeys of underserved engineering students. I augment Bourdieu's notions of capital with Community Cultural Wealth (CCW) (Yosso, 2005) to avoid the deficit narrative that can accompany examinations focusing on dominant-group capital. Using CCW in addition to Bourdieu's notions of capital acknowledges and explores the unique capital and agency of underserved students and moves the rhetoric away from the deficiency approach. My study is exploratory in its examination of the educational journeys of underserved students and its use of narrative interviews to span multiple educational segments. Additionally, my study contributes to literature on Bourdieusian theory by using Bourdieu's broader framework and focusing on the capital of a non-dominant group.

Chapter 3: Research Methods

In this chapter, I discuss my research design with particular emphasis on alignment between each of the design phases. After offering my researcher positionality statement, I will discuss my research design, reiterating the purpose of my inquiry and my research questions. In alignment with the pragmatist worldview, my methodological decisions stem from my purpose and research questions, so it is appropriate to use my purpose of inquiry as a foundation for this chapter. Next, I will provide an overview of case study methodology and discuss why a single case study design with embedded units of analysis was chosen. I will then discuss data collection, followed by case and participant selection. Finally, I will discuss the collaborative development of my research protocols, followed by a discussion of measures of quality and study limitations.

3.1 Researcher Positionality

Before discussing the methodological decisions of my research, I should first acknowledge that this research is not a neutral endeavor. The framing and design contain heavy undertones of activism for increasing access to higher education—undertones that culminate from my personal and relational experiences. My experiences cannot be “unknown” and undoubtedly shape my positionality as a researcher. Therefore, I transparently declare that my research aims not only to understand deeply rooted inequities, but to *challenge* them—to illuminate the voices and agency of engineering students from underserved backgrounds who navigate structural systems of oppression to persist in engineering. While my methodological decisions stem largely from the pragmatist paradigm—collecting whatever data are necessary to best answer my research questions (Creswell, 2013)—this research is also grounded in both critical and liberatory paradigms. By aiming to develop an understanding of deeply-rooted oppressive societal structures, this work embodies the critical paradigm (Creswell, 2013). On the other hand, my work is exploring the powerful, and—at times—transformative agency of students. In this regard, my research draws from liberatory frameworks, which “[empower] students to free themselves from and to transform oppressive institutions and social structures” (Secules, Sochacka, & Walther, 2018, p. 6). Because this exploratory research does not align perfectly with a single paradigm, rather than claim a paradigm, I will discuss my own my positionality by thoughtfully engaging in racial and cultural consciousness.

To ground my process of cultural consciousness in this research, I utilize Milner's (2007) framework for researcher positionality. Milner's (2007) framework is designed to assist researchers with being "actively engaged, thoughtful, and forthright regarding tensions that can surface when conducting research where issues of race and culture are concerned" (p. 388). Milner's (2007) positionality framework adamantly rejects the notion that researchers should uncouple themselves from the research process and doubts if researchers have the ability to do so. Milner's (2007) positionality framework asserts that I, as a researcher, must first pursue an intimate cultural and racial understanding of myself before I engage in research with various communities (Milner, 2007). In the following sections, I discuss my positionality as a researcher using Milner's (2007) framework, which outlines three dimensions to guide research inquiry: 1) researching the self, 2) researching the self in relation to others, and 3) engaged reflection and representation.

3.1.1 Researching the Self: Cultural Heritage

Dillard (2000) asserts that researchers "(re)search" themselves with every new research endeavor. Milner (2007) elaborates that until researchers liberate themselves, they cannot work to "solve problems with and on behalf of others" (Milner, 2007, p. 395). Therefore, I begin my positionality statement by using Milner's (2007) framework to engage in cultural reflection. Perhaps most pervasively, my heritage and world view are shaped by my Appalachian upbringing. Like many from my region, my family entered and never left, perhaps indicative of the deep "sense of place" Appalachians feel to the mountains where they are born (Elam, 2002). A full discussion of Appalachian culture is outside the scope of this chapter, though I do wish to highlight here a few aspects of the culture that, upon reflection, are most salient in my positionality as a researcher. Firstly, Appalachia is intensely collectivist, meaning that culture emphasizes "we" over "I". Unlike the broader United States, which ranks as one of the most individualistic societies in the world ("Country Comparison," 2018), Appalachian culture emphasizes interdependency, believing firmly that we are all connected. Interconnectedness shapes my inspiration for this research and desire to illuminate the experiences of underserved students. Additionally, because of my upbringing in Appalachia, I empathize heavily with regions that are geographically and/or socially isolated (Elam, 2002). Geographical and social

isolation, in my region, has resulted in a distrust of systems of power (Elam, 2002), and my experiences in my region no doubt shape my worldview.

Perhaps the most salient part of my cultural heritage is a painful familiarity with the injustices of poverty. In fact, some scholars assert that poverty remains the most persistent factor shaping Appalachia—more specifically, education in Appalachia. I do not wish to belabor the point, but here, again, I acknowledge my privilege. Though the generation immediately before me (e.g., my mother, my father) grew up in extreme poverty, my own nuclear family experienced economically stability, albeit within frugal economic means. However, my larger community was not economically stable. My experiences in my home community significantly impact the way I see the world and the things I believe are important. Recurrent encounters with poverty in my community shape my positionality as a researcher and the very nature of the topics, embedded inequalities and individual agency, that I am interested in studying.

3.1.2 Researching the Self in Relation to Others

Next, Milner's (2007) framework emphasizes the importance of the researcher reflecting on their relationship to the people involved in their research studies. This reflection is imperative due to embedded relational power dynamics and the danger of our own research agendas (Milner, 2007). In relation to others, I first wish to note my privilege in relation to systems of oppression in the United States context, and how my privilege impacts my relationships with my participants. At the time this research was conducted, I was not experiencing financial or material hardship. I navigate the world as a cisgender, able-bodied white woman, and I am not a first generation student. These intersecting privileges shape my relationships with my participants. I recognize racism, sexism, classism, homophobia, and ableism as adaptive systems that enact oppression. I do not believe I am exempt from these systems, but rather I remain unwaveringly committed to a lifelong process of critical reflection, working to transform my paradigms, continually identify my implicit biases, and actively work to interrupt systems of oppression, beginning with interrupting my own biases (DiAngelo & Dyson, 2018).

3.1.3 Engaged Reflection and Representation

With caution, I note that reflection on researcher positionality should occur continuously throughout the research process; it is not sufficient to write a positionality statement at one

moment in time. Instead, continuous reflection on my positionality, both written and non-written, independently and collaboratively, was a pivotal part of my research inquiry. To balance my own research agenda with the priorities of participants, I employed a few key strategies. To begin, all phases of the research design incorporated key stakeholders at the research location. My intention was to be as participatory as possible in every stage of the research process, ensuring that this research was both relevant and appropriate in the research context. Research protocols were reviewed by gatekeepers and modified as necessary to be appropriate for the context. Additionally, my interview protocols were narrative in nature, which inherently avoid leading questions to participants and instead empower participants to share their own stories (Kvale & Brinkmann, 2008). Most importantly, in order to balance my own research interests with the interests of gatekeepers and participants, my research process was grounded in continuous self-examination of racial and cultural consciousness.

3.2 Purpose of Inquiry

The purpose of this study is to explore how students from underserved backgrounds navigate their educational trajectories, focusing on the interplay between structures and agency. Accordingly, the overarching research question guiding this study is:

In their narratives, how do students from underserved backgrounds describe navigating their educational trajectories towards a bachelor's engineering degree?

The sub-questions guiding this inquiry are:

- RQ1: What strategies do underserved students use in pursuit of an engineering degree?
- RQ2: How do social environments (e.g., community, family, economic, political) shape the educational trajectories of underserved engineering students?
- RQ3: What critical incidents do underserved engineering students perceive to alter their educational trajectories?
- RQ4: What agency do underserved engineering students believe a bachelor's engineering degree will provide?

This research is exploratory in nature as it aims to interrogate the interplay between structure and agency in the educational journeys of underserved students. Through student narratives, this research aims to understand the barriers that engineering students encounter and the various agentic strategies that students use to negotiate barriers. Through a richer understanding of student experiences—including barriers and strategies to overcome barriers—this research aims

to contribute to efforts aiming to increase access to engineering for future engineering students from underserved backgrounds.

3.3 Introduction to Methodology

To explore these research questions, my study uses a single case study design with embedded units of analysis. I use case study research as a methodology, echoing Creswell's (2012) conceptualization of case study research as "a type of design in qualitative research that may be an object of study, as well as the product of inquiry" (p. 97). Similarly, my work aligns with Yin's (2009) definitions of case study research, which conceptualize case study methodology as "[investigating] a contemporary phenomenon within its real-life context, when the boundaries between the phenomenon and context are not clearly evident" (p. 23). Aligning with the pragmatist paradigm—which often supports collecting whatever data are necessary to best answer the research questions (J. Creswell, 2013).case study design is often characterized by the use of multiple sources of data (Creswell, 2012). As was discussed previously in this chapter, my methodological decisions stem largely from the pragmatist paradigm.

3.3.1 Appropriateness of Methodology

The single case study design with embedded units of analysis is appropriately aligned with my purpose of inquiry. In addition to providing methodological alignment to my research questions, advantages of the single embedded case study design include the ability to 1) study contemporary phenomenon within context and 2) conduct multilevel analysis. I will briefly outline the alignment of single embedded case study design with my research questions in the paragraphs below.

First, single embedded case study design provides an opportunity for studying contemporary phenomena *within context*. The methodology heavily emphasizes context, exploring contemporary phenomena within cultural, historical, social, economic, and political contexts (Stake, 2005). Recall that my exploratory research aims to understand the contemporary phenomena of the interplay between structure and agency in the educational journeys of underserved engineering students. I assert the phenomena of study is heavily influenced by context. Therefore, it is imperative to situate findings within the research context, warranting case study an appropriate methodology. As Stake (2005) elaborates, "each case to be studied is a

complex entity located in its own situation” (p. 12). For this reason, a single embedded case study design was chosen to situate the journeys of underserved engineering students within the research context.

Second, case study research is unique in its ability to conduct multilevel analysis (Creswell, 2012). Case study research can include analysis at the individual level as well as the institutional level, which aligns with my proposed research questions. In my research, analysis will occur at the level of the storyline elements (elaborated on in section 3.7), individual students, and across students at the level of the institutional context.

Finally, literature suggests that case study research may help connect the research-to-practice cycle. Describing the case context in rich detail is often useful for project stakeholders, offering insights that may be used to improve programs, policies, and overall experiences for engineering students from underserved backgrounds. In addition to contributing to gaps in current literature (see Chapter 2), I aspire for my work to be pragmatically useful for institutional partners, perhaps enabling a connection in the research-to-practice cycle. With this aim in mind, my work is integrating institutional partners at each stage of the research process to ensure that this research remains appropriate and relevant to the research context.

3.3.2 Single Case Study Design with Embedded Units of Analysis

The following sections will discuss the single embedded case study design, summarizing in Figure 7. Yin (2009) discusses five components of a case study research design, including: 1) research questions, 2) propositions, 3) unit(s) of analysis, 4) logic linking data to propositions, and 5) criteria for interpreting findings. In this section, I follow Yin’s (2009) recommendations by outlining my research design using components 1-4. I will discuss data analysis in section 3.7. I conclude this section by offering a discussion of transferability of this study, situated in case study methodological recommendations, as well as a brief summary of the relevancy of case study methodology for the proposed research.

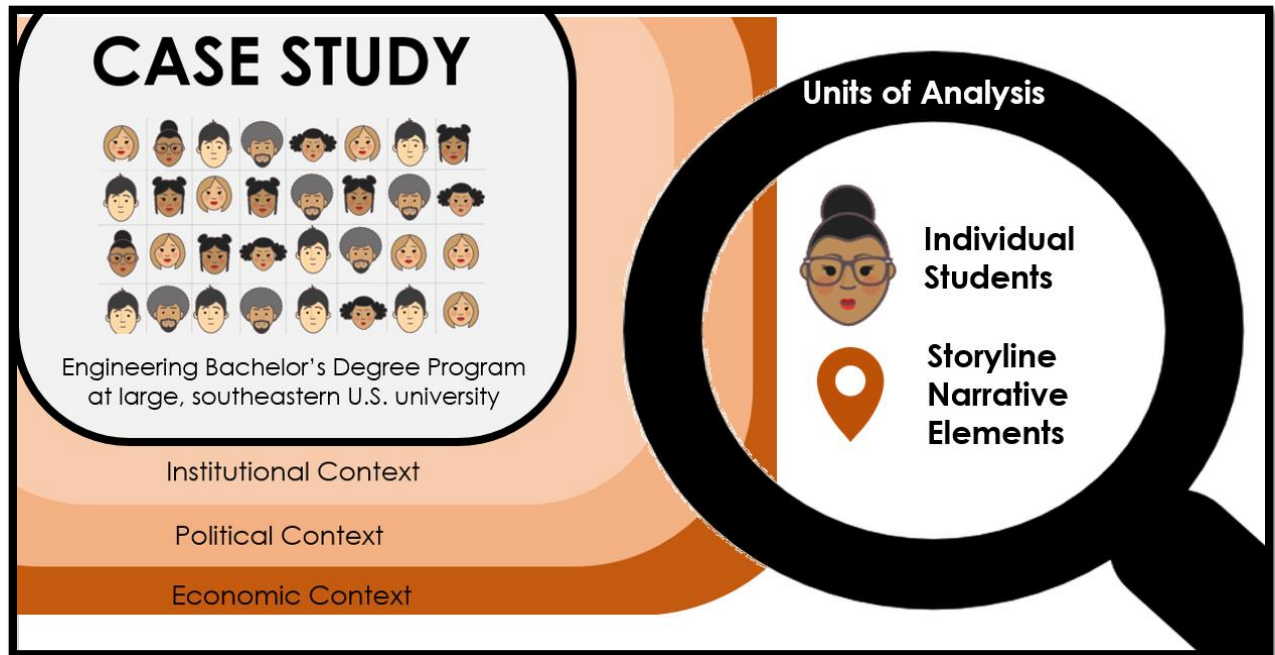


Figure 7. Summary of single embedded case study design with embedded units of analysis

Case Study Research Questions.

Yin (2009) notes that case study research must begin with an appropriate set of research questions, which typically take the form of a *how* or *why* question. Recall the overarching research question guiding my study: *In their narratives, how do students from underserved backgrounds describe navigating their educational trajectories towards a bachelor's engineering degree?* The sub-questions guiding this inquiry are:

- RQ1: What strategies do underserved students use in pursuit of an engineering degree?
- RQ2: How do social environments (e.g., community, family, economic, political) shape the educational trajectories of underserved engineering students?
- RQ3: What critical incidents do underserved engineering students perceive to alter their educational trajectories?
- RQ4: What agency do underserved engineering students believe a bachelor's engineering degree will provide?

This research is exploratory in nature as it aims to understand the interplay between structure and agency in the journeys of underserved engineering students.

As discussed previously, single embedded case study design aligns with several key facets of this research. Case study research, which allows the researcher to examine a

phenomenon in context (Stake, 2005; Yin, 2009), is particularly aligned with RQ3 which explore social environments (i.e., contexts) that influence the educational journeys of underserved engineering students. Case study research also enables multilevel analysis. My embedded single case study design permits two sub-units of analysis for each participant: 1) individual engineering students and 2) narrative storyline elements, which I operationalize as critical incidents in each student's narrative. Examination of the data at each level is imperative to capture the diverse experiences of individual underserved students, who are not a monolithic group and whose experiences are not homogenous.

In summary, the strengths of single embedded case study design—including the consideration of context, the ability to conduct multilevel analysis, and the pragmatism of individual case study reports as a stakeholder communication tool—are particularly well-aligned with my research questions. In summary, the single embedded case study design provides an opportunity to explore the interplay between structure and agency in the educational journeys of underserved engineering students.

Addressing Propositions and Linking Data to Propositions.

Propositions are appropriate for explanatory case study research (Yin, 2009). However, this case study research is exploratory in nature and therefore does not include a set of propositions. Instead, following Yin's (2009) case study methodological recommendations, this study explicitly defines a purpose statement. As initially discussed in Chapter 1, the purpose of this study is to explore how students from underserved backgrounds navigate their educational trajectories, focusing on the interplay between structures and agency.

Unit of Analysis.

A single embedded case study design was chosen because it enables two units of analysis for each participant: 1) individual engineering students and 2) narrative storyline elements, which I operationalize as critical incidents in each student's narrative. Embedded units of analysis were chosen to explore experiences within the journeys (i.e., within participants) and across the journeys (i.e., across participants) of underserved engineering students. Examination of the data at each level is imperative to capture the diverse experiences of individual underserved students, who are not a monolithic group and whose experiences are not homogenous. Recognizing the need to analyze data for each individual student, the embedded unit of analysis of *individual*

engineering student was included. Including the embedded unit of analysis at the individual student level allows this research to examine variation *within* context. The second unit of analysis will analyze data at the institutional level. By analyzing institutional level data, this research will examine barriers and student agency that may be unique to the institutional context. Importantly, both units of analysis refer to within-case comparison, where the researcher analyzes data within a given case and provides case context in reporting. This study will also include cross-case analysis, as addressed by research question 4. Through cross-case analysis, this study will compare and contrast the results from to research questions 1-3 across institutional contexts.

Bounding the Case.

Yin (2009) emphasizes the importance of bounding case study research in space and time. My research design bounds the case as the engineering bachelor's program at a large public research institution in the Southeastern United States. It is important to note that the case is situated within a broader institutional, political, and economic context, and also bounded by space as a function of its geographical location. Additionally, all data was collected between 2018 and 2019, bounding the case in time.

3.3.3 Data Sources

Case study methodology is often characterized by the collection of multiple sources of data to investigate the research questions (Stake, 2005). In alignment with the methodological recommendations for case study research, my research draws from multiple sources of data as outlined in Table 5. Narrative interviews constitute the primary data source. I also integrate quantitative community level data, screening surveys, and exit interview surveys for each student.

Table 5. Summary of Data Sources

Phase	Data Source	Description	Research Aim(s) Addressed
0	Understanding Context(s) of Access to Engineering Education	Document analysis; preliminary literature review; contextual review of case	Understanding context
		Informal focus groups with low income students at research site	Instrument and protocol development
	Instrument and Protocol Refinement Based on Context	Interviews with 2 engineering students	Instrument and protocol refinement
		Informal conversations with administrators at each site to refine survey and interview protocols based on context	Instrument and protocol refinement
1	Screening surveys <i>(Mixed Methods)</i>	In addition to serving as a source of data, surveys were used to recruit and select interview participants	Participant selection; Data for RQ1-RQ4
2	Interviews <i>(Qualitative)</i>	Conducted narrative interviews with 32 engineering students from underserved backgrounds to understand how students negotiate barriers and navigate the pursuit of an engineering bachelor's degree.	Data for RQ1-RQ4
	Exit Survey <i>(Qualitative)</i>	Students completed a voluntary exit survey with information about lived experiences with material hardship, including housing insecurity, food insecurity, access to healthcare, etc.	Data for RQ1-RQ4
3	Integrating Community-Level Data for Each Student	Pulled databases of census community-level data on poverty rate and college graduation rates for each student's zip code	Data for RQ1-RQ3

3.4 Research Context

The research context is a large, predominately white research institution in the southeastern United States with characteristics summarized in Table 6. The Institution is a land-grant institution with a tri-partite mission of research, teaching, and service. To protect institutional anonymity, numbers are approximated. At the time of this research, the institution served approximately 27,000 undergraduate students with approximately 8,000 enrolled in engineering degree-seeking programs. At the time of this research, the average net cost of attendance (including tuition, fees, room, board, etc.) for full, time in-state students totaled ~\$27,000 and \$46,000 for full time, out-of-state students. The institution offered 13 engineering bachelor’s degree programs, and across engineering programs the average time to degree was 4.25 years. At the institutional level, 14.7% of students were from underrepresented populations. Across engineering degrees, 10.7% of students were from underrepresented populations at the time of this study. Females represented 22.7% of full-time engineering students. At the time of this study, 17% of students at the institution received a federal Pell grant intended for low income students. Approximately 12% of students in engineering degree seeking programs were first generation.

Table 6. Description of Research Context by Institutional and Case Levels

Metric	Institutional Context	Engineering Degree Programs (Case Bounded)
Net Cost of Attendance, Full Time In-State		~\$27,000
Net Cost of Attendance, Full Time Out-of-State		~\$46,000
Number of Undergraduate Students	~27,000	~8,000
% Underrepresented Students	~15%	~11%
% Female Students	~43%	~23%
% Pell Grant Eligible Students	~17%	Not available
% First Generation Students	Not available	~12%

3.4.1 Gatekeeper Collaboration

Gatekeeper collaboration is crucial for conducting qualitative research (J. Creswell, 2013). The selected case represents an institutional context where I, the primary researcher, have

existing, sustained relationships with current gatekeepers. These relationships have been established and sustained through multiple years of engineering outreach and research endeavors. My dissertation research, therefore, is an extension of these relationships and a continued collaboration with my mentors and colleagues at the research site. The decision to explore cases with existing relationships is in alignment with Stake's (2006) recommendation to choose cases in a case study design that are most accessible. Throughout the design of this study, gatekeepers at the research site were consulted in order to ensure that the research contributes to institutional efforts in addition to its theoretical contributions. This research is intended to connect the research-to-practice cycle for supporting and increasing access for engineering students from underserved backgrounds. Gatekeeper collaboration was crucial for ensuring this research remained appropriate and relevant for the research context.

3.5 Data Collection

In the following sections, I describe each phase of my data collection. I began with foundational work, followed by screening surveys, narrative interviews, and exit surveys. I concluded my data collection by integrating community level geospatial data with each student's narrative interview.

3.5.1 Phase 0. Foundational Work

Phase 0 describes the initial work for this research study, focused on understanding the research context and refining protocols and instruments for the research context. In Phase 0, I conducted a *document analysis* and *literature review*, beginning by identifying potential cases based on gatekeeper collaborations and then reviewing literature and publicly available documents to better understand the prospective case. Additionally, I used informal focus groups with students from low-income backgrounds and informal interviews with higher education and K-12 school administrators as pilot sources of data to shape this research. In addition, I conducted pilot interviews with 2 engineering students outside of my target population. Through each of these processes, I refined my instruments and protocols to align more appropriately with the research context. The insights gleaned from Phase 0 formed the foundation for Phases 1-3 of this research study.

3.5.2 Phase 1. Participant Recruitment and Screening Surveys.

During Phase 1, I worked closely with gatekeepers (e.g., departmental contacts, student support program administration, and advisors) to recruit participants. Gatekeepers were contacted and asked to forward an initial contact email to students who met the inclusion criteria for the study, shown in Table 7. This initial contact email, provided in Appendix A, served to recruit participants by explaining the purpose of the study and inviting prospective participants to complete a screening survey. Participants were notified of research protocols and informed consent process in the initial contact email. The screening survey, provided in Appendix B, asked questions about students' agentic beliefs and perspectives and demographics, including the inclusion criteria for the study.

Table 7. Inclusion Criteria for this Study

Pell-Grant Eligible OR
First Generation (i.e., neither parent has received a bachelor's degree) OR
Self-Identify as Experiencing Material Hardship

In an open-ended question on the screening survey, students were provided an opportunity to share anything about their educational experience. On this open-ended question in the screening survey, two students who were not Pell grant eligible or first generation indicated that they were experiencing material hardship; therefore, these two students were included in the study. All other students who participated in the study were Pell grant eligible or first generation, in addition to experiencing material hardship in many cases. To characterize material hardship, I modified survey items developed by Mayer and Jencks (1989) for use in an exit survey in Phase 2 (see section 3.5.3).

My explorations of material hardship aim to create a broader definition of underserved and intentionally problematize the way economic disadvantage is viewed in higher education. In university settings, we tend to operationalize underserved status in two ways: parental educational attainment and Pell-Grant eligibility. However, such proxies for economic disadvantage are ridden with measurement error (Delisle, 2017; Neckerman et al., 2016). For example, when we operationalize economic disadvantage through Pell Grant eligibility, we exclude students who are at the margins of the "cut-off" for Pell-Grant eligibility. Similarly, parental educational attainment may speak to a family's familiarity with higher education

contexts, but it does not inherently speak to a student's lived experiences with economic disadvantage.

Still, it is worth noting that literature often discusses first generation college (FG) student status and low income background together, though these factors do not always intersect. One clear justification for this approach to operationalizing underserved status is that both low income backgrounds and FG status significantly impact access to higher education (Chetty et al., 2014; Terenzini et al., 1996a; Thayer, 2000). Furthermore, studies strongly suggest that low income backgrounds and FG status are often—though not always—interrelated; as a result, FG status is sometimes used as a proxy for low income (M. Strutz et al., 2012). Several longitudinal studies have reported that FG students are more likely to be from lower income communities/households than non-FG students (Nunez & Cuccaro-Alamin, 1998; Pascarella et al., 2004; Terenzini & And Others, 1996). For instance, a 1996 study found that only 5% of persons from families in the bottom income quartile complete a baccalaureate degree, compared to 74% of persons from families in the top income quartile (Mortenson, 1998). This example, however, confirms the issues raised about how we operationalize economic disadvantage, as evidence shows that students in the bottom income quartile (i.e., low income) are not always first generation.

Therefore, I use the term *underserved students* in a liberal way, including students who are first generation, Pell-eligible, or who self-identify as experiencing material hardship (e.g., housing or food insecurity). My intention with this broad definition is to critically examine our measurement of economic disadvantage while exploring students' lived experiences. Put simply, my conceptualization of underserved students avoids missing students “at the margin” of the measurement boundaries we have perhaps arbitrarily or bureaucratically drawn.

Due to the recruitment method for this study, which included collaboration with gatekeepers, I cannot determine the precise number of prospective participants that the invitation was sent out to. However, major gatekeeper collaborations on recruitment include: 1) sharing the invitation email with a need-based scholarship program for engineering students at the institution (~40 students); 2) sharing the invitation email with all departmental advisors; 3) student support administration sharing the invitation with work study students; and 4) emailing all first generation students in the institution's engineering degree programs (n=951). In total, 118 students completed the screening survey in Phase 1. Of these students, 66 met the inclusion

criteria for the study (i.e., first generation, Pell-Grant Eligible, or self-identified as experiencing material hardship). Participant selection is discussed in section 3.6.1.

3.5.3 Phase 2. Narrative Interviews and Exit Surveys

Students who met the study's inclusion criteria were invited via email to participate in a narrative interview (Appendix C). The interview invitation email described the narrative interview protocol and asked students to bring with them to the interview up to 5 photos (on their phone, laptop, or printed) that described their engineering journey. Students were informed that these photos would not be collected as official data, but rather would serve as a visual aid and communication tool in the narrative-style interview protocols. Narrative interviews were scheduled at the convenience of the participants in a conference room at the institution.

The narrative interview protocol, provided in Appendix D, followed modified recommendations for narrative interviews from Jovchelovitch and Bauer (2000). My modified four stage narrative interview process is shown in Table 8 below. Before interviews with participants, I examined students' answers to questions in the recruitment survey to develop questions for the questioning phase of the interview protocol and to help contextualize students' narratives. I then noted any questions based on each student's responses before the interview. Next, during the initiation phase, I asked students to describe their engineering journey through five pictures of their choosing. Participants were to bring images with them to the interview that they felt helped tell the story of how they navigated to engineering at university. The decision to use a visual aid in the initiation phase of the narrative interview is consistent with Jovchelovitch and Bauer's (2000) recommendations. During the participant's main narration, I did not interrupt or ask clarification questions. Instead, I only offered non-verbal cues to encourage the participant to keep telling their story. Lastly, during the questioning phase, I followed up on parts of the participant's story and ask any remaining questions.

Students images/photos were not collected during the narrative interview. However, my field note process including sketching each photo shared by a participant in order to recall the photo during analysis. An example of field notes is provided in Figure 8.

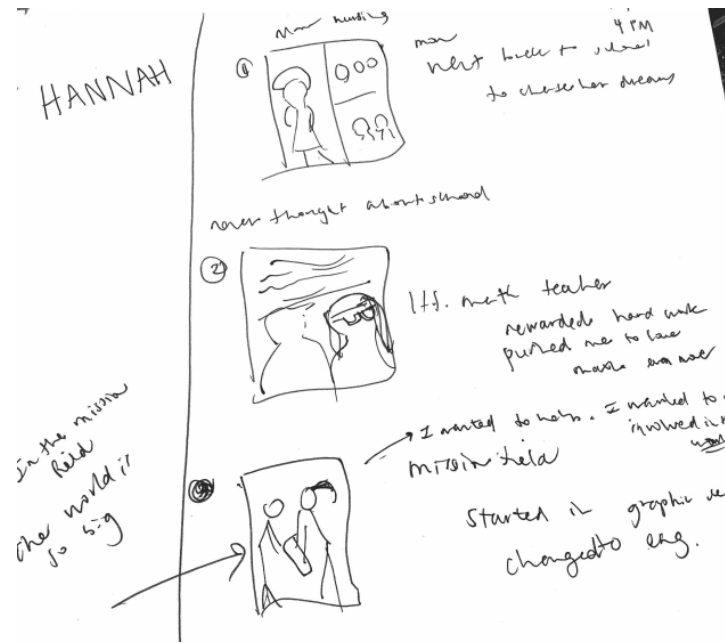


Figure 8. Example of Field Notes with Sketches from Narrative Interview

Table 8. Narrative Inquiry Phases (Revised from Jovchelovitch and Baeur, 2000, p. 62)

Phase	Description
Preparation	Prior to each interview, I explored the context and participant's survey responses. I formulated analytical questions specific for each participant for interview questioning phase.
Initiation	The narrative interview began by offering the initial topic for narration. Participants were asked to bring 5 photos (on their cellular phones, computers, etc.) that they felt shared the story of their journey to an engineering university program. The narrative interview initiation phase began with participants explaining their story using the photos as visual aids.
Main Narration	During participant's main narration, I did not interrupt or ask follow up questions. Instead, I offered non-verbal encouragement to encourage participants to continue telling their story. I noted questions to follow up in the next interview phase.
Questioning Phase	Following the participant's main narration, I followed up on their story by asking additional questions as needed (see protocol, Appendix II).

At the conclusion of each narrative interview, participants were provided an exit survey, provided in Appendix E. The exit survey allowed participants to choose their own pseudonym, if desired, and asked questions about experiences with material hardship. Questions about material hardship were included because commonly used metrics of socioeconomic disadvantage (parents' educational attainment, Pell Grant Eligibility) do not necessarily reflect an individual's lived experiences with poverty. Participants were also given the opportunity to refer the researcher to someone from their pre-college context (an adult representative, such as a teacher, coach, or family member) who they thought might help the research team better understand their story. Providing a community contact was optional for each student. This data was not used in my dissertation analysis but will be used for future work.

3.5.4 Phase 3. Integrating Community Level Data.

During Phase 3, I examined community level quantitative data for each student. Using the Opportunity Atlas (Chetty et al., 2018), which combines data from the National Census Bureau and American Community Survey, I created a database of geospatial data for each student. Specifically, I examined poverty rates and college graduation rates for each student's self-identified home zip code. I then leveraged analysis tools from mixed methods to create joint displays of qualitative data (students' narrative interviews) with quantitative community level data.

3.6 Participants

In the following sections, I discuss participant selection and participant demographics. As I discuss below, participants represent a diverse range of lived experiences in their academic, geographic, and economic backgrounds. In addition, participants represent diversity in race, ethnicity, and gender.

3.6.1 Participant Selection

Combined, 118 students completed the screening survey (Phase 1) for this study. Of students who completed the screening survey, 66 met the study's inclusion criteria (first generation, low income as defined by Pell Grant Recipient, or self-identified as experiencing financial hardship). All 66 students who met the inclusion criteria were contacted to participate in an interview. I contacted all students who met the broad inclusion criteria for this study in

order to seek a diverse range of student lived experiences and trajectories. Ultimately, 32 participants elected to participate in the narrative interviews in Phase 2 of this study. These students constitute the participants for this study. Demographic information for these 32 participants is discussed below.

3.6.2 Participant Demographics

In total, 32 participants participated in the study. Participant demographics are provided in Table 9. Students represented a diverse range of academic backgrounds. Students represented 10 of the 13 engineering degree programs offered at the institution, and some students were in their first year of study (i.e., general engineering program). Most students (20/32) were junior or senior level students, while 10/32 were in their first or second year at university. Two students requested that their academic level remain anonymous. The majority of students in this study (26/32) were first time college students directly from high school. However, six students were transfer students from community colleges.

Participants also represented a diverse range of geographic backgrounds, as shown in Figure 9. Most participants were from the United States, but one participant was an international student from China. An important caveat here is that this geographic background represents the permanent address the participant indicated as their “home” community. In essence, this zip code analysis is a “snapshot” of each student’s geographic background. This does not represent each participant’s geographic background over time, as many participants shared in their narratives that they had lived multiple places during their childhood. In addition, several students were first generation immigrants.

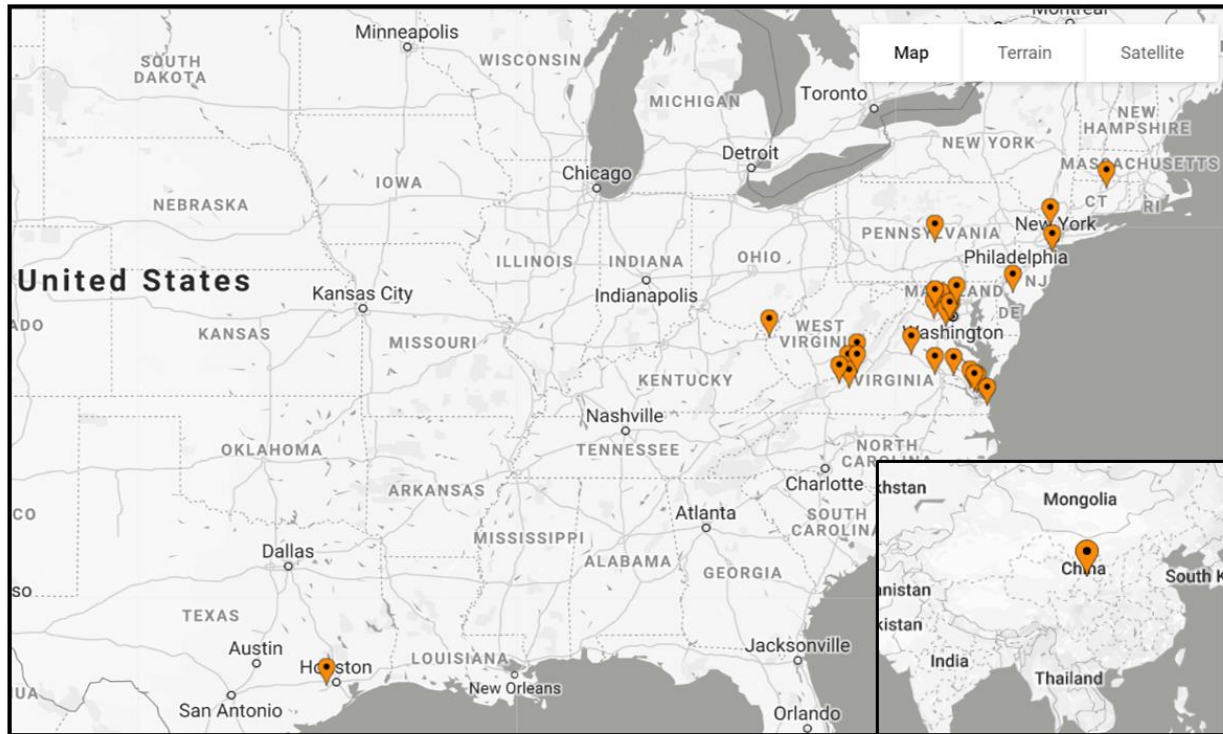


Figure 9. Participants represented a diverse range of geographic backgrounds.

As shown in Table 9, participants were diverse regarding self-identified race and gender. For race, participants were asked to select from the following list: American Indian or Alaskan Native; Black or African American; Hispanic or Latino; South Asian (e.g., Indian, Pakistani, etc.); East Asian (Chinese, Korean, Japanese, etc.); Southeast Asian (e.g., Thai, Vietnamese, Burmese, etc.); Middle Eastern or North African; Native Hawaiian or other Pacific Islander; or white. Participants were also provided the option to self-identify a race/ethnicity note specified through an open-ended question. Gender identity was self-reported through an open-ended question.

Participants also represent socioeconomic diversity, as indicated by metrics of Pell Grant Recipient and first generation college student. A majority of participants in this study (21/32) were working to pay for college. As shown in Figure 10, 75% (24/32) participants had experienced or were experiencing material hardship, a measure which examines lived experiences of economic disadvantage including housing insecurity, food insecurity, and access to healthcare.

Table 9. Participant Demographics

Race	
Afro-Caribbean	1/32
Black or African American	7/32
East Asian	4/32
Hispanic or Latino	2/32
Middle East or North African	3/32
Southeast Asian	1/32
White	12/32
Two or more races	2/32
Gender	
Women	18/32
Men	14/32
Socioeconomic Demographics	
Pell Grant Recipient	18/32
First Generation College Student	24/32
Working to Pay for College	21/32
Material Hardship (see Figure 10)	24/32
Academic Backgrounds	
First time college students directly from high school	26/32
Transfer students from community college	6/32
Year at University	
1 st	3
2 nd	7
3 rd	10
4 th	5
5 th	5

Material Hardship

24/32

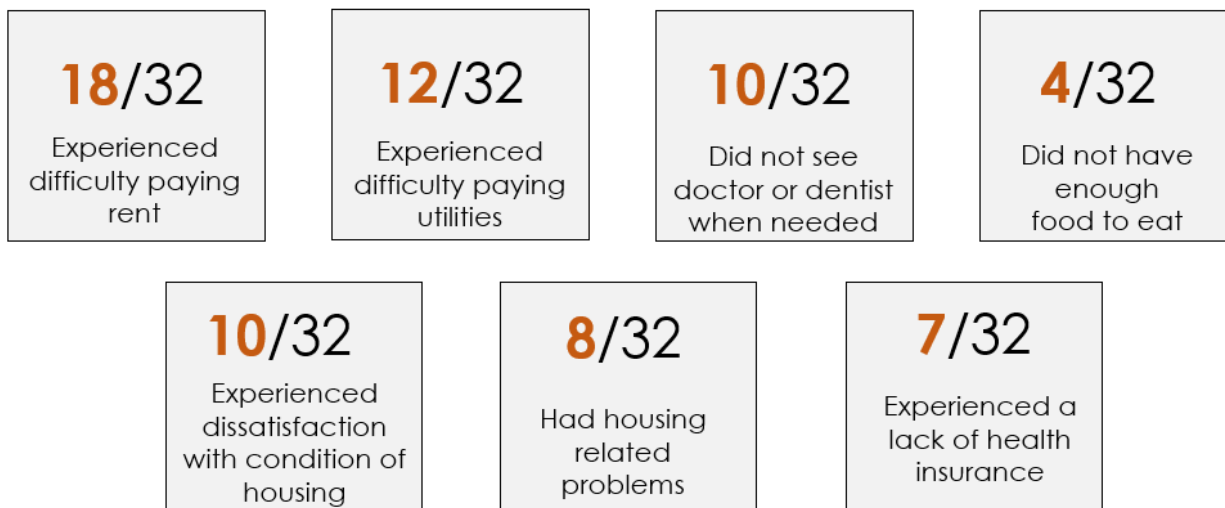


Figure 10. Participant experiences with material hardship

3.7 Data Analysis

In alignment with my research questions and narrative interview protocols, my data analysis was a recurrent process of constant comparative coding (Glaser, 1965) underpinned by narrative analytical tools. In Phase 1, I leveraged hybrid narrative coding schemes, including storyline coding, analytic storylining, and theoretical coding (Saldana, 2013). In Phase 2, I conducted narrative portraiture for each participant, creating a visual display of each participant's educational trajectory. In Phase 3, after all qualitative inductive data analysis was completed, I leveraged mixed methods approaches, including pattern coding, to create joint displays of students' home geographic economic disadvantage with narrative themes.

3.7.1 Phase 0: Familiarizing

Prior to initial analysis, each interview was transcribed verbatim by a third-party transcription service. To protect participant anonymity, identifying information was removed prior to initial analysis.

My analysis began in Phase 0 by familiarizing myself with the data. Due to the non-linear nature of narrative interview data (James, 2017), it was necessary to spend time immersed in each participant's interview. As shown in Figure 11, each participant's narrative was typically circuitous in nature, not chronologically ordered or following a set of predetermined questions. Therefore, it was imperative to spend extensive time engaging in what Barone (cite- in James, p. 456) calls "narrative construction"- a "recasting of data into a storied form [which] is more accurately described as an act of textual arrangement than of analysis."



Figure 11. Visual representation of structure of narrative data with field note sketches of photos shared by participants

My process of narrative construction in Phase 0 largely centered on drawing students' trajectories as a form of data analysis. An example of my analytical drawing process is found in Figure 12. In this process, I followed Zweifel and Wezemael's (2012) recommendations by using drawing as a qualitative analysis tool to foster diagrammatic thinking. As Zweifel and Wezemael (2012) note, visually representing data in diagrammatic ways is particularly useful during analysis of large, complex data sets. Diagrammatic representations of data aided my process of

meaning-making, providing a mechanism to maintain the complexities of each participant's narrative and avoid a reductionist approach to initial analysis (Zweifel & Wezemaël, 2012).

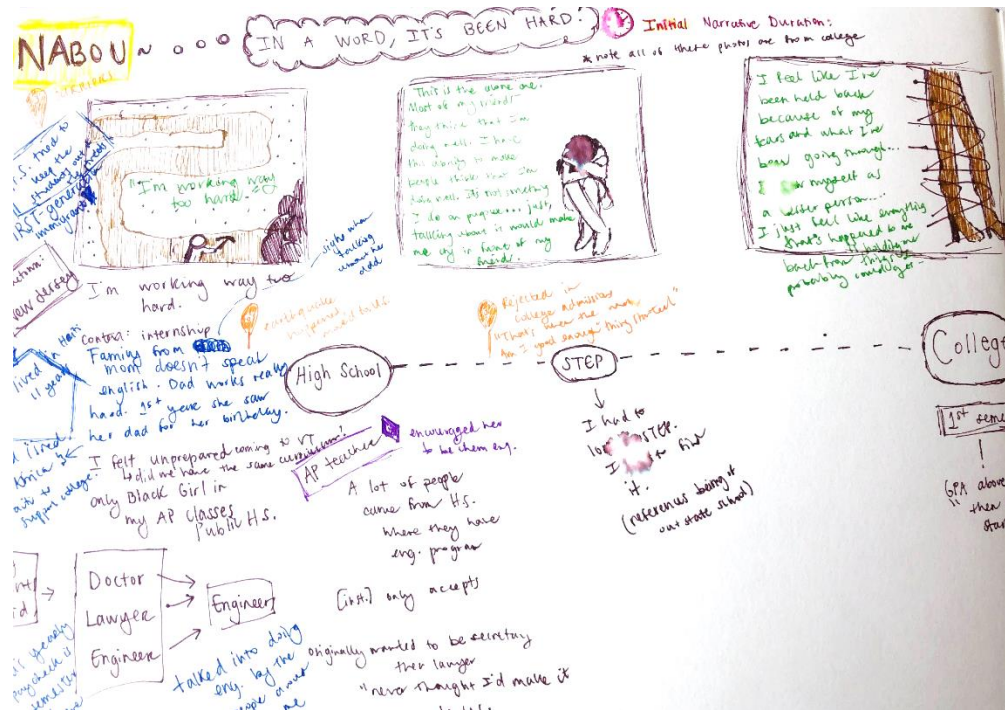


Figure 12. Example of analytical drawing process used in initial analysis of each narrative interview

3.7.2 Phase 1: Narrative Coding, Narrative Portraiture, and Theoretical Coding Schemes

In Phase 1, I inductively developed a hybrid narrative coding scheme to enable data condensation (Miles et al., 2013). The hybrid coding scheme, situated in larger data analysis, is shown in Figure 13. The foundation of Phase 1 was storyline coding (Saldaña, 2012), a narrative coding scheme that identifies, maps, and explores critical events in an individual's narrative account. Using storyline coding, I explored major events, epiphanies, and experiences that each student identified in their narrative as critical in their educational journey. I completed storyline element coding while listening to the recording of each interview. The audio component of data analysis was critical for my process, allowing me to note participants' emotions, pauses, redirects, and trail offs in the context of critical events in their journeys (James, 2017). Listening

to each interview during the hybrid coding scheme also enabled me to be fully present in the coding process, as recommended for narrative data (James, 2017).

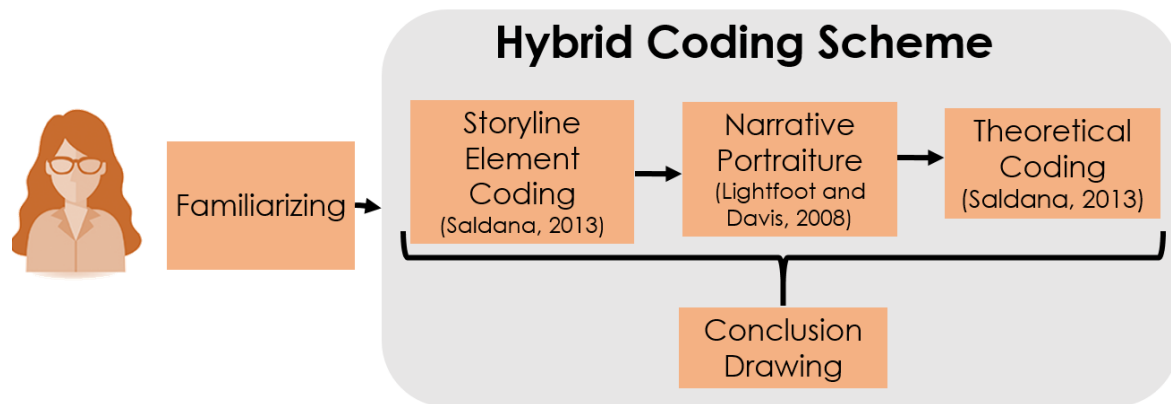


Figure 13. Hybrid coding scheme situated in broader data analysis plan

Next, I created narrative portraitures (Lawrence-Lightfoot & Davis, 1997) for each participant. An example of the narrative portraitures I created is shown in Figure 14. As a methodology, portraiture emphasizes consideration of context in meaning-making (Brooks, 2017). In addition, portraiture is simultaneously a form of inquiry, analysis, and documentation (Brooks, 2017). In my analysis, I used portraiture to systematically consider each participant's layered contexts alongside their storyline elements. In addition, creating narrative portraitures for each participant provided a tool to begin to systematically compare and contrast students' journeys.

Genesis // Engineering



Says "my path to get here was so different from everyone else's." Knew from the time she was 6 years old she wanted to leave her home community, "but people like me didn't do that."



Material Hardship



First Generation



Pell Grant Recipient



African American Woman



9th grade Math SOL: prior to this, wanted to study psychology. Teacher said, don't do that, hard to get job. Do engineering. Impacted her decision.
After this advice from her high school math teacher, went to talk to H.S. guidance counselor.
Researched engineering majors, decided civil was best fit.
Even as a little girl, would use her free time to build things. She reflects on turning a paper towel roll into a remote control
Took classes in summer bridge program at institution to help her be more academically successful
Reflects on how low income housing shaped her agency: "I don't want my children to live the same childhood I did."
never focused on career in HS. "My goal was to get really good grades so I could do whatever I wanted to do. "Reverse" from "I want to be an engineer therefore I'll get good grades."
Couldn't afford programs/events at school, and had limited transportation.
In H.S. was involved with ministry and initially wanted to build churches.
Now wants to work for FEMA, believes eng. will let her travel and design things, change things.
Most folks in home community wanted to stay. But at 6 years old she remembers that she knew she wanted to leave. But "it was hard to envision myself... because people like me didn't do that."
I knew I could do it, just hard envisioning myself.
decided to pursue engineering while at an art magnet high school... "everything I had planned for myself was different from the culture around me."
Couldn't go to eng. class- never heard about it and by the time she found out schedule was too full

Figure 14. Example of narrative portraiture created during analysis

After narrative portraitures were completed, I used theoretical coding in a second-cycle theoretical coding method. In my theoretical coding scheme, I used the Bourdieusian (1990) and Community Cultural Wealth (Yosso, 2005) theoretical lenses to analyze each critical incident identified in each student's educational journey. Put simply, I narrowed in on each critical incident and asked "what agency, structures, habitus, fields, and capital are at play in this critical incident?" Rather than apply these constructs deductively at the beginning of analysis, I used the theoretical frameworks as a lens for meaning making and drawing conclusions.

Throughout my analysis process, I engaged in constant comparative coding (Glaser, 1965) to continuously compare and contrast students' journeys. Using constant comparative

coding, I iteratively compared analysis from each interview to the subsequent interview being analyzed, inductively generating codes throughout. This process is outlined in Figure 15. Ultimately, by using constant comparative techniques, I inductively identified themes across students' educational trajectories.

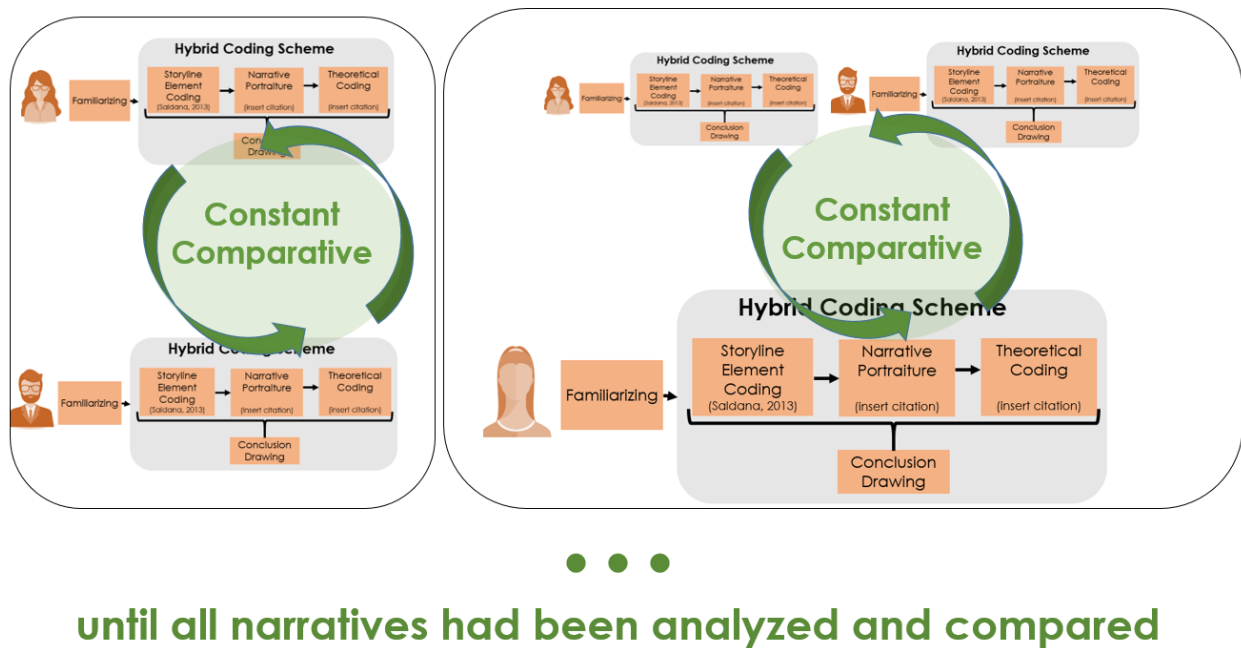


Figure 15. Visual representation of constant comparative coding scheme

3.7.3 Phase 2: Mixed Methods Joint Displays

During Phase 2, I examined community-level quantitative data for each student. Using the Opportunity Atlas (Chetty et al., 2018), which combines data from the National Census Bureau and American Community Survey, I created a database of geospatial data for each student. Specifically, I examined poverty rates and college graduation rates for each student's self-identified home zip code. I then leveraged analysis tools from mixed methods to create joint displays of qualitative data (students' narrative interviews) with quantitative community level data. Mixed methods joint displays provide a tool for systematically integrating quantitative and qualitative data in order to generate a meta-inference that would not have been possible with one strand of data alone (Guetterman et al., 2015). Joint displays are also powerful tools for helping the researcher see the data in a new lens and purposefully integrate quantitative and qualitative

data (Guetterman et al., 2015). Using joint displays, I searched for patterns in students' narratives based on students' home (geographic) backgrounds. An example of a joint display generated during analysis is provided in Figure 16. I elaborate on this joint display in section 4.3.2.

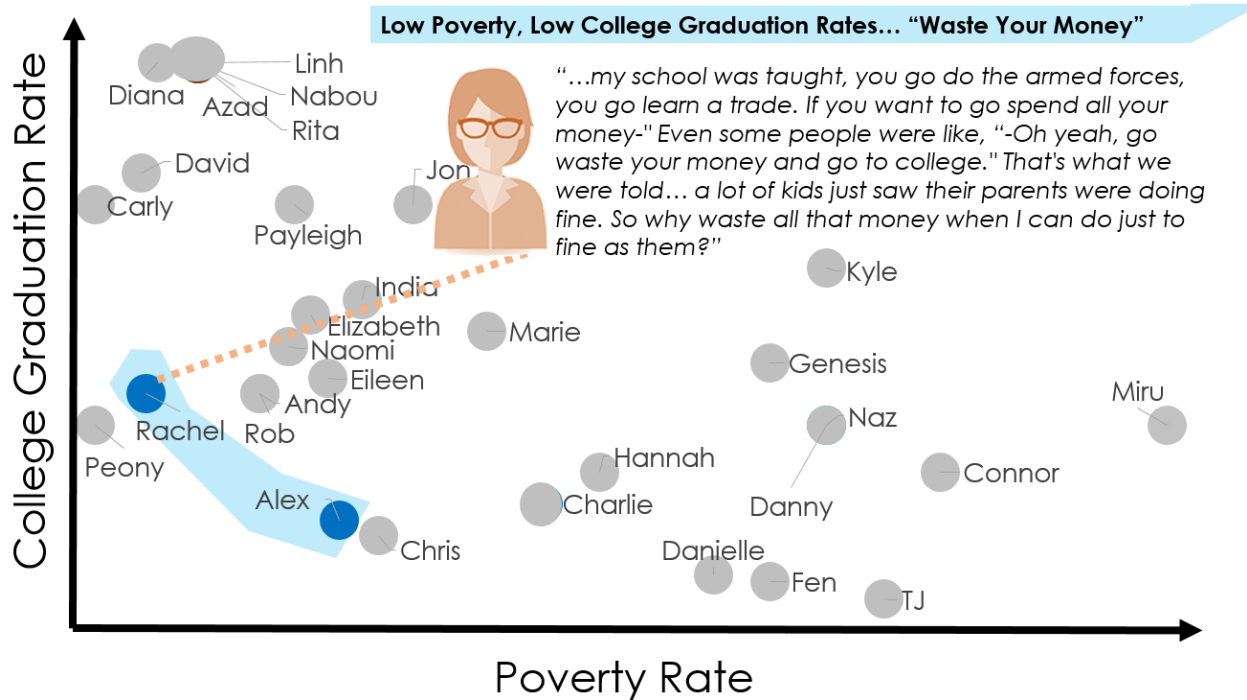


Figure 16. Low Poverty, Low College Graduation Rates... "Waste Your Money" joint display

3.9 Measures of Quality

Because my study uses qualitative inquiry, I follow Leydens et al. (2004) suggestions by discussing measures of quality in terms specific to qualitative work. Combined, measures of quality contribute to a qualitative study's *trustworthiness*, a term which is used to describe the extent to which a study meets criteria such as reflexivity, dependability, and validity (Borrego et al., 2009). *Reflexivity* refers to the researcher's examination and disclosure of in their bias(es) (Borrego et al., 2009). As a measure of quality, I have offered a statement of positionality (i.e., reflexivity) in section 3.1. Additionally, I used *peer debriefing*, which involves reviewing the research process with other researchers, to improve the trustworthiness of the study (Creswell, 2013; Leydens, Moskal, & Pavelich, 2004a). Peer debriefing helped ensure that my familiarity with the research context did not result in research bias (Creswell, 2013; Leydens et. al 2004). *Dependability*—often referred to as *reliability* in quantitative studies—refers to “consistency of the research findings” (Leydens et al., 2004, p. 70). Again, peer debriefing was used to ensure

dependability of results (J. Creswell, 2013). Lastly, my study uses triangulation as a measure of quality. Golafshani (2003) asserts that triangulation is an essential methodological issue that can mitigate bias and improve trustworthiness of a study. By using multiple sources of data, including student interviews, surveys, and community level data, I triangulated multiple information sources.

Finally, I followed the American Educational Research Association's (2006) recommendations when reporting research results by describing all sources of evidence in detail, including the research context, participants, and data collection processes. My case report for institutional gatekeepers focuses on creating a rich, detailed description of each research context, allowing "the reader to make connections between the study and his or her own situation" (Borrego et al., 2009, p. 57). By reporting rich descriptions of each case study, I contribute to my study's *transferability* (Leydens, Moskal, & Pavelich, 2004).

3.9.1 Researcher Bias

As I have previously discussed in section 3.1, this research is not a neutral endeavor, stemming from my personal and relational interests in access to higher education. My geographic region (Appalachia) remains underrepresented in higher education, particularly in engineering. The persisting challenges to college access are keenly felt by my home community; my experiences have created in me a sense of connection and community with other communities and populations that encounter significant college access barriers. My experiences undoubtedly influence my position as a researcher. Because my role as the researcher plays an instrumental role in this qualitative inquiry (J. Creswell, 2013), I have aimed to thoroughly disclose my positionality and how I addressed researcher bias in section 4.1. To briefly summarize how I have addressed researcher bias, I worked closely with other researchers, gatekeepers, and institutional partners in each stage of the research process to mitigate research bias. I also engaged continuously in culturally conscious reflection during each stage of my research process as recommended by Milner (2007).

3.9.2 Negative Results

At times, this research revealed negative results (e.g., results running counter to my beliefs) about increased access for underserved engineering students. For instance, some students

held negative views about their experiences, degree program, and/or institution. To minimize bias in the study and remain open to negative results, I established trustworthiness of data analysis by 1) using multiple sources of data to triangulate findings (Borrego et al., 2009); 2) debriefing study analysis and interpretations with peer researchers (Borrego et al., 2009); and 3) logging a detailed audit trail to link data and findings (Borrego et al., 2009). Additionally, questions in all research phases were open-ended to avoid influencing participants' responses (Patton, 2002). Lastly, participants' identities remain protected at all times to avoid repercussions of negative results (Yin, 2009).

3.10 Limitations

Case study research has inherent limitations that should be acknowledged. First, case study research can be resource-intensive because it requires in-depth data collection of multiple sources of data (J. W. Creswell, 2012; Stake, 2005). Creswell (2012) also notes the potential difficulty in establishing a clear rationale for purposeful selection of cases. Finally, Creswell notes that cases may be difficult to bound, particularly regarding time. To address the aforementioned resource limitation of case study research, I secured resources, including funding and time, to conduct this research within the proposed timeline. I also clearly bounded the case in space and time as the engineering bachelor's degree program in the research context with data collected between 2018 and 2019.

This study is also limited by self-selection of participations and limited to the institutional context. To address this limitation, I have provided detailed descriptions of the institutional and participants to aid with transferability of this study. Another limitation of this study is the retrospective nature of students' narratives. Lastly, limitations exist regarding the relational dynamics between the researcher and the interview participants. To address this potential limitation, I worked to build rapport with participants. I have also shared my positionality statement in detail in this chapter.

3.11 Research Ethics

All research protocols were approved by the [University Blinded] Institutional Review Board (Project #18-1058). Participation in this study was voluntary. Informed consent occurred before all data collection procedures. At the conclusion of narrative interviews, participants were

asked to choose a pseudonym for reporting of results. Personally-identifying information was removed from data to protect participant anonymity. In addition, as narrative interviews concluded, the researcher asked, “is there anything you shared today that you would rather not be included in reporting of this research?” This exit question provided participants with the opportunity to redact any information shared during the interview. Because many participants are from underrepresented populations at the research site, demographic information is presented in aggregate. Combinations of identities are not disclosed to protect student anonymity. By maintaining confidentiality, providing a risk assessment to each participant, and ensuring informed consent through each data collection procedure, this research follows Patton’s (2002) recommendations for ethics in qualitative research.

3.12 Summary

In summary, I conducted a single case study with embedded units of analysis to explore the overarching research question: *In their narratives, how do students from underserved backgrounds describe navigating their educational trajectories towards a bachelor’s engineering degree?* To examine this research question, I leverage case study methodology to conduct multilevel analysis and examine how underserved students navigate their educational trajectories within contemporary contexts. I collected multiple sources of data, including screening surveys, narrative interviews, and community level data in three phase research protocol. I developed a hybrid coding scheme, leveraging narrative element coding with theoretical coding to enable the development of thematic narratives across participants. To ensure quality of the study, I provided a detailed positionality statement, overview of research ethics, and triangulated data sources. I also engaged with gatekeepers throughout the research process to maintain appropriateness and relevancy of this study for the research context.

Chapter 4: Results

4.1 Introduction

As noted, the purpose of my study was to explore how students from low income and/or first generation (underserved) backgrounds navigate their educational trajectories in pursuit of a bachelor's engineering degree. To address this purpose, my study was guided by the overarching research question: *In their narratives, how do students from underserved backgrounds describe navigating their educational trajectories towards a bachelor's engineering degree?* Using a single case study design with embedded units of analysis, I conducted narrative interviews with 32 underserved students at a single large predominately white institution in the Southeastern United States. By integrating students' narratives profiles with community-level quantitative data from federal censuses and surveys, I explore multiple sources of data. I used a Bourdieusian framework to explore the following questions:

- RQ1: What strategies do underserved students describe using in pursuit of an engineering degree?
- RQ2: How do social environments (e.g., community, economic, political, etc.) shape the educational trajectories of underserved engineering students?
- RQ3: What critical incidents do underserved engineering students perceive to alter their educational trajectories?
- RQ4: What agency do underserved engineering students believe a bachelor's engineering degree will provide?

In this chapter, I describe my results for each research question. In-depth analysis of narratives reveal a variety of strategies leveraged by underserved engineering students to plan, optimize, and—at times—redirect their educational trajectories (RQ1). Students clearly discuss social environments, including family, community, institutional, economic, and political environments, as significant and distinct influences on their trajectories, with emergent findings about the impact of contemporary economic and political rhetoric on their experiences pursuing an engineering degree (RQ2). Additionally, students' narratives highlight the dynamic nature of social environments, with students' trajectories changing based on critical incidents (RQ3) such as moving to a new social context (e.g., first generation immigrants) or a change in economic situation (e.g., loss of job). Finally, underserved students hold various beliefs about the agency

an engineering degree will provide, include opportunities for upward mobility, societal prestige, and freedom to pursue work they find personally meaningful and interesting (RQ4). In the following sections, I provide further detail about each of these main findings.

4.2 Agentic Actions of Underserved Engineering Students (RQ1)

Underserved students narrate a number of proactive, intentional agentic actions used in their past endeavors or present pursuit toward the bachelor degree in engineering. Using the concept of path planning, I illustrate the four emergent themes of agentic actions narrated by underserved students. Path planning is a form of motion planning where an “end point”, or goal destination, is first determined by an agent. Subsequently, an algorithm calculates the optimal route to the goal destination from the agent’s current location. Importantly, the algorithm’s parameters for optimization are also determined by the agent; for example, an agent could elect to choose an optimal route based on shortest time to the goal destination, fewest stop signs, lowest traffic, etc. Readers may be familiar with the concept of path planning from mapping applications such as Google Maps and Waze, which allow a user (i.e., an agent) to optimize their travel routes according to desired optimization functions.

In this same way, as underserved students recount the narratives of their educational trajectories, distinctive trends in path planning emerge. Using “path planning” agentic actions, underserved students set clear “goal destinations”—both within and outside the context of pursuing an engineering degree. After setting distinct “goal destinations,” students enact agency to strategically map and re-map “optimal” paths to their goal destination based on a host of factors, such perceived attainability of the goal destination, shifts in perspective about desirability of the goal destination, or—in some cases—the desire to intentionally leave multiple options open as they move along their trajectories. My analysis here focuses on the Bourdieusian idea of agency, and I also use the Bourdieusian lens to examine the constant negotiation of agency within structures, socioeconomic and otherwise. After all, to quote Stahl (2015), “agency is, according to Bourdieusian logic, not reducible to structures; it is not determined by experience, but it is constrained by it (p. 25).” To be clear, I explore path planning strategies with the understanding that an individual’s path planning strategies are in constant negotiation. I view the path planning strategies discussed here as students’ reflections on their negotiations of agency with the constraints of their experiences. In the following sections, I illustrate four

distinct path planning agentic actions that underserved engineering students recount in their narratives.

4.2.1 Dreaming and Contingency Path Planning.

The first path planning actions fall under the category I term “*Dreaming and Contingency Planning.*” In this type of path planning, visually represented in Figure 17, students actively set a goal destination, such as “attend a top-rated engineering institution.” Many students describe mapping a direct or “dream” path to their end goal, while sometimes also developing a contingency plan—active strategies to pursue an alternate path if the “dream” path to their goal destination was impassible for any reason, real or perceived.

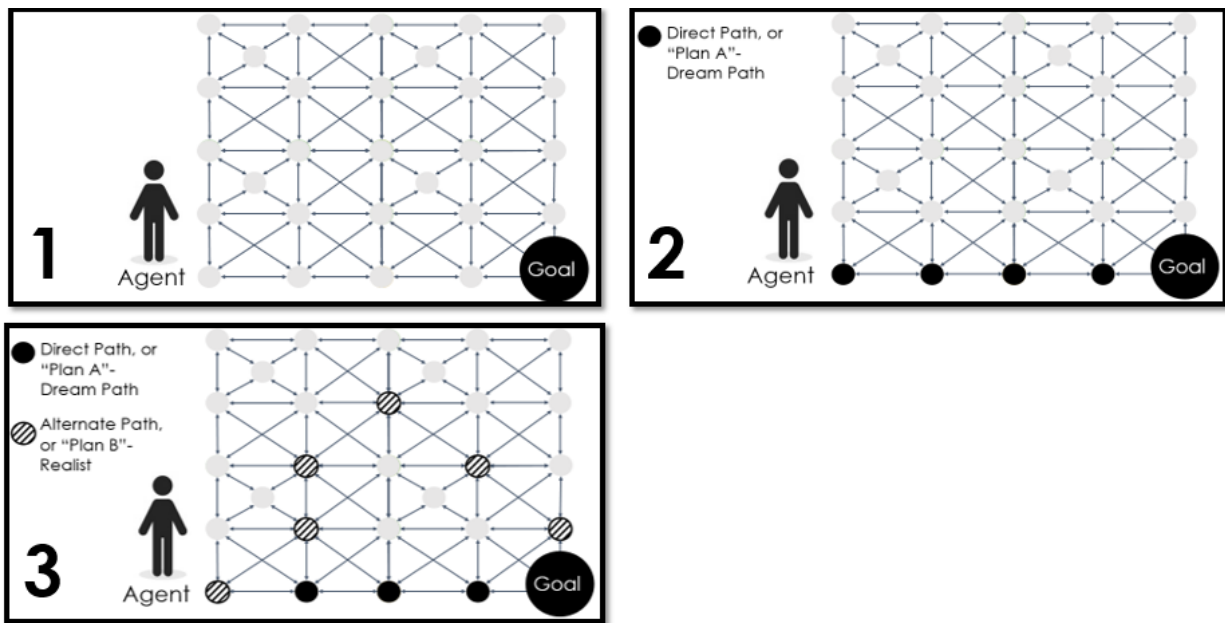


Figure 17. Dreamer and Contingency Planning. After setting a goal destination, students map direct and circuitous pathways to their goal.

Students tended to reflect on their contingency plans when describing their past educational trajectories, particularly when describing their process of applying to engineering programs at selective institutions. For example, TJ reflects on setting a resolute goal in high school to eventually attend the top-tier engineering program he was enrolled in at the time of his interview: “So, it sounds bad, but I only applied to [top choice institution] as an early acceptance, and it was the only college I applied to... only place I wanted to go.” While receiving his bachelor’s degree from this institution was his unwavering goal, he also planned alternate routes to reach his goal:

But I had a back-up plan, if I didn't get accepted to [top choice institution] I would continue my time at our local community college and get my Associate's and then transfer into [top choice institution], because of the guaranteed acceptance with local community colleges in [state]. After that time, I applied and then I just kept doing my best and working, studying, and trying to help out when I can until I heard the news [that I was accepted].

Of note here is that, like TJ, many students in this study credited the state-level transfer policy for community college students (guaranteed admittance after 2 years with minimum GPA) as a salient factor in their contingency path planning.

Most often when students discussed contingency planning it was in the context of career planning, or planning for life after the bachelor's degree. Several students reflect on aspiring towards a specific career in industry, with a direct plan to get there and a contingency plan to get there eventually, even if in a circuitous manner. Azad, a software engineering student, reflected on his aspirations to conduct research in the area of artificial intelligence (AI), calling research "so much more satisfying" than other career avenues. He says, "If I was in a position right now where money wasn't an issue, I would probably love to research AI simply because it's such a fast-growing field. It's just so exciting to talk about." For Azad, pursuing a career in artificial intelligence research is his dream path. However, he believes that conducting artificial intelligence research requires a post-graduate degree, which he describes as a "financial opportunity cost." He therefore develops his contingency plan:

I am probably just going to look for a traditional software engineering role after next semester. So I'm talking to a few companies right now and I'll probably just take the best offer I can and then maybe save up a little bit of money and I am going to apply [to graduate school] in the fall, which would put me into, the applicant pool that will start next fall. That would be working for six months or so. Alternatively, I would be open to maybe working in a year or two and I'm applying [to graduate school].

Through Azad's narrative, we glimpse his unwavering goal destination, to work in artificial intelligence research. As he considers how to best reach his goal destination, he reflects on direct path planning and contingency planning, mapping a circuitous route to reach his goal destination.

In a similar way, Genesis talks about her "dream job" in civil engineering:

I would like to work for an organization like Habitat for Humanity, or maybe FEMA. I just want to be able to work in communities. I can't really say that I've ever been super involved in my immediate community outside of ... Through school. But I think it would be ... I don't know, I think it would be a nice balance of getting to know people and then also being able to be an engineer and give back.... My dream job would be, where I could

travel, and get to know these communities, but still be innovative and not just come with a set blueprint.

Like Azad, she is conscious of barriers on her trajectory that may make a direct path to her “dream job” difficult. Contrary to Azad, however, she does not map out overt circuitous routes to her ideal career, but instead discusses her plans at a broader level:

...like I said, there are a lot of barriers in my life, but I'm still holding on to that dream career. And even if that doesn't happen, I still know what I want to do, and I know [studying engineering] is a great way to get there.

In this quote, we see Genesis sharing her certainty that her choice to study civil engineering will eventually—even if via a roundabout trajectory—enable her to pursue her dream career of working with communities.

Through various segments of their educational trajectories, students’ narratives reflect *dreamer and contingency path planning*. This emergent theme in path-planning actions describes students’ retellings of setting an unwavering goal destination followed by planning direct and circuitous routes to reach their goal destination. Students most frequently discussed dreamer and contingency path planning in their college application and choice processes, as well as their career planning for life after completion of their bachelor’s degree.

4.2.2 Rerouting Paths.

A second theme in path planning was *rerouting to a new goal*, visually summarized in Figure 18. In this set of path planning actions, students would set a goal destination, and map a route to their goal. As the student begins to move along the mapped route to their goal, they acquire more information about the goal destination. Once acquiring more information, students tended to respond in one of two ways. For some students, acquiring additional information about their original goal as they moved along their planned route led to the epiphany that they no longer wanted to move toward that destination. In these scenarios, students completely rerouted, or set a new goal destination and rerouted their paths accordingly. For other students, acquiring additional information did not change their long-term goal, but instead resulting in them realizing that their planned path would not help them reach their long-term goal. These students also change to reroute their paths towards their unchanged long-term goal.

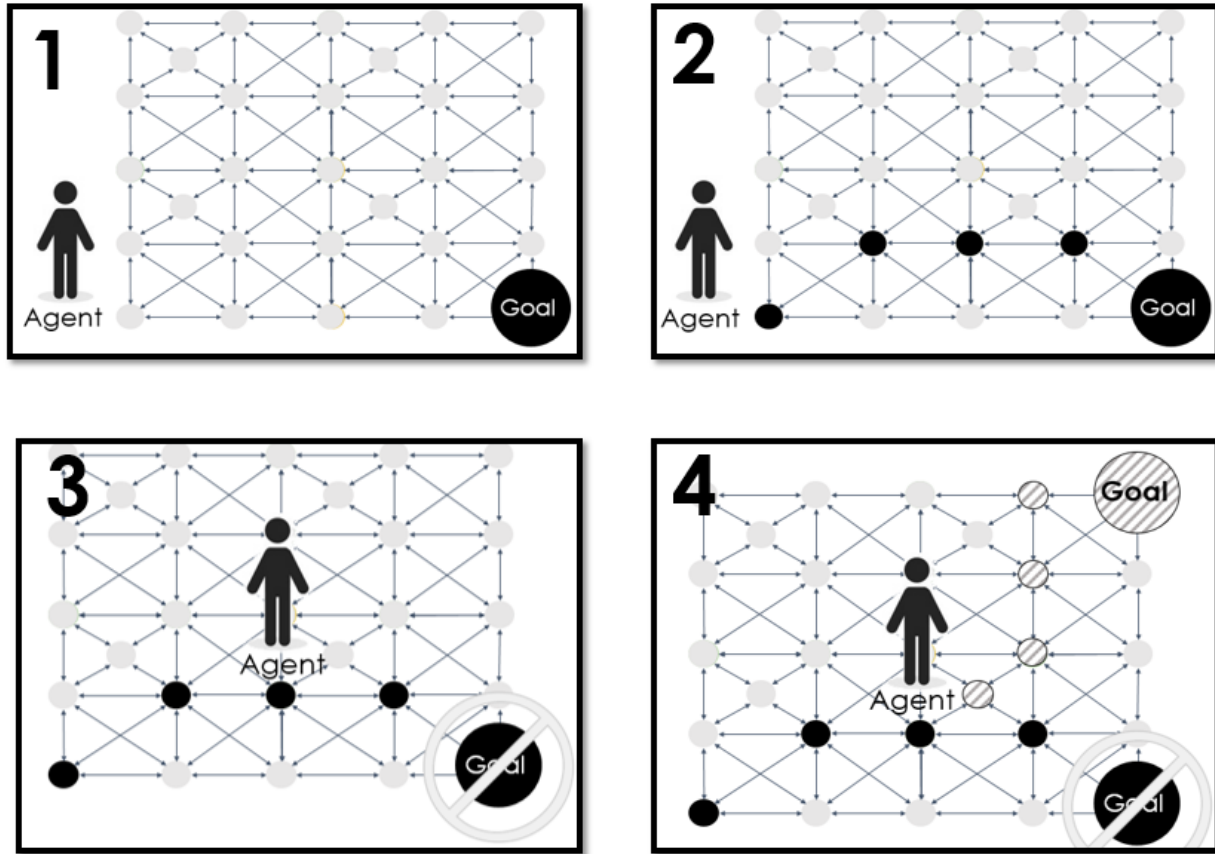


Figure 18. Rerouting paths. As students move along their trajectory to their goal destination, they acquire more information about their long term goal. This acquisition of new information results in students changing their long-term goal and rerouting their path.

The *rerouting paths* actions were most salient in students' narratives immediately prior to or during their time at the four-year institution that served as the institutional context for this case study. In several narratives, students discuss rerouting their paths in the context of changing majors, or deciding that the major they had originally intended to pursue was no longer their goal destination. In the context of engineering, students reflected on switching majors in two distinct ways: 1) transferring to engineering from a science degree program, or 2) switching majors within the College of Engineering. In both of these scenarios, students decided to switch majors because of increased financial or flexibility opportunities. The narratives of Jon and Andy provide two salient examples of *rerouting paths* towards a new major. Jon originally entered his institution as a biology major, but later decides to reroute to engineering because he desired more flexibility in his career path. He shared:

I had always thought I wanted to be pre-med or doctor, physician and that just seems like the generic logical approach if you want to go to med school, Bio major. That's just what everyone thinks, that you need to be here, just what makes the most sense, that's why I originally applied as Bio. Then I realized maybe I don't want to be a doctor, go to med school or ... so I wanted to change it to something that could give me more flexibility or freedom and potential career.

Jon, who starts out in a science degree program, decides to transfer to engineering because he perceives engineering will provide increased flexibility in career opportunities. In contrast, Andy begins his journey in the College of Engineering but decides to switch to an alternate engineering major, perceiving more lucrative financial opportunity. Though originally enrolled in biological systems engineering, he rerouted to chemical engineering after talking to industry recruiters at a career fair. After sizing up his job prospects at the career fair, he decides “*you can do the things that a [biological systems engineer] can do as a [chemical engineer], but I don't think you can do all the things that a [chemical engineer] can do as a [biological systems engineer].*” He elaborates “*chemical engineering had a lot better recognition than compared to [biological systems engineering]. There [were] more jobs, and more jobs equals more money.*” He concludes that he can more efficiently reach his long-term goal of a financially lucrative career by pursuing chemical engineering.

Charlie’s narrative reflects another salient example of switching majors, though his journey is unique as he reroutes from a four-year institution to a community college after becoming unsure of his long-term goals. Charlie had always aspired to study physics in college. He reflects on his aspirations in high school:

I guess going back probably high school is when I really kind of ... is I guess when anyone gets interested in where they wanna go to college, what they wanna do, things like that. And it wasn't always originally engineering. I had a personal interest always in science and things like that, sort of how things work, like an innate curiosity about things I see. And so I initially wanted to go into physics, cause I was really drawn to the high level of ... like theoretical physics, like study of the universe, things like that, I was really interested in... In my senior year in high school, I actually ... I was mostly decided on physics. I thought I wanted to go into physics.

Due to his personal fascination with physics, Charlie applied to physics programs at several institutions during his senior year. To his delight, he was accepted to the physics program at his top choice institution. However, when he came to tour the institution’s physics program after being accepted, he acquired new information:

I came to [institution] to look around, see what the campus was like, but just wasn't entirely sure that was the right step, so I ended up going to a community college near [home community], [local community college], to really see ... to get more exposure to both physics and engineering before I could determine what I wanted to really go into.

He later elaborates on the new information he acquired during his tour of the institution (e.g., tuition cost, ability to transfer majors) and how it shaped his decision to attend a local community college and explore both physics and engineering:

Mostly it came down to cost, really...because I came here, I was physically looking around the physics department, things like that, and I asked, 'Say I come to [institution] with the expectation of pursuing physics, and then at some point in time, I want to change to engineering?' And the response to that was, 'Yeah, that's really, really hard to do. We have students with 4.0 GPAs in the physics program that wanna do that, and it's just not ... Not everyone can do that. It's really hard to do once you're in major.' So that was definitely probably the biggest thing. I didn't want to come to [the institution], be stuck in a program that I didn't entirely want to do ... The best other alternative would be going to a two-year school, getting more exposed to both physics and engineering, and then being able to say, "Hey, this one is for me." Save the money while doing so, and then know for sure what I wanna do.

Charlie's narrative is unique because as he acquires more information about his goal destination, he becomes less certain that he wants to pursue that goal. As he mentions, he doesn't eliminate that goal, but instead decides he needs to reroute his path and explore his options in community college before narrowing in on his physics goals exclusively.

In contrast, other students do reflect on eliminating their original goals and rerouting their paths accordingly. In these situations, as students moved along their planned trajectory, they acquire more information about their goal destination and become absolutely certain that they no longer wish to pursue this path. A salient example that emerged for one participant, Naomi, was deciding to reroute their paths after realizing she no longer wanted to commission with the Reserves Officers' Training Corp (ROTC). Naomi had always dreamed of commissioning as an officer in the Air Force. She shares:

Okay, so my freshman year, I actually started off with ROTC my first semester. I guess that was another thing as well was the ROTC scholarship was also involved on top of a couple of other scholarships. I was like, "Okay, I'm actually going to do mechanical engineering, and I'm going to be an ROTC in the Air Force. I'm going to be an officer when I graduate," and all these things... that was originally my plan, mechanical engineering, and I would be in the Air Force and would be an officer. I don't know what exactly I would be doing, but that was my vague plan of what I would be doing.

In this glimpse of Naomi's narrative, Naomi shares that she had set her goal destination on commissioning as an officer in the Air Force. To reach this goal destination, she had routed a path that included participating in the ROTC program at her institution. However, soon into her high school to college transition, she decided to shift her goal destination and reroute her path:

My first semester, I took 19 credits on top of being an ROTC and on top of being a freshman, because I had this high sense of self, because I was very successful in high school. I was taking a bunch of classes in high school too. I think I took seven classes at school plus two classes online. I did fine. I got A's on all of them, so I thought, "Okay, college is going to be the same way." But no, it wasn't. I struggled a lot. I still made good grades, but I basically had no life my freshman year.

I ended up making the decision of dropping out of the [ROTC] at the end of my fall semester, because the stress was just getting to be too much. I literally got no sleep, because I would go to bed probably at 12:00 or 1:00 in the morning, because I would ask permission from my upperclassmen, the higher ranked [ROTC members] to stay up later so I could finish up all my homework, because I was taking 19 credits. They would allow me to do that, but I was basically doing that every single night. You have to wake up at 4:00 in the morning to get ready to go do [physical training], so I was sleeping only three or four hours every single night.

It got to the point where I basically had an internal breakdown with my parents, and we had a serious talk, and I said, "Something's got to give. I either have to drop credits or I have to drop out of ROTC. It's already my first semester, but I'm already worried that I'm failing." So we decided that I'm just going to drop ROTC, especially because I realized while hanging out with my other ROTC peers that I just didn't share that passion for the military that everybody else did. Everybody would be so excited talking about the different planes and whatnot, because I was Air Force ROTC, and a lot of them had pilot dreams. I was just there sitting like, "Okay. I'm not really that interested in this conversation and military in general." That's when I realized, "Okay, this is probably not the path for me.

In this passage, Naomi shares a number of factors that influenced her decision to shift her goal destination and reroute her path. These included a heavy academic work load, intensified by the ROTC program time commitment, and a realization that her long-term interests did not align with her ROTC peers' interests. Naomi's narrative excerpt also reflects her family's instrumental role in her decision-making, evident in the collective language she shares in "we decided that I'm just going to drop ROTC" (emphasis added). Combined, these influences led Naomi to modify her long-term goal of commissioning in the Air Force and reroute her goal accordingly.

Miru shared a similar experience rerouting from an ROTC program, though, unlike Naomi, she never intended to commission as an officer. Instead, she originally joined the ROTC program because she believed it would help her develop professional skills. She shared:

So, I chose [current institution]. I came here. I don't know if this really relates to the story, but I was in the [ROTC] when I first started out. Obviously, I am no longer in it. I dropped after the bad phase, which is this first six weeks of school and that was because I knew that I wasn't going to be an officer. I had no intentions of becoming an officer. I just joined because I wanted to try it out, and I felt like it would build discipline and the time management skills.

Miru's motivations for joining the ROTC program were focused on developing professional skills, and Miru believed having strong professional skills would help her reach her goal destination. However, as she continued on her planned trajectory by enrolling in the ROTC program, she determined that remaining enrolled in the ROTC program would be counterproductive to her long-term goal.

I found out that it wasn't really for me, and it was taking away time for me to study. I was physically very tired. It's not entirely about the [ROTC program], but I knew that I wasn't going to succeed academically if I stayed in the [ROTC program]. And my primary focus was academics and was engineering, so I decided to disenroll.

While the accounts of Miru and Naomi share some common storyline elements (e.g., physical exhaustion, demands of academic work load), we also see distinct differences in their choices to reroute their paths. For Naomi, commissioning as an officer in the Air Force was her long-term goal, and her choice to reroute her path was sparked from a direct change in her long-term goal (i.e., she no longer wanted to commission). In contrast, Miru's long-term goal of completing her engineering degree never faltered. Instead, she decided that her path in the ROTC program was counterproductive to her long-term goal and therefore rerouted her path, remaining resolute on her long-term goal.

Lastly, for some students, pursuing higher education in and of itself was a direct result of shifting their long-term goals and rerouting their paths. For example, Azad had always planned to forego higher education, questioning “*what's the point of secondary education and post-secondary education... What's the end game for a lot of people going through the pipeline?*” Azad shares he “*didn't really acknowledge the [education] system as being worthwhile*” and

therefore “[*didn’t*] want to participate in this system.” He decides to pursue online marketing as a career, but reroutes to higher education after a community college teacher encourages him to consider a different path. Similarly, during his senior year of high school, Alex questions if higher education will really “*make a difference*” in his job prospects because “*no one’s hiring and everyone’s being laid off.*” He decides pursuing higher education would be a waste of time and money, affording him a “*piece of paper that isn’t going to do [me] anything.*” He originally begins his career working in the mines but eventually becomes disappointed with that path. He then sets a new long-term goal for higher education and reroutes his path, through a community college and ultimately to a four-year institution.

Ultimately, *rerouting paths* emerged as a path planning strategy most saliently in the contexts of deciding to pursue higher education, changing paths to long-term career goals (i.e., exiting the ROTC), or changing majors once in higher education.

4.2.3 Leave Multiple Doors Open

In a third theme of path planning strategies, students focused on *leaving multiple doors open* for their future careers, as shown in Figure 19. In this theme, students planned their trajectories based on their strategic desire to keep an array of long-term options open for themselves. Students reflected on planning their paths to leave multiple doors open in three distinct ways: 1) academic achievement in high school; 2) pursuing higher education broadly, and 3) specifically, an engineering degree.

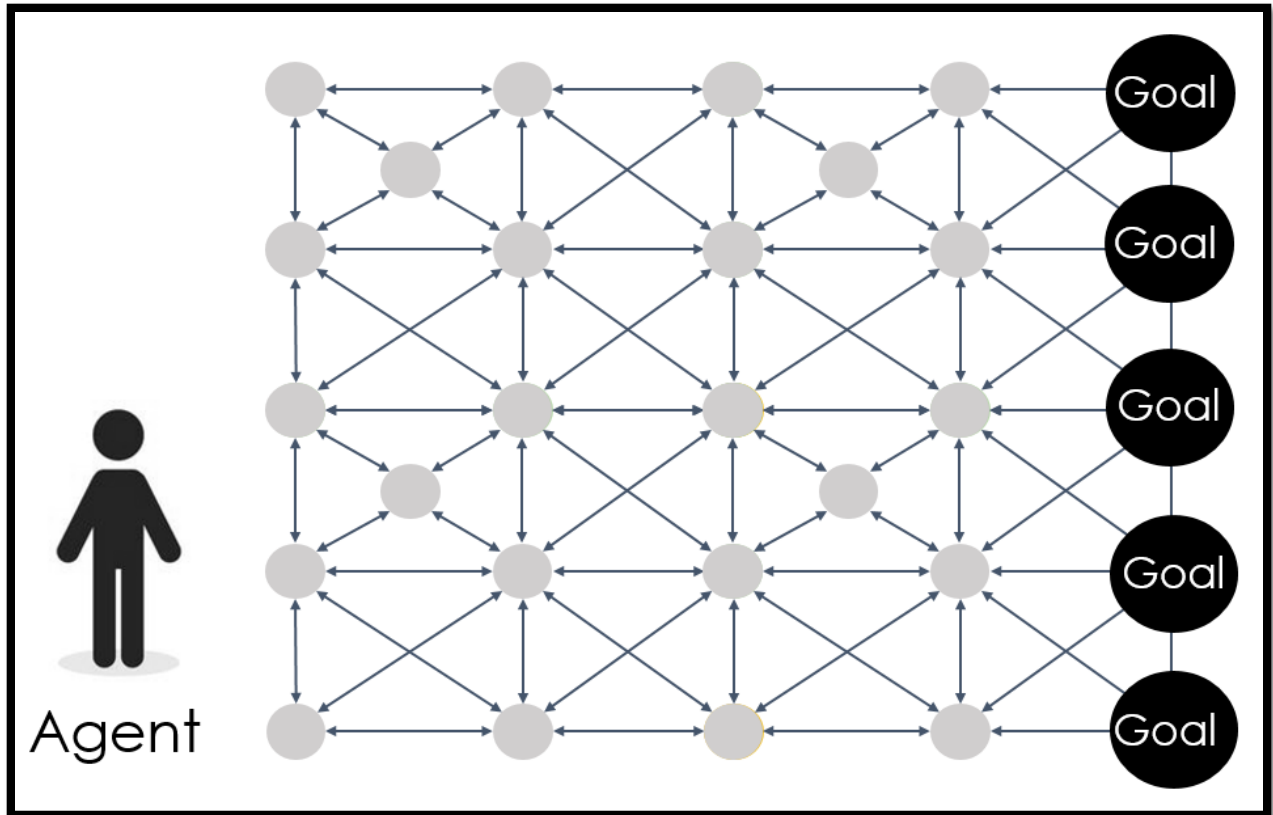


Figure 19. Students planned their trajectories based on their strategic desire to keep an array of long-term options open for themselves.

First, several students emphasized their strategy to “get good grades” in high school so that they could do whatever they wanted to do in the long run. For example, Genesis shares:

I was never super focused on career in high school, because I didn't really know what I wanted to do. My goal was just get really good grades so that I could do whatever I wanted to do. But then I saw that other people were ... Their career was their motivation. It's like, “I want to be an engineer, therefore, I want to get these good grades.” And so I think that was reversed [for me].

In this excerpt, Genesis notes that she strategized to build a strong academic record so she could have a variety of options open to her after high school. Her sights were not originally set on engineering; rather, her goals were broadly focused on performing well academically so that she could pursue any number of long-term goals—as she says, “whatever I wanted to do.”

In planning for her future, Miru used a similar strategy, focusing all of her efforts in high school on building a competitive resume. She shared:

I feel like even if you don't know what you want to do...it's important to have the foundations to pursue whatever you want to pursue if you find out later. And that's why I was trying so hard to build my resume, so I had the ability to pursue whatever I want to do at the end.

Like Genesis, Miru was uncertain about her long-term goals but believed that a strong academic record, which she refers to as her “resume,” would open any door for her in the future. While she was undecided about her career aspirations in high school, she poured her energy into building her resume so that she could leave multiple options open for college, and consequently, careers, in the future. Miru elaborated:

going to a good college was very important to me... I just knew that having a good resume and going to a good college would be a good foundation no matter what I wanted to do. It's something definitely that employers look at, so I thought it was important. So, even if you don't know what you want to do, having that on your resume would look good. It's a good foundation for anything else. So, that's why I really struggled to build my resume.

While some students discuss pursuing higher education in a broad sense as a strategy to *leave multiple doors open*, other students zoom in on their specific choice to study engineering. For example, Linh discusses her choice to study engineering as a strategy to have multiple career options in the future:

Another reason why I wanted to be [industrial engineering] or at least engineering in general because, I feel like once you get your degree its very open ended and you can go into anything you really want to. So, I think engineering opened a lot of doors for me because, since, I feel like through the whole course plan of study you've learned so much within that time, so you've gained so many skills, not just academically but, just like organizing your life and planning and organization, so I'd know how to get a job in different aspects whether its business or hardcore engineering firms... So, that's why I feel like you can get hired in a lot of places. Engineering not just only teaches you skills that you learn like your manufacturing lab or something, but it also teaches you problem solving in general and any employer would want that.

For Linh, obtaining a degree in industrial engineering is assurance that “any employer” will hire her. Coincidentally, Danielle, another student studying industrial and systems engineering, similarly chooses to study industrial and systems engineering because she believes she can work in any industry with her degree, sharing “[industrial and systems engineering] was also one of the degrees that I figured if I found an industry I really wanted to work in, I could probably go there as an [industrial systems engineer].” David, a student in Aerospace Engineering, shares his views on the “endless” possibilities his degree will provide him:

I feel like it's, the possibilities are endless and like engineering, there's so much out there... I could choose to work for like an Aerospace company. I could do a start up, I know one of the things I experienced at [my internship] was, even though people would have Physics Degrees, they could do code or they could do stuff outside the degree. I feel like there's just so much to do, just getting the Degree in Engineering... gives you that solid foundation and you can kind of tailor that to what you want to specifically do.

Though they were pursuing different engineering degrees, David, Linh, and Danielle all perceived their engineering degrees as essential to keeping a variety of options open for their futures.

The strategy of *leaving multiple doors open* was salient in many student narratives. In high school, students tended to discuss this strategy in terms of academic achievement, believing that if they could “get good grades” they could do “anything.” Other students discussed higher education as a way to leave multiple doors open for the future, referring to higher education as a “good foundation” for any career. Lastly, some students honed in with specificity on pursuing an engineering degree as a strategy to leave multiple career options open. These students believed an engineering degree would make them competitive for any job, including jobs outside of engineering, because they would build a skillset in engineering that would the demands of “any employer.”

4.2.4 Resisting the Paved Path

A final set of path planning strategies centered on *resisting the paved path*, where students reflected on actively recognizing and resisting an expected path. As visually represented in Figure 20, students who discussed actively resisting a path that was expected of them demonstrated a heightened consciousness of social forces, often reproductive in nature, that were pushing on them. Using the lens of the Bourdieusian framework, students using this strategy were intimately aware of and familiar with societal *structures* and actively enacted *agency* to resist them.

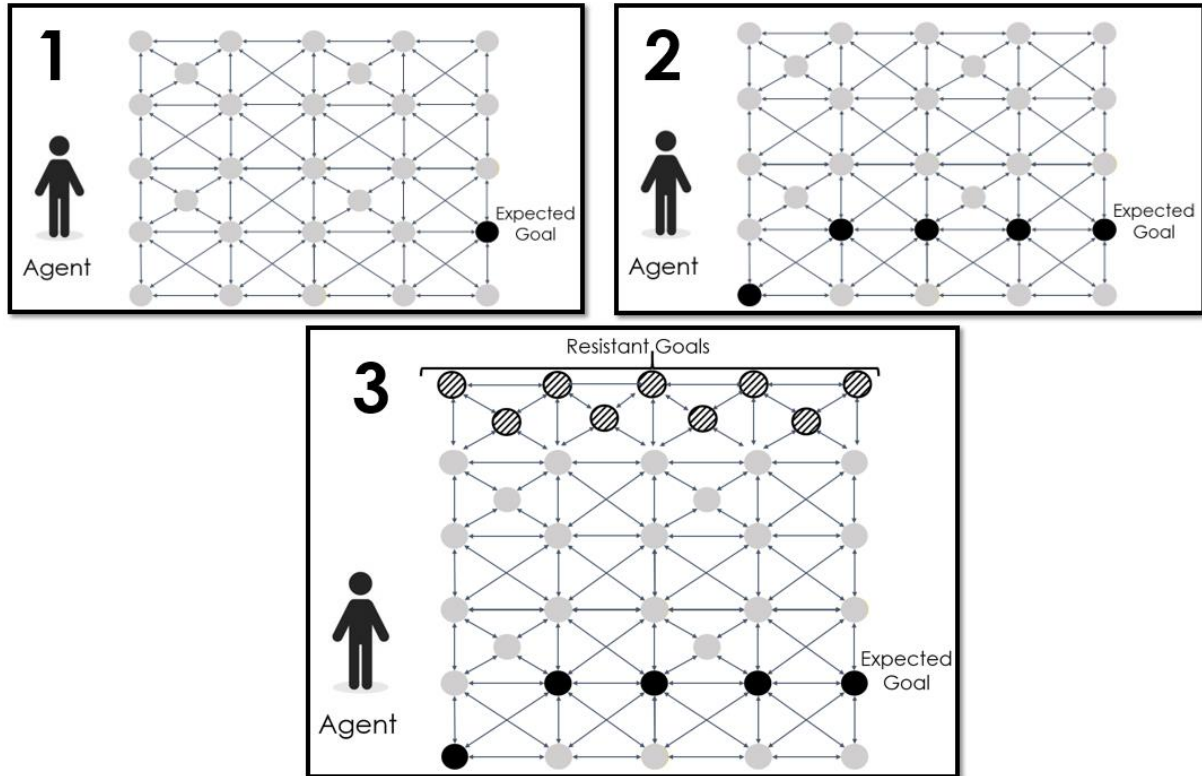


Figure 20. Resisting the paved path. Students who discussed actively resisting a path that was expected of them demonstrated heightened consciousness of social forces, often reproductive in nature, that were pushing on them.

Zooming in their engineering majors, some students reflected on active resistance to the career path that their major was pushing them toward. These students were conscious of the interrelated dynamics between industry and their engineering curricula; put simply, they were cognizant of the fact that their engineering degrees were preparing them for specific careers in industry. Some students' long-term career goals did not align with the career opportunities being "pushed" on them by their degree curricula. Rather than switch degree programs, however, these students elected to pursue the knowledge, skills, and training of the degree program with a different end-goal in mind. These students reflected on actively resisting the metaphorical paved path of their major, and instead intentionally structuring their education to lead towards some other outcome. For example, Diana resisted the expected path for graduates of her chemical engineering program:

All the other ChemE classes got really interesting, but there's always this aspect in my mind that I didn't want to be a process engineer at the end of my four years, and that's what Chemical Engineering was training me to be... I didn't hate the major because it

was gearing me towards becoming a process engineer, but I kind of looked at it from a different approach... grad school was the way I was going to end up going.

In this narrative excerpt, Diana demonstrates heightened awareness about the expected career paths of chemical engineering graduates in her program. She develops a “different approach” to navigating her curriculum, resisting the expected outcome of becoming a process engineer and instead striving to use her chemical engineering degree as a gateway to graduate school.

Ultimately, Diana was determined to pursue research as a full time career after completing her summer research experience. Cognizant that most of her chemical engineering peers would become process engineers, Diana developed a resistant plan within chemical engineering. She consciously worked to tailor her chemical engineering education to prepare her for graduate school and, subsequently, a career in research.

It is poignant that some students explicitly highlight resistant capital (Yosso, 2005) as they discuss their intimate awareness of and resistance against oppressive societal structures. Genesis discusses reproductive forces in her community, reflecting on the inequitable impact of these structures on people of color:

So I think it was, I don't know, it was just interesting being around, or being in a city where everyone was content, staying where they were and I mean, that's awesome. I'm not saying that's wrong. But I think it was harder for me to envision myself elsewhere because it just wasn't what people did. They didn't really ... At least people like me, minorities. There were a lot of minorities where I was. They didn't just go to these top tier colleges and get careers and leave.

In this excerpt of Genesis’s narrative, she indicates a keen awareness that most people from her home community never leave. She reflects that her “desire to get out” was the most important aspect of her educational trajectory, alluding to a fervent, unwavering resistance to the most common paths in her community. She also acknowledges the underlying racist structures in the social reproduction in her community, reflecting that “minorities” didn’t have the opportunities to “get careers and leave.” She recalls recognizing these structures as young as six years old, and developing resistant capital to “get out” and resist the reproductive forces.

While Genesis reflects on resisting the paths defined in her community, Eileen reflects on resisting expectations from her family. While her father always encouraged her to develop aspirational capital, including for the pursuit of an engineering degree, her mother imparted

deeply held cultural values that women should “stay at home.” During her narrative, she painfully recounts her mother’s expectations for Eileen as the daughter of the family:

My dad was just always like you can do whatever you want with your life. My mom was complete opposite. She was like girls should stay at home. Which I didn't understand cause I was like, why can't I be a teacher, then? She's like you should be at home. She didn't want me to go to college far away. She wanted me to just go to community college. And I think that was more of just she didn't want me to leave. And she, they see daughters as staying home to take care of their families. So, that was hard. I'm crying a little bit, I'm sorry.

Eileen reflects about her mother’s expectation for her college choice process—where she would go to university, and what she would study. Eileen resisted her mother’s expectations from her, and was continuing to resist these expectations at the time of her interview as she considered the next steps of her journey after university. She shared:

Yeah, just thinking about it, it's still rough because she still thinks like, she still expects me to stay at home right now. When you graduate college, you're coming home to take care of me. And I'm like, no, I'm gonna go get a job. And she's like, but, but you're supposed to take care of me. And I'm like, well my brothers are still home. So it's hard.

In this segment of her narrative, Eileen reveals she is cognizant of the contrasting expectations for her and her brothers. Eileen attributes these discrepancies in expectations to gender, and her frustration with these gendered expectations for women in her household fuel her passion for mentoring other women in engineering. Later in her narrative, she shares why she is fervently committed to mentoring women in engineering at her institution:

Because I think it was because my mom was always like, no, you, girls aren't engineers, you should stay home. And I was like no. I was like, that's just not, I don't think that's right. So I think just having that thought that girls, having her my entire life be like girls shouldn't do these things. I was like I want more girls to do it now so I want to be involved in making sure other girls do it.

In this excerpt, we see Eileen actively resisting her mother’s expectations for her. However, for Eileen, resisting her mother’s gendered expectations also means actively advocating for other women in engineering. At her institution, Eileen served as a leader in the women in engineering living learning community and a resident advisor for the women in engineering pre-college program. During her narrative interview, many of the photos Eileen shared were of the women

she actively mentors. She stays in daily contact with her mentees, encouraging them and checking in. As she points to the women in her narrative photos, Eileen shares:

And then, this is all my mentees, actually...So, those are like my children. So, those, they're my kids. So, they're like, ah, and they're always texting me like, I hope you have a good day. They come to me with questions about everything. I always check up on them. And so they mean a lot to me. So, those are my little babies... And then these are my [pre-college program] girls. Yeah. And so actually, [mentee A] went to [institution A] and [mentee B] to [institution B]... I talk to [mentee C] about once a week..."

Through her narrative, Eileen's persistent efforts and energy devoted to sustaining relationships with the women she mentors are evident. She discusses details about each of her mentee's stories, knowing where they are studying and what they are pursuing. She shares that she talks to each of her mentees weekly, and in many cases daily. She discusses her mentoring efforts as her way of intentionally resisting gendered expectations—notably, embodied by her mother—for women in engineering. By engaging in these efforts, she exercises resistant capital in her individual journey, but she also works to build resistant capital for women in engineering collectively.

4.2.5 Summary

When examining the strategies students use to navigate their trajectories to an engineering degree (RQ1), four distinct path planning strategies emerge. First, students often reflected on *dreaming and contingency path planning*, where students describe mapping a “dream” path to their end goal, often in addition to a contingency plan—active strategies to pursue an alternate path if the “dream” path to their goal destination was not possible. A second theme in path planning was *rerouting paths*, which was often salient in the context of changing majors or shifting long-term goals. Instead of setting a single long-term goal, some students routed their paths to *leave multiple doors open*, making decisions that would allow them to pursue a variety of career paths in the future. Lastly, students sometimes reflected on actively *resisting the paved path*, demonstrating a heightened awareness of societal structures pushing them in a direction and embracing resistant capital to move in a different direction.

4.3 Influences of Social Environments on Trajectories (RQ2)

My second research question examines how social environments shape students' educational trajectories. Bourdieusian theory acknowledges the capacity of individual agency, explored in RQ1, but it also acknowledges the "power of the social" (Stahl, 2015, p. 25). Therefore, in this discussion, I critically examine social environments that students' highlight in their narratives as shaping their educational trajectories. In my analysis, five types of social environments emerge as significantly shaping students' trajectories: (1) family environments, (2) community environments, (3) economic environments, (4) peer and institutional environments, and (5) political environments. In the following sections, I describe how each of these environments shape student trajectories.

4.3.1 Family Environments: Collective Agency

One of the most salient themes in students' narratives was their families' influences on their journey. To be clear, a few spoke of their family's influences negatively, referencing tensions with their family for their choice to pursue engineering education. The large majority of students, however, discussed the positive impact of their family on their journey. Most often, students discussed the influence of their family environments in notions of collective agency, where their families would combine acts of agency toward collective goals. Collective agency was discussed in students' narratives in two distinct ways: 1) pushing from behind, and 2) pulling from the front. Importantly, when I refer to "pushing," I am referring to the student feeling pushed by their community. When I refer to "pulling," I am referring to students pulling their communities forward. Below, I elaborate on each of these ideas of collective agency.

Pushing from behind. Many students discussed their familial influence on their trajectory by highlighting how their families had collectively worked to push them towards higher education. Students often expressed deep cognizance of the collective sacrifices of their families that enabled them to pursue an engineering degree. Sometimes, collective familial agency was discussed in the context of collectively navigating how to pay for higher education as a family. One student, Nabou, shared extensively about her father's daily efforts to help her persist in her engineering degree and offload as much of her financial burden as he could:

“ accepted [offer of admission at institution] and then I thought about how am I going to afford this because this is pretty much my father's paycheck every year. His yearly paycheck is a semester here so how are we going to do this? My aunt didn't want us to take loans because obviously it's just going to pile up and when I get out I have an enormous amount of debt to pay back to the school. She didn't want me to do that but my dad, he's like a standard immigrant, the United States is the land of opportunity and you've got to do what you've got to do until you get where you want to and then you can figure out how to fix it later. We did take loans...I did end up getting a couple [scholarships], but again, we still had to take loans out because my dad is the only provider. My mom doesn't work. She doesn't do anything that could bring us any money. It was pretty difficult but my dad is also the type to always tell me to not worry about things like that. He wants me to be comfortable. I try to work and make my own money. He won't let me spend it, even if it's just to buy food like an \$8 burrito or something like that and I use my card for that. He's like, "Why did you use your card? You could've used mine?". It just hurts a lot because he's the only one working. He doesn't have a car. We live in [hometown] right now and he works in [neighboring city] so he has to take the train every day to work. He doesn't have a car because he can't afford it because he has to provide money for me to go to [current institution].

In this excerpt, Nabou reflects on her father changing his daily work transportation routine significantly, selling his car to help her finance her education. Later in her narrative, she elaborates on how her father's choices directly impact her trajectory, emphasizing her admiration of her father's work ethic and resiliency:

He went to a school in [home country] and because it is a third-world country, a lot of people don't value what they learned over there so he had to work for a lot of different companies, a lot of years just learning a bunch of things and that's why he was able to get a decent enough job to be able to pay for [current institution]. Right now he just got a new job for [government organization]. He is going to be working for them. That's a pretty big bonus but he's also going back to school as he's working right now to get his master's or his MBA. I can't remember which one it was. He is currently taking Econ. I was looking at his notes and they're basically what I learned last semester and it was pretty cool but it's also really sad because he has to wake up at 6:00 AM, eat, get on the train, get to work. He gets to work before 8:00 and he works for hours then he gets home, eats and takes his class and does his homework until 11:00 PM or 12:00 AM and he does that every single day. Someone shouldn't have to do that honestly. [cries] Sorry. I'm just really proud of him. That's again why I'm here and trying to push through.

Nabou keenly feels the collective support of her family pushing her forward in higher education. She expresses a deep sense of duty to finish her engineering degree because her family has invested so much in her. She credits her family's collective agency as the only reason she has not already “quit”:

I just really don't want to disappoint [my family] because they've spent a lot of money and time on me. That's the only reason why I just haven't quit college yet... a lot of people put me on a very high pedestal and expect a lot from me. I just feel like I have to keep pushing and graduate out of here... That's pretty much the only reason why I'm still here and pushing through because honestly I've had days when I'm like, I want to go back. I just want to quit and get a basic job and have to support myself and just call it quits.

Throughout Nabou's narrative, she continually anchors her agency and choice to persist in her engineering degree to the collective agency of her family, particularly her father.

While some students, like Nabou, highlight how their family's collective agency has impacted their financial burden, other students explicitly note that their families were not able to help them fund higher education. Still, these students highlight other ways that their families have supported them through collective agency. For example, TJ described how his family used "what little [they] had," to support someone getting a seat at the table of higher education. TJ shared:

My mom really pushed me to be the best I can be and tried to help me as much as she can, and she is very caring and loving and honestly she does so much for me, with what little she has and it's really inspiring. I think that's probably one of the main reasons I am the way I am, and try to push other people, and try to help as much as I can...

Though TJ discusses his family's collective agency at an overarching level, some students share in great detail pooled together acts of agency to get one family representative into higher education on behalf of the family. Perhaps the most powerful example of this type of collective agency is found in Naomi's narrative, where she describes her mother's agentic actions to support her education even while working "low wage type of jobs" and experiencing housing insecurity:

We were actually homeless for a couple of years in terms of we lived out of the kindness of other people. We would go to church, and then someone would take us into their house, and we'd live with them for a couple of months. We'd just move around from house to house. We would just live with random people. Once my mom met this one woman at a gas station, she was really nice. She had three different ... She was also Latina. She had three different children, and also she lived with her sister or something. But she was also a really kind person, so she offered us her home as well.

My mom also met this Columbian woman. I don't know how she met her, but we also ended up living with her at some point. It was just a bunch of moving around within the state of [southern state]. What else? At some point, we also moved to [southern city 1] to

live with another woman that was offering to have us live in her apartment with her. So moved to [southern city 1], but then eventually they had a fight or something, so we had to move back to [southern city 2]. It's just a bunch of moving around. I don't know how my mom met all these people, but luckily they were, for the most part, really nice people. Not sketchy or anything.

So we lived with them, but eventually something happened that we had to leave the houses and move on to the next house. Eventually we ended up homeless homeless, like at the homeless shelter, and we lived for a couple of months there as well. I think there was probably six months or something at the homeless shelter, because they have time limits and whatnot. I'm still not really sure how the law worked, but I remember that I was 13 at the time, so I was eligible to start doing chores around the homeless shelter, clean bath rooms or something like that, but my mom just wanted me to focus on studying. So she was like, "Hey, listen, I'm going to do all your chores for you so that you can just focus on studying. Look at how hard I'm working. Just make sure that my sacrifices are not for nothing.

Naomi describes her mother's strategic acts of agency to support her educational trajectory, even when family financial support was not feasible. Instead, her mother enacted agency to take on Naomi's portion of chores at the homeless shelter they resided in, enabling Naomi to focus her time and energy on studying. In this way, Naomi says her mother pushed her forward on her educational trajectory. At a young age, Naomi recalls becoming aware of her mother strategically pushing her forward. As a result, she says she developed clear goals, fervently pursuing academic achievement as a route to scholarships for higher education. She describes:

...So that's part of the reason I was always really focused on studying, because I was like, "Okay, my mom's working so hard. We got to make sure that I'm successful so that all her hard work isn't going to waste, all the sacrifices that she's making so that I would have my time to study." That's part of the reason why I was always super obsessed with studying. I was like, "Okay, I got to make sure I'm successful, get scholarships," especially scholarships, because I was like, "Okay, my mom can definitely not pay for college, and I don't want to take out a loan or anything." I wasn't sure if I was even going to go to college if I had to take out a loan, because I was like, "I don't know if I want that much debt." So I was like, "Okay, work really hard and make sure you get the scholarship.

Like Naomi and Nabou, it is noteworthy that many of the students who discussed being pushed from behind by their families were first generation immigrants. Jon, whose family immigrated from a country in Central America, discussed how his higher education journey would not have been possible without his family's decision to immigrate:

I guess I'm just always conscious that I'm [Central American Country] American, I have my dual citizenship technically and I've been fortunate enough to actually go back to [Central American Country]. So not just ... so I have more of direct tie with it, my grandparents are still there, tons of cousins and uncles. So when I've gone I've been able to see what my parents' lives were before they came here, so there's that bridging the gap of where my parents and I are right now and where they used to be. Kinda seeing if they hadn't come here I'd probably be still back there like some of my cousins just doing field work or agriculture stuff versus ... I definitely wouldn't be in college in America right now.

Jon believes that his educational trajectory was directly influenced by the collective agency of his family, who immigrated to the United States to provide better opportunities for him and his siblings.

Most often, as discussed in the examples above, students discussed being the one pushed from behind, with their families doing the “pushing.” However, one student, Rob, discussed his efforts to push his younger siblings from behind on *their* educational journeys, even if it meant sacrificing his own opportunity to pursue higher education. He shared:

I have two younger sisters and they also wanted to come to school. But one of them wanted to become a lawyer and the other one wants to go towards criminal justice. But again because of the financial strain with my family I felt like I preferred them to go than for me to go. But then at the same time I didn't want to, I don't want to sound selfish but I didn't want to give up my opportunity to learn. But if I was giving it to my younger sisters then why not? At least you benefit. And I was actually planning to go into the military just to try to get funding through them, and I guess just get some hands on experience while I'm there, too.

Rob recognized that it would be difficult for his family to support all three siblings in higher education, and he was willing to forego his opportunity to pursue higher education so that one (or both) of his sisters could attend. In this way, Rob demonstrated the deep value he placed on his family’s collective agency—“giving” an opportunity to his sisters because he believed the whole family would benefit. Though Rob considered this route, it was ultimately his family’s collective encouragement that convinced him to pursue an engineering degree:

But again, because of my parents support me and saying, "Nah, just go, if you want to get an engineering degree just get your engineering degree, and don't let anything stop you from doing that." Money comes and goes, that's something they always say. You shouldn't put so much stress on that...

...basically almost everybody around me did say, "Go to school, go to school, that's your way you, that's your way of not..." Like my dad would say, "I'm over here, yeah I guess I like my job, but I'm over here working under the hot sun. It sucks." Basically that's what he would say. Work in an office doing something you like, doing something you enjoy while you have air conditioning. Don't work out here like the rest of us. So they would put examples like that.

In this excerpt, Rob reflects on his father's advice to "don't work out here like the rest of us" and instead to pursue engineering, knowing that Rob's passions were in aerospace engineering. A trend across students' reflections on *being pushed from behind* is a recollection of their families' aspirations for their children to have a different trajectory than the generations before them (i.e., upward mobility). As discussed above, many families positioned higher education as a guaranteed deviation from the family trajectory. Many students reflected on their family's influence on their educational trajectories in terms of being *pushed from behind* toward higher education.

Pulling from the front.

A second salient theme in the way students discussed their family's influence on their trajectories was the idea of *pulling from the front*, where students would describe their aspirations and strategies to climb the upward mobility ladder and lift (i.e., pull) their families up with them. This theme was typically discussed in conjunction with a deep sense of duty to family, particularly for students who hailed from communities where most people—even those who excelled academically—were not afforded the opportunity to go to college. Students often reflected on the societal barriers in their community that impeded persons' trajectories to higher education, and sometimes considered themselves an unlikely exemption from the social reproduction in their communities. To use Bourdieu's terms, students recognized that even when their family members had "played their cards" right, they may still have not had the opportunity to pursue higher education. For these students, there was a deep commitment to lift their families as they climbed, feeling a sense of duty to their family in their pursuit of higher education.

A salient example of *pulling from the front* is found in the narrative of Naz, a computer engineering student whose greatest role model was his uncle. He describes his uncle as "really, really big on computers" and credits his uncle for sparking his interest in engineering. Naz describes his uncle's talents in working with computers, and how his uncle's interests shaped Naz's educational trajectory:

[My uncle] knows more about computers than most of my TAs. And I've had conversations with some of my teachers, and it sounds like he knows a little bit more than them. So I have a really good connection with him. So him being my big brother in a sense really, and looking up to him as I grew, really gave me and piqued my interest of being able to have computer talks with him, and it just kind of our dialogue and how we kind of mesh.

However, Naz notes that his uncle, despite being talented with computers, never had the opportunity to pursue higher education, like many others in his home community:

because where I come from ... All right, so my uncle right, who knows a lot about computers, he was never in the right environment to really do anything with it. So he's not, his current occupation or what he's going to do in the future is completely unrelated. So his talents are kind of wasted in that potential or at least his potential to be very great in the field. Right.

And that's the case for a lot of people in my family since we come from the not so good parts from New York. So our status quo so to speak, our bar for success is kind of low at this point. So I'm not the first person to go to college. So, my dad went to college and he wanted to show that we could. And even though he's not I guess the smartest person, he's still valedictorian just through hardworking and stuff. So I'm the first person to really have the college experience, to live in dorms and be young while I'm doing it.

Because Naz recognizes the rarity of college opportunities for his community, he feels a passionate sense of responsibility to lift his family as he climbs. In fact, one of Naz's main aspirations for pursuing higher education is to help his uncle. He shares:

[my uncle] is the reason why I'm on my journey. Like he is the reason why I like technology. He's the reason that I have a strive to do better so I can put him in a better position. He is one of the reasons why a lot of my passions are how they are. He shaped my personality in a sense of growing up in admiring someone and finding myself through seeing how he moves and operates through life. In seeing him dealt a bad hand in life, even though he was given the mindset that I know successful people have, is part of the reason why I want to be in a position to elevate him and his quality of life. Just because he has done so much for me, and has shaped the way that I think in shaped the way of the path that I'm on. Once I am successful, I would like to make sure that he is going along with me.

As he acknowledges the “bad hand” his uncle was dealt in life, Naz acknowledges the societal barriers in his community, and more specifically, in the life of his uncle. Recognizing the barriers that kept his uncle from pursuing higher education, Naz vows to pull his uncle along with him in his trajectory towards upward mobility.

In a similar way, some students discussed their commitment to using their position in higher education to pull their younger siblings “up” toward higher education. Students would often empathize with their younger siblings’ potential trajectories, comparing the future possible trajectories of their siblings to their own trajectories to engineering. Students would anticipate the barriers their siblings would encounter and try to mitigate those barriers for their siblings. For example, Azad, a computer science student, describes in detail his purposeful, ongoing efforts to encourage his younger sister to pursue a career in coding:

I am trying to teach or help my sister out a little bit. Because at the same time, she goes through a similar environment as I did growing up. I want to hopefully get her maybe take some AP classes. I came in, I didn't have any AP courses or anything like that. Just having, because most people that come here, their backgrounds are different. They do come, a lot of people I talk to in CS particularly, they do have parents, fathers, mothers that did do CS or did do some form of engineering and did kind of push them and get them settled in. I feel that is one way to really get people into this kind of field. I feel if you just have no one that's in the field, you have no sort of online or in real life community, you really have nothing to look forward to or examples to look at. It's much harder to just say, yeah, I want to get into this subject field...

For her, I was always thinking in the back of my mind when I came to college, okay, if I want her to potentially live a really good life and have opportunities, I don't want to force her into anything. I don't want to force her into engineering or whatever. She's 15 years old right now. I was like, "Okay, how about you take an extra math class in the summer just so you'll be a year ahead of your peers or whatnot? That way you can take these AP classes and stuff like that." Because in my mind I'm like, okay, now I'm thinking ... Because when I think about the people around me, when I think about how their parents may have influenced them, I'm sure there's similarities there. But they'll be in seventh, eighth grade and their parents are like, "Okay, what's the most optimal path to get you to the best school possible?" Or something that. Right? "Okay, well, you should take these math classes, you should do these activities. You should do community service." I didn't really have that kind of guideline. So, I'm trying to provide it in a sense to my sister the best I can.

Azad reflects on the barriers he faced not having anyone “pushing” him into computer science. Through encouraging her and teaching her coding skills, he commits to breaking down these barriers for his sister, personally serving as her “push” towards computer science. Remarkably, when anticipating barriers his sister might face pursuing computer science, Azad goes beyond his personal experience in computer engineering; instead, he truly strives to anticipate barriers his sister might encounter as a woman in computer science, which vary from his experiences as a man in computer science:

... I'm trying to teach [my sister] programming semi-successfully on the side. Just at least get her exposure and to get her comfortable with the idea of, yeah, engineering is something you could do. Because I feel it's easy. Especially for girls that don't have someone in your lives that can kind of say, "Yeah, you can do this. Here's proof you can do this. We'll work on this. Here's the benefits, here's the cons."

Because I'd say it's harder because the communities, like let's say online communities for instance, I feel like they are not as welcoming to girls. There's bro culture or whatever, I'd say if a girl would join these online communities or whatever, it's probably just like you'd get hit on or something or they'll just look at them skeptically. I'm sure there's a lot more research to this than what I'm putting out. But I am aware of barriers that do exist for girls, for engineering. And I personally at least want to set up my sister in a way where if she wants to go down this path, I don't want to force her down, anything, but if she wants to, and I think it's a very nice path to go down to, she'll feel comfy.

Azad is peripherally aware of the challenges women in computer science face, and he actively works to break down barriers for his sister in anticipation of the unique challenges for women. Just as Naz is committed to pulling his uncle up, Azad is committed to pulling his sister up, though they strive to *pull from the front* in different ways. Naz plans to climb the upward mobility ladder and pull his uncle up once he “is successful.” In contrast, Azad acts on his commitment to pulling his sister up by anticipating the barriers she might face en route to a computer science degree and actively working to break those down.

To conclude, I note here that not all students talked about their family’s influence on their trajectories in terms of collective agency. Not all students’ families were *pushing* them forward on their trajectories, and as a result, not all students felt a sense of duty to support their family that I have described in these sections. To be specific, only four students mentioned negative family influences on their educational trajectories. These negative family influences differed for the four students. For one student, Marie, tension with her family arose after a critical incident;. Marie shared that her family’s influence became negative when she came out to her parents as a lesbian and transgender (see section 4.4.2 for this storyline element in Marie’s narrative). For Eileen, defying her mother’s gendered expectations for her (as the only daughter in her family) presented a constant source of frustration and hurt as she pursued her engineering degree. The final two students who noted negative influences, Rachel and Hao, shared that their families and their broader communities discouraged them from pursuing college because lucrative jobs were available in their home communities that did not require a college degree. While these barriers intersected with family, Rachel and Hao discussed this family barrier as intersecting with their

home community (i.e., not unique to their families specifically). Both of these scenarios are distinct from the family influences I discuss in this section, which focuses on the persistent, unchanging influence of family that students discussed in terms of collective agency. I reserve highlighting the barriers posed by families for my discussion of community environments (section 4.3.2) and critical incidents (4.4).

4.3.2 Community Environments

Community environments were a second distinct type of social environment that emerged in students' trajectories as an influencer on their educational trajectory. In this discussion of results, I operationalize students' community environments by their self-reported home zip code (i.e., geospatial community). As shown in Figure 21, students in this study hail from range of communities. Two caveats are important to note on this discussion of community level data. First, some students resided in multiple community backgrounds during childhood, so this depiction of communities represents only a single geospatial "home community" as self-reported on the screening surveys. Second, these data only represent students who identified their home community by a zip code in the United States (31/32 students). For simplicity, when I refer to a student's "community" throughout this section, I am referring to the geospatial community (zip code) identified by each student.

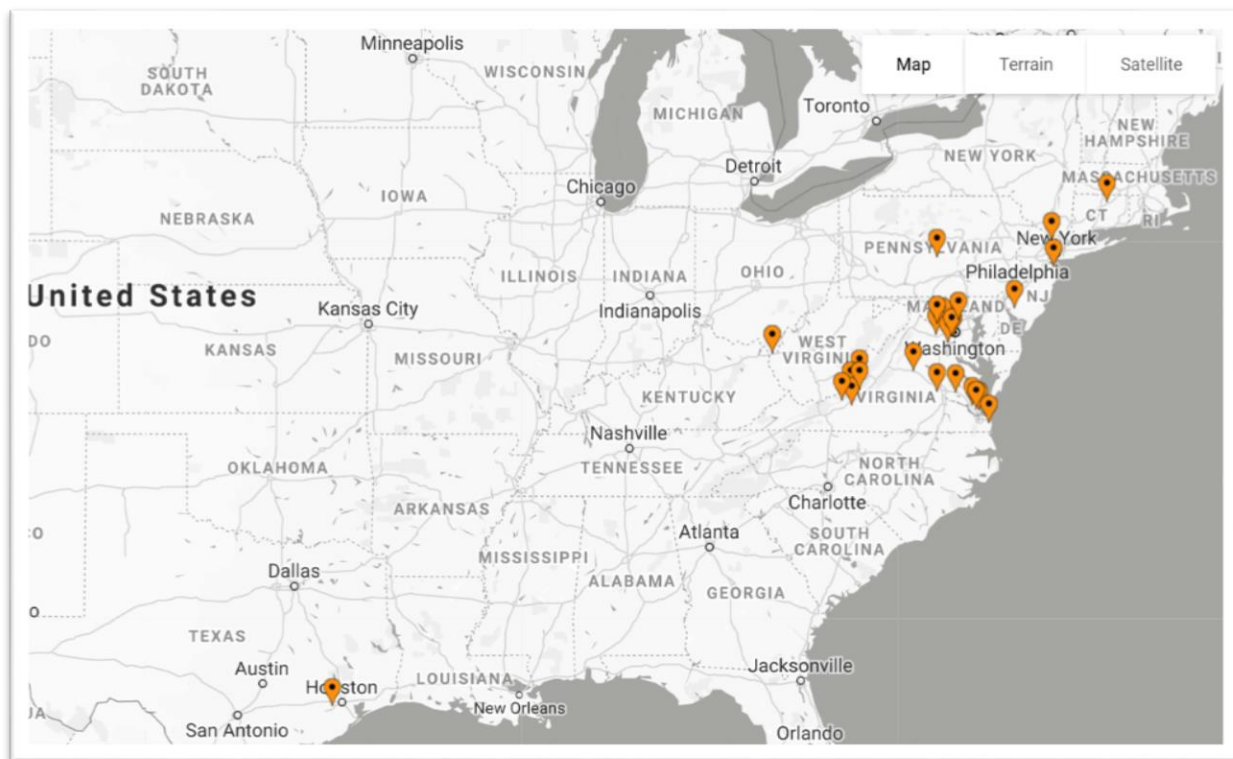


Figure 21. Students home communities mapped by zip code.

In students' narratives, distinct patterns emerged about the influence of communities on trajectories. Importantly, using the Bourdieusian lens, community influences are part of *structures* that shape students' educational trajectories. As a reminder, I pulled data for each zip code from a national level dataset, the Opportunity Atlas (Chetty et. al, 2018). The Opportunity Atlas compiles zip code level data from the U.S. Census Bureau and the American Community Survey (Chetty et. al, 2018). I performed a maximum minimum transformation (MMT) on each variable (e.g., poverty rate, college graduation rate) to display all data in the same quadrant and to help compare data point relative to each other rather than focusing on the magnitude of each data point. Figure 22 shows the results of the maximum minimum transformation for each student's community.

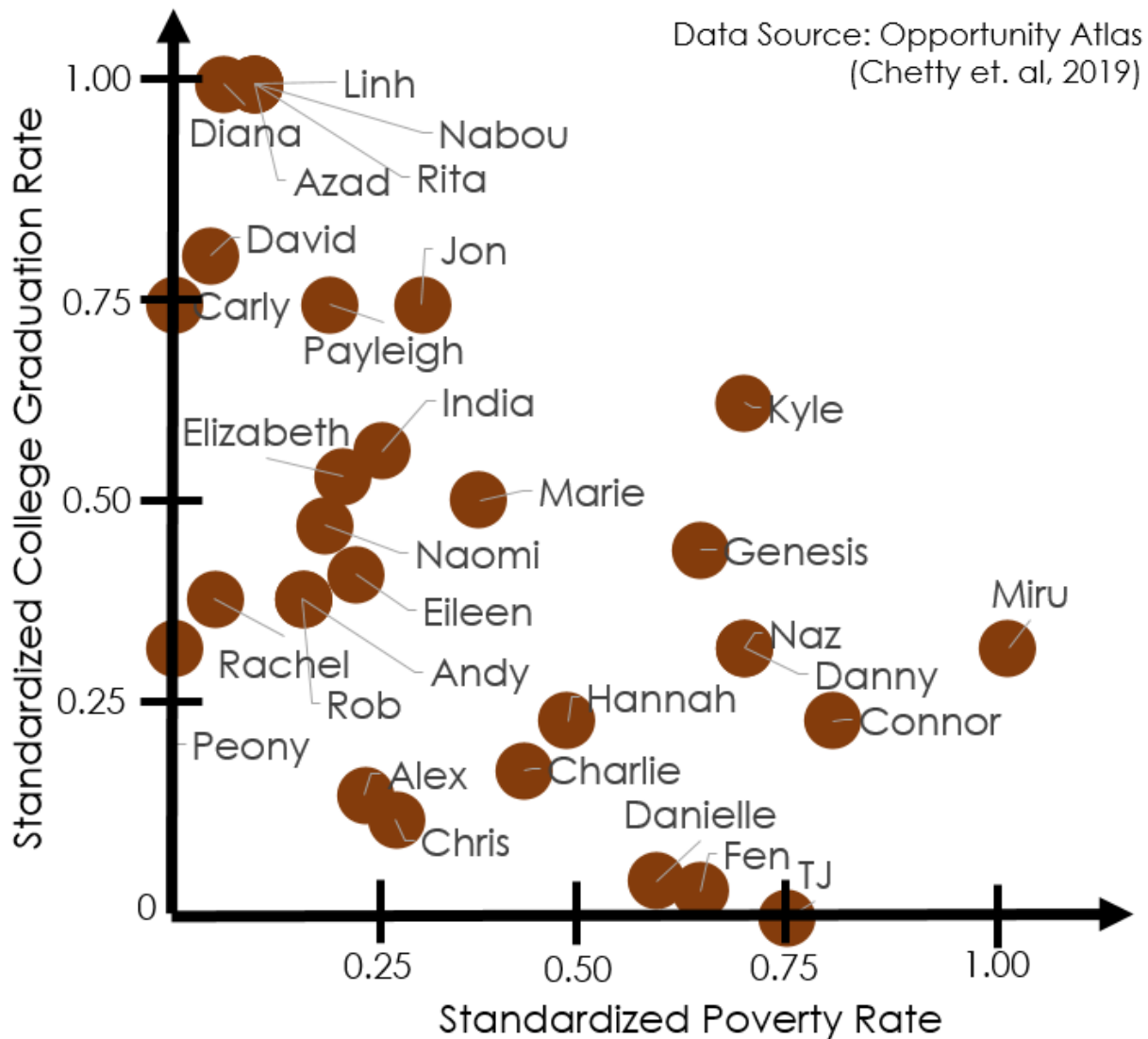


Figure 22. College Graduation Rate vs. Poverty Rate for each participant. Maximum minimum transformation conducted on both variables to visualize data in one quadrant and help compare data relative to each other. Data source: Opportunity Atlas, 2019.

I leveraged joint displays from mixed methods analysis and display strategies (source) to overlay my qualitative data analysis from students’ narratives with quantitative trends in poverty rate and college graduation rate observed from community level data. The joint displays reveal three distinct trends about the influence of communities on the trajectories of underserved engineering students, which I refer to as 1) “Get Out”, 2) “Fine Without It”, and 3) “Waste Your Money”. I discuss each of these trends below.

“Get Out:” Leaving High Poverty Communities.

First, as highlighted in the joint display in Figure 23, students from communities with high poverty and low graduation rates expressed variations on their desire to “get out” of their home communities. Notably, only these seven students mentioned actively working to leave their home community on their path to engineering as highlighted in Figure 23.

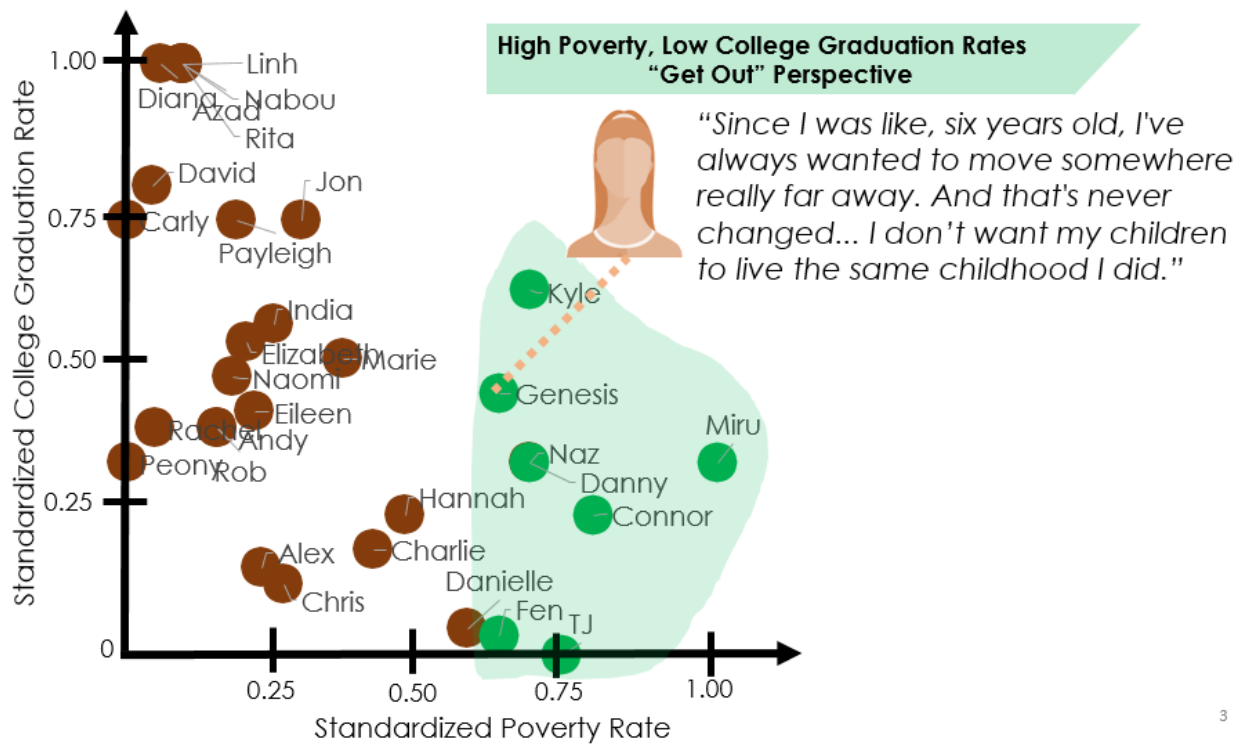


Figure 23. “Get Out Strategy” Joint Display. Students from areas of high poverty and low college graduation rates discussed variants of the strategy to “get out” of their home community.

Students candidly reflected on the poverty in their home communities, triangulating the community level data on poverty rates. TJ, for example, discusses the limited resources at his home high school. When asked about barriers he faced on this educational journey, TJ shares:

I'd say the lack of resources from my High School, because I literally came to [institution] with no knowledge of Engineering, no knowledge of most tech-knowledge or anything like that, and the resources my High School had were not very well in prepping me for college. So, I had to learn almost everything from scratch coming here to [institution].

Despite limited resources at his high school, TJ had enrolled in a Basic Technical Drawing class, which sparked his career interests in mechanical engineering. He “went to Google a good engineering school” and from then on set his sights on the engineering institution in this stud

However, TJ discussed the compounding barrier that most people in his home community did not attend college, again triangulating quantitative data on college graduation rates in his community:

A lot of people don't go to college, it's either you go directly into the workforce or you go to a technical school, there's not really much help with getting to colleges or searching for colleges, so that's why I went through my community college and talked with them to actually get college-help.

TJ shared that he knew he would need to access resources outside of his high school if he wanted to leave his home community and attend college. For TJ, getting out of his community was a means to an end for pursuing an engineering degree.

While TJ developed aspirations in high school to leave his home community, Genesis—also a student in a high poverty community with low college graduation rates—recalled developing a “get out” strategy from a very early age. She reflects unambiguously on the poverty in her community and her desire to get out, sharing:

Yeah. So, the city I grew up in was pretty ... There aren't a lot of people who want to leave, who want to go to college, study something, get a job outside of the city, most people end up staying. Most of my friends in high school, went to community college, and they want to stay in the community even after they graduate from community college. So that was different. And I've always 100%, since I was like, six years old, I've always wanted to move somewhere really far away. And that's never changed.

In this excerpt, Genesis acknowledges the social reproduction in her community and discusses developing a “get out” strategy for resisting social reproduction. For most of her pre-college journey, Genesis was not sure what she wanted to pursue after high school. However, she was resolute in her desire to leave her home community regardless of what her future plans would involve.

Just as Genesis and TJ discussed poverty in their home communities, Naz discusses growing up in “not the best neighborhood” and coming “close enough to very bad things.” Unlike Genesis and TJ, however, Naz’s does not desire to “get out” of his home community, necessarily, but instead desires to “get out” of poverty. He shares that no one in his family has ever been on vacation, and—through upward mobility provided by his engineering degree— Naz aspires to provide such an opportunity to his family. Put another way, Naz’s community upbringing shaped his determination to “get out” of poverty—not just for himself, but for his

entire family. He reflects on his community's influence on his trajectory, alluding to social reproduction and poverty at home:

...I don't come from, I come close enough to very bad things to know how to move within very bad things... I've learned more through second hand and the first hand, but I've been so close to it to where I have lived, I have experienced more than the people around me, so to speak. So, things in terms I guess drugs, gang violence, death unexpectedly. Just not in the best of neighborhoods, so and that's one of the reasons why I am so gung ho about changing the mindset. Just because we don't come from the best of places.

Though Naz keeps his reflection brief here, he shares that he is profoundly familiar with the hardships of growing up in an underserved community. This familiarity, he shares, fuels his goal to be “the bar for success” for his family:

I found what I want to do... to where I can be able to be the new status quo the bar for success and be able to teach the people under me how I got there. So like now instead of us all being at a low point, we can all strive to be better than how I was or at least close. So if I can, I want to say make as much money, but the things that I am interested in make a lot of money. So I feel getting to that place in my life where I'm comfortable, and scaling that way, sets a new bar for my family and the generations therein, and then they can strive to be better the same. And that changes the whole mindset of our legacy.

For Naz, the strategy of “getting out” is less about leaving his physical neighborhood and more about leaving the constrained trajectory of poverty. As Naz reflects on in the excerpt above, he believes his purpose for attending college is to “[set] a new bar for his family and the generations therein.” He believes if he can succeed in obtaining his engineering degree, he will help his family rupture from the trajectory of poverty. In contrast to Genesis, who directly discusses leaving her geospatial community, Naz speaks more metaphorically about leaving the poverty in his community and, moreover, shifting the narrative of poverty in his home community.

Other students anchor their community narratives less on poverty, but still note the influence their community had on their educational trajectory. For example, Miru expressed her persistent desire to get away from her home community, but she never mentions poverty. Miru shares:

I didn't know where I was going to get to like for college, I just knew that I don't want to stay in state. I wanted to go somewhere bigger... So, yeah, going to a good college was very important to me. Again, I didn't want to stay in state. I wanted to be away, because I don't really have a lot of good memories there.

While the quantitative data reveals that Miru was living in a high poverty community, she does not directly associate poverty with her desire to get out. Instead, she says quite simply that she was not happy there and wanted to get out of her home community as soon as she could. On a similar note, Fen discusses wanting to “get out” of his “small town,” but does not refer to poverty directly:

Where I grew up was a very small town. There's one entity that provides everyone a job. I don't want to work somewhere like that, because I guess that's the fact of being born in a small town. You want to get out of it.

An important note here is that while students in this group had shared experiences of growing up in high poverty areas (as determined by the quantitative geospatial data), there were no other distinct trends in shared demographics, such as race, gender, first generation status, or lived experiences of material hardship. Table 9 summarizes demographics for the students who expressed a variation of the “get out” strategy. Note that race, gender, year in school, and major are purposefully left out to protect participant anonymity.

Table 10. Participant Demographics for the "Get Out" Trend in Geospatial Joint Display

Participant Pseudonym	Pell Eligible	First Generation Student	Experienced Material Hardship
TJ	Yes	Yes	Yes
Miru	No	Yes	Yes
Naz	Yes	Yes	No
Genesis	Yes	Yes	Yes
Kyle	Yes	No	Yes
Fen	No	Yes	Yes
Connor	Yes	Yes	No

“Fine Without It:” Low Poverty Areas with High College Graduation Rates.

A second key community influence on students’ educational trajectories was the community rhetoric that people would be “fine without [higher education].” As visualized in Figure 24, the only three students who mentioned their communities sharing the idea that people would be “fine” without higher education were from communities where poverty rates were

relatively low and college graduation rates were high. Azad, Payleigh, and Jon each reflected on their community influence in this manner. For each of these three students, their communities were not unsupportive of their higher education journeys; their communities did not actively work against the students' pursuit of higher education, nor did they vocalize any disapproval for the students' chosen path. Rather, Azad, Payleigh, and Jon's home communities each conveyed that higher education was a rather nice thing to pursue, albeit unnecessary to have a secure future. For instance, Jon shared his community's thoughts on higher education:

Just a lot of Hispanic parents, at least in my community they didn't go to college either. They still get by, all their basic needs and stuff, so it doesn't seem like it's a necessity, something that you have to do, you can just get a job, be fine without it. So that's another thing, not a backup but if you don't go to school you'll still be fine.

Jon's home community neither pushed him toward or away from higher education. Rather, they offered a "back up" plan and generally believed college was nonessential to a stable life, or as Jon simply puts it, "[being] fine."

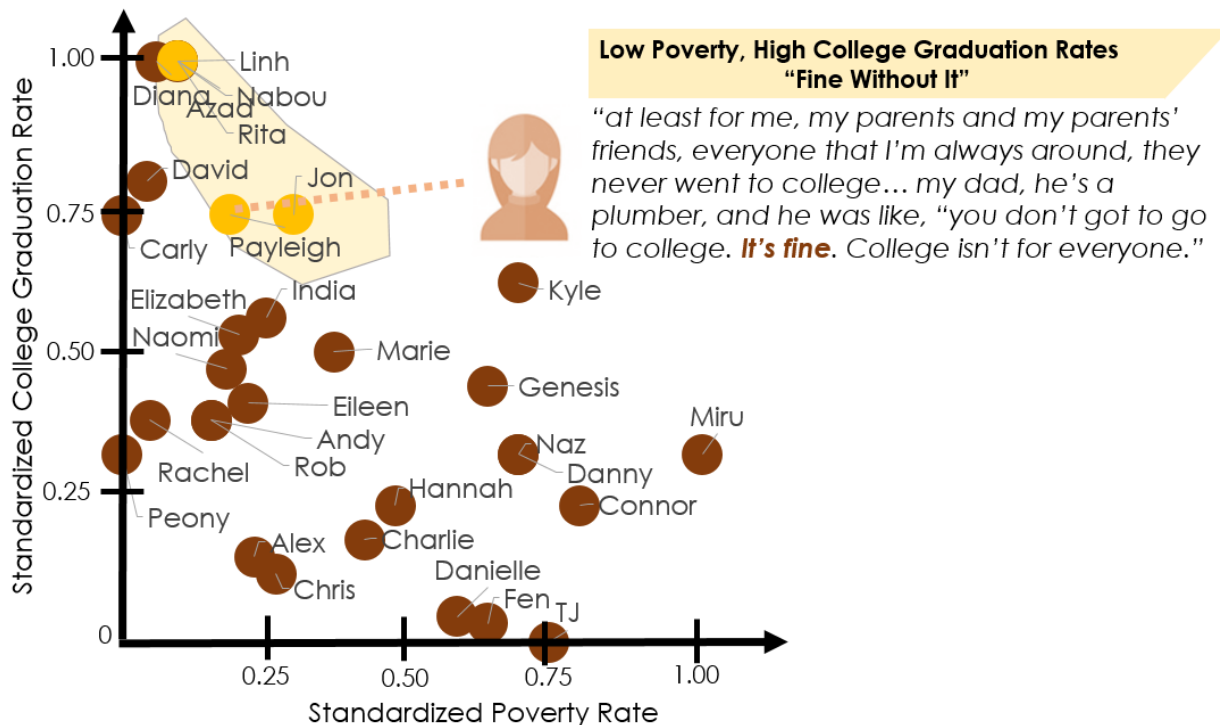


Figure 24. "Fine Without It" mixed methods joint display. Some students from areas of low poverty and high college graduation rates described their community view of college

education as something that people would be “fine without.” Payleigh, a mechanical engineering student whose mother and father did not attend college, summarizes her community’s thoughts about higher education in the “fine without it” trend. She specifically highlights the impact of her close community—her parents and her parents’ friends—on her educational journey:

At least for me, my parents and my parents’ friends, everyone that I’m always around, they never went to college, so I never thought, until [guest engineer] came, and introduced me to this engineering thing, that was the whole idea for me.

Payleigh says she never even considered higher education, much less engineering, because people in her community—most notably, her close community—managed to get by without having a college degree. She reflects on an early conversation with her father that embodied this community rhetoric:

I’d always been interested in science, and math, and stuff, that was always my favorite subject, but my dad, he’s a plumber, and he was like, “You don’t got to go to college, it’s fine. College isn’t for everyone, it wasn’t for me, wasn’t for your mom.” That was my philosophy about, I was just going to be a plumber, like my dad.

This father-daughter conversation Payleigh recounts provides insight into her inner community’s thoughts on college. Ultimately, this community-level person led Payleigh to believe, for most of her childhood, that she was a “college type of person.” She shares:

Yeah, so I think it was I never thought I’d be a college type of person. I was always more into sports, and like, “Yeah, school’s okay, but I really like working with my hands.” My dad would take me to work with him, instead of paying for a babysitter, he’d take me to work and plumbing. He’s like, “Here, help me solder these pipes.” I’m like 12 years old, like a blowtorch, I’m like, “This is cool, I want to do this.” Yeah, so that was always my mindset, and I didn’t think I could do it...

Ultimately, Payleigh’s mindset about higher education—and her ability to pursue an engineering degree, specifically—were changed by a pivotal interaction with an engineer in 8th grade. However, until that critical incident in 8th grade change Payleigh’s trajectory, her views of higher education were largely shaped by her home community.

As shown in Table 10, the three students who discussed the community higher education rhetoric as “fine without it” were all first generation students and had experienced material hardship. However, only 1 of the 3 students who discussed this community influence were eligible for a Pell Grant.

Table 11. Participant demographics for the "fine without it" trend in geospaital joint display

Participant Pseudonym	Pell Eligible	First Generation Student	Experienced Material Hardship
Payleigh	No	Yes	Yes
Jon	Yes	Yes	Yes
Azad	No	Yes	Yes

“Waste Your Money:” Low Poverty Areas with Low College Graduation Rates.

Finally, two students discussed their community’s deeply held beliefs that higher education was a “waste” of time and money. Unlike students in the “fine without it” trend, students from these communities reflected on their communities efforts to dissuade them from pursuing higher education. As shown in Figure 25, Rachel and Alex—the two students who mention this particular community influence on their journey—grew up in similar communities. Both students describe their communities as rural, and quantitative data shows similar low college graduation rates and low poverty rates in their home community.

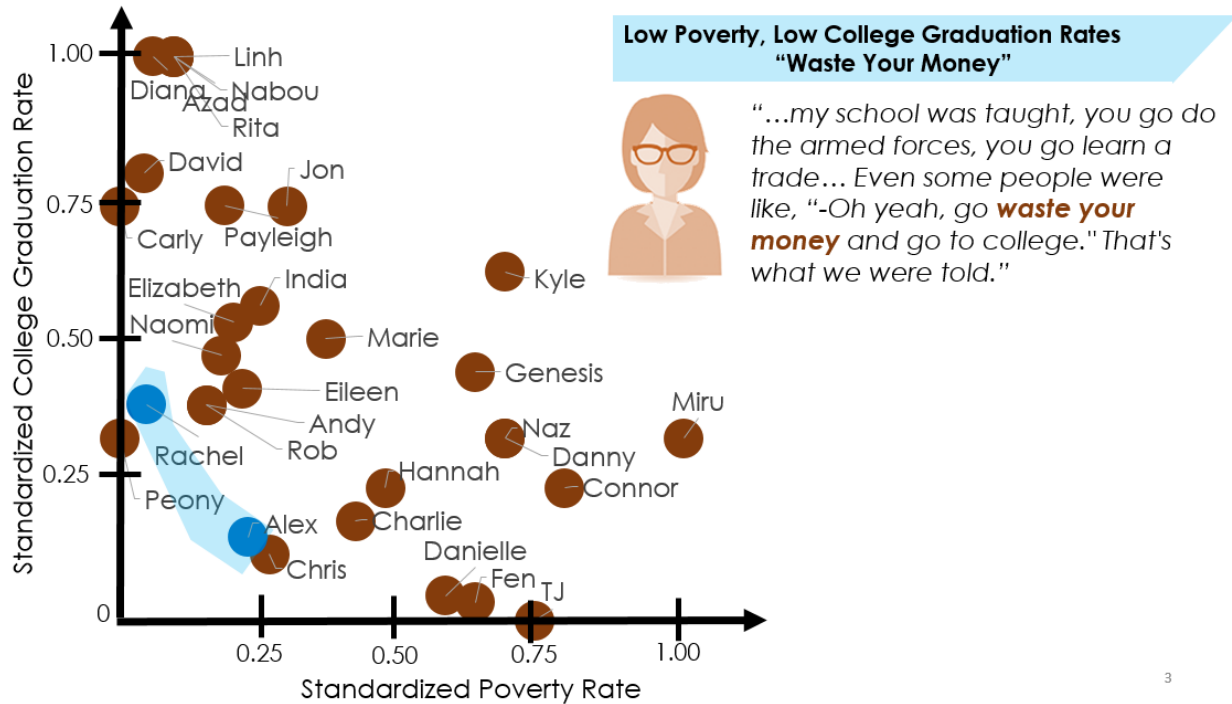


Figure 25. "Waste Your Money" mixed methods joint display. Two students from areas of low poverty and low college graduation rates discussed their community's view of college as a waste of money."

Rachel triangulates this community level data in her narrative, reflecting on the "middle class" status of most people in her community:

My community is more, it's not that it's a poor area per se. I think we do have some poor area. I mean we're a very normal county and we have some richer areas. We have some poor areas. We have a lot of middle class.

Rachel also shares that most people in her community don't see the value of college, instead deciding to follow in footsteps of their families:

...a lot of my peers just did what their parents did. They graduated high school, they got a job doing. Yeah, I don't know, doing electrician or being a plumber or doing hair dressing, which are all fine if people really want to go do that. But they just kind of did what they thought. They checked off the boxes from their parents that they had. And that was that. They just really didn't, I guess, go the extra step.

Rachel concedes that her community's contentedness with following family footsteps is "all fine." However, she also warns her community's beliefs about higher education escalated beyond benign ideology, actively dissuading her and her peers from attending college:

My school was taught, you go do the armed forces, you go learn a trade. If you want to go spend all your money." Even some people were like, "Oh yeah, go waste your money and go to college." That's what we were told.

The danger of this community narrative, Rachel warned, was the way that it became the uncontested cultural norm. Students like Rachel, who pushed against the cultural norm by pursuing higher education, were largely viewed as pursuing an unprofitable path. Rachel describes these community views as imposed on her peers, describing the norms as “shoved down people’s throats:”

They just kind of thought what their parents were doing was fine and I'm just going to stick with that. And then we also get a ton of the army recruiting thing. Everybody just wants to go join the army and do that. Like I said, we had booths, we had army booths and navy booths maybe every other week. We always had recruiters there. Which is also a great profession if people really want to go do that. But I think a lot of those things were just shoved down people's throats that they thought, 'That's what I need to go do.'

Alex reflects on a similar sentiment in his home community, though he believed the 2007-2009 recession was culpable for the change in his community’s feelings about higher education (see section 4.4). During the recession, he shares that community members started to question the value of higher education, similar to the rhetoric in Rachel’s community:

I don't think a lot of people really thought that they would be working in their degree if they go to [college] and if it'd really make a difference on their job. So, I don't ... I didn't keep in touch with many of my ... actually any ... when I graduated high school with, so I don't really know. All I know is their high school perspective but that was basically, "Oh, yeah, we can go to college but we're paying all this money and is it really going to make a difference?" Especially if no one's hiring and everyone's being laid off.

In contrast to Rachel, who rebelled against community norms by pursuing higher education, Alex at first did not pursue higher education. Instead, he decided to enter the workforce immediately after high school, though he would eventually return to pursue his engineering degree. He credits his community’s thoughts on higher education, in part, for his winding trajectory to higher education.

In addition to the similar college graduation and poverty rates in their home communities, Alex and Rachel shared experiences with material hardship and both identified as first generation students. While Alex identified as Pell Eligible, Rachel did not. Participant demographics for the “waste your money” geospatial trend are provided in Table 11.

Table 12. Participant Demographics for the “Waste Your Money” Trend in Geospatial Joint Display

Participant Pseudonym	Pell Eligible	First Generation Student	Experienced Material Hardship
Rachel	No	Yes	Yes
Alex	Yes	Yes	Yes

In summary, students’ reflected in three distinct ways about their community influences on their educational trajectories. Using joint displays to weave students’ narratives with quantitative community level data, three key community influences emerge. First, students in high poverty areas tended to discuss variations of desires to “get out” of their home communities. Second, first generation students in communities with low poverty and high graduation rates discussed their communities’ passive views towards higher education, with a prevalent community rhetoric that people would be “fine without it.” Lastly, students from communities with low poverty and low graduation rates discussed communities actively trying to dissuade students from going to college, viewing higher education as a “waste” of time and money.

Out-of-State Students

It is notable that one-fourth (8/32) of the students in this study were out-of-state students; these students are highlighted in Figure 26 below. One student was an international student, who is not included in these joint displays because standardized graduation and poverty rates could not be determined. As shown from the joint display in Figure 26, no trends were observed regarding poverty rates or graduation rates for out-of-state students. Out-of-state students represented a diverse range of community college graduation rates and poverty rates.

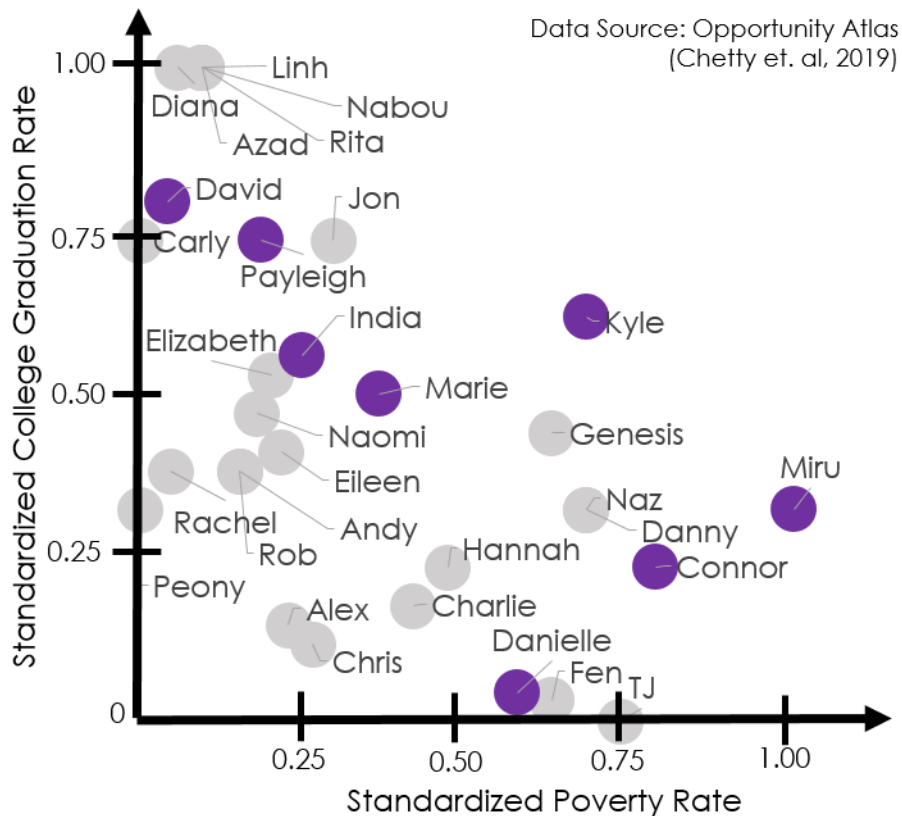


Figure 26. Joint display of out-of-state students

Still, some trends in the narratives of out-of-state students should be noted. All 8 out-of-state students had received federal loans. In addition, all out-of-state students had—at least at one point—been receiving help from their parents to pay for school. For one student, Marie, this situation changed when she came out to her family as lesbian and transgender; after this incident, her family cut off all financial support, and Marie experienced significant hardship (see section 4.4.2). In addition, it is notable that 6/8 of the out-of-state students in this study were working to pay for school.

Overall, out-of-state students discussed a clear cost-benefit analysis about their decision to attend an out-of-state college. David vividly describes his decision-making process:

I applied to a whole bunch of colleges. I'm a pretty analytical person... When I made my decision, I just kind of made a huge Excel sheet and put it on a chalkboard and made a bunch of categories and rated each one, and then took a step back and looked at all my choices and how they hand-up against each other. It was pretty easy to tell [current institution] was my best option, considering everything. I didn't really go on a gut feeling or anything, the number showed me that [current institution] was great.

David refers to “categories” he developed for rating institutions. Like David, all out-of-state students reflected on a process of weighing their options for university. It is striking that every out-of-state student in this study cited the perceived prestige of the out-of-state engineering program as the primary factor in their college choice process. One student, Kyle, noted that he received significant scholarships to other engineering institutions but still chose the out-of-state school because of the rankings of the engineering program.

It should also be noted that half of the out-of-state students (4/8) mentioned their desire to “go away” from their home community. For 3 of these four students (Miru, Kyle, and Connor), their desire to “go away” overlapped with the “get out” of poverty strategy discussed previously in this section. For one student (India), however, her desire to “go away” to college was rooted in a desire to explore, not a desire to flee poverty. One student, Danielle, reflected that the out-of-state institution made her feel “wanted,” particularly as a woman in engineering. However, she shared that she wished she would have known about community college transfer options:

I wish I would've known a little bit more about application processes. Or even going to community college for a year and then transferring because it's way less expensive. And I didn't know that much about applying to scholarships or loans or grants 'cause my family hadn't done it before... [student loans are] pretty bad. So my parents they make enough so that I don't get a lot of federal help and or financial need based scholarship help. But they don't make enough where they can help me more than with rent and things like that. And maybe if I would've gone back in time, I would've spent a year or two at community college and done that whole deal.

Like Danielle, all of the out-of-state students mentioned cost of tuition as a significant stressor. Notably, 3/8 out-of-state students referred to their engineering degree as a sort of leap-of-faith investment. They believed that the debt they would incur at an out-of-state school would be “okay” because they could repay it with their high-earning engineering salaries later. Payleigh describes a high school teacher who encouraged her to attend an out-of-state engineering school. She shared that the teacher told her she would make enough money as an engineer to be “fine,” so she was “taking their word for it.” All 8 out-of-state students reflected on navigating student loans, but no one mentioned having access to social capital to provide support on loan repayment plans. As Kyle summarized:

I basically taken out loans for essentially all of my tuition. I'll have to pay it back eventually. That's a future worry, and not a present day one, 'cause I just got to focus on graduating, and getting a job

While out-of-state students were worried about debt, debt tended to be viewed as a problem to be figured out after graduation. Considering the current state of predatory loan repayment schemes in the United States, coupled with students' lack of access to information about higher education loans, this finding is particularly troubling.

4.3.3 Economic Environments

Two students highlighted the influence of the national economic environment on their educational trajectories. Notably, both Alex and Chris discussed the impact of the United States economic recession, which began in December 2007 and officially ended in June 2009, though the impacts of the recession lingered for afterward. Alex and Chris both shared how the recession impacted their families and communities, and—as a result—influenced their educational journeys.

Alex, a mining engineering student, grew up in a “coal region” where many community members worked in coal but “only negative things were said about [coal]”—such as “oh, it’s a declining market” and “it’s unhealthy.” Alex shared that several of his extended family members had fought deadly battles with black lung disease, further cementing his desire to stay away from coal. Right before the recession, in 2007 or 2008, Alex recalls, his family pooling their efforts to start a small business. The timing, however, would render his family’s business efforts fruitless, and cause significant financial stress to his family. He recalls:

So in 2009, I think, or maybe it was in 2008 or late 2007, my dad opened a retail store and pretty much our family invested heavily into that. So, in 2009 there wasn't really much of a market for anything, so our family felt that pretty hard.

In addition to hurting his family’s business, the economic recession also significantly impacted Alex’s home community. He describes the influence of the 2007-2009 national economic environment:

So, the region I grew up in there wasn't many jobs going around. I would say there's a point where ... I would say, 50% of my friends had one or both parents unemployed. So, there was a really poor outlook on our future and our jobs.

This grim national economic environment, in turn, shaped his peers' trajectories after high school. He shared, "people I knew didn't try to further their education" and instead looked to the job market as the best career path. He elaborates:

[My peers'] high school perspective... was basically, "oh yeah, we can go to college but we're paying all this money and is it really going to make a difference? Especially if no one's hiring and everyone's being laid off.

In this excerpt, Alex highlights the community chatter passed to him and his peers about job prospects. Even college graduates struggled to find jobs during the recession, so Alex and his peers began to question whether college would "make a difference." After thoughtfully weighing his options for the future, Alex decides to work in the mines after high school to avoid going in debt for a college degree that might not even pay off. He shares why he decided not to pursue higher education:

I didn't want to pay, what, \$15,000 in tuition a year plus all your living expenses and extra expenses, just to get a piece of paper that isn't going to do them anything.

Ultimately, Alex entered the work force and held multiple mining jobs. During this time, Alex said his wife "really saw how much [college] meant to me" and encouraged him to pursue it. At the time of Alex's interview, he was in his junior year in mining engineering at a four-year institution, having transferred from a community college. In his narrative, Alex directly links the national economic recession, which coincided with his formative period of decision making, as the reason why he did not pursue higher education immediately after high school.

While the economic recession pushed Alex away from higher education, it pushed Chris—a computer engineering student—toward higher education, and more specifically, toward computer engineering. Like Alex, Chris's family acutely felt the influences of the recession of 2007-2009. He discusses his family's financial tribulations, emphasizing the impact of unemployment during the Great Recession:

My parents have always been financially unstable. I would have to pay for things in high school myself, I got a job when I was 17. They, my mother has had health issues since 2010. She had back surgery that went wrong and then she had a stroke in 2012, 13. Then the housing market crashed and of course in 2009 my parents are both truckers, truck drivers. They lost their jobs and then dad ended up getting a job with Norfolk Southern,

but all the time, no matter how much money they had, they could never maintain it. They always spent more than they had. I always bought stuff myself with money I had.

Chris says his parents' financial situation was always unsteady, but their financial insecurity was exasperated when they lost their jobs during the Great Recession. This feeling of insecurity, he said, pushed him directly toward computer engineering, which he viewed as a stable, reliable career:

I would like to get money. I would like to be financially secure... I would like to feel safe and feel like I have a future... Everything is becoming a computer and that's been the big door. Okay, I could have been a math major if it weren't for the money, but then I was like, computers are everything. The jobs that are going to exist in the next 20 years are the jobs essential to our human life. They're seeing in doctors until we come up with a system where we can prevent everything, the housing market, people are always going to want houses. Everything is becoming more like a computer and that we're always going to need people to program them until we can create something of a higher power that can do it themselves. So that's always been like the end goal. I'm like, hey, I'll have a job that will be sustainable and I really think that bases off of my parents losing their jobs. I was like, no, I'm not ever having that happen because of the economy. I was like, I need to be somewhere that's stable.

For Chris, the instability caused by the Great Recession created a yearning for stability. His parents' lack of employment during the Great Recession was a pivotal period in Chris's life. Ultimately, Chris's family experiences in the Great Recession would lead him to pursue computer engineering as a direct pursuit of stability and security.

In summary, two students in this study specifically highlight the impact of the Great Recession on their educational journeys. However, the influence of the bleak national economic environment from 2007-2009 pushed them in starkly different directions. Chris, whose parents experienced job loss during the Great Recession, ran directly toward computer engineering in search of a stable, secure career. In a way, the Great Recession pushed him toward higher education and toward computer engineering, specifically. Alex, on the other hand, was repelled away from higher education by his family and community experiences during the Great Recession. For Alex, the Great Recession created doubt about higher education's ability to result in gainful employment.

4.3.4 Institutional/Peer Environments

A fourth social environment students discussed as an influencer on their trajectories was their institutional environment. In particular, students highlighted their interactions with their peers in their institutional environments, particularly as they navigated their transition from high school to college. Across participants, two distinct trends emerged in the way students' talked about the role of their institutional environment in their trajectories. In both trends, students discussed assessing their institutional environment and subsequently shifting their trajectories based on their evaluation. I discuss both of these trends below.

Finding People Like Me to March With.

For many students, a pivotal period of their trajectory was navigating the transition from high school to college. While most students discussed their transition period to college in their narratives, students of color tended to reflect on this transition in a common way, recalling their prioritization of finding people with which to march. Some students of color talked about the “culture shock” of entering a predominately white institution (PWI) environment—an environment that looked nothing like their home communities. India reflects on her experience navigating from a diverse community to a PWI:

It was very different to come from this culturally diverse area of Houston, Texas, where I'm living on the same street with African Americans, white people, Pakistanians, Asians, to coming to this place where it's just predominantly white people. And so, the culture shock was huge for me. And I missed my family a lot coming here. I went to [bridge program] and so, I was in a small track, it was about 20 of us, and I was the only African American girl.

India continues in her narrative, describing her experience in the summer bridge program she participated in before her first year in engineering. She recounts feeling “so behind” her peers because she had not been exposed to engineering tools such as MATLAB. These feelings escalated one night at the library while working with her project group:

And so, I remember one night in the middle of [summer bridge program], I just broke down crying because I was in the library with my group and they were telling me to do all the stuff that I didn't know how to do, you know, and I was scared to ask, how do you do it? I really don't understand. I really don't know because I've never experienced it, I've never done this before. And so I broke down and cried.

Feeling frustrated and isolated in her new environment, India reached out to her family, who had remained a consistent source of support in her life. However, she became more frightened when she realized she was “in this whole different setting without them:”

I talked to my mom and she, we were talking for like hours and she was really encouraging me, telling me that I could do it, I could do it. But it was so not weird, but the fact that they were so far away and the fact that I'm very family oriented, it was just, I don't know, she was telling me one thing and I was in this whole different setting without them. And it was just extremely scary for me. And I think that's when it really started for me where, I just felt like I really didn't belong and I didn't really have a chance within engineering.

Note that India recalls concluding “I didn’t really have a chance within engineering” before her first semester at the four year institution began. Her experience in the summer bridge program, where she was the only African American woman, left her feeling isolated and unsure of her ability to persist in engineering as she entered into her first semester in engineering. She recalls persisting in engineering “even though I [had] a continuous sense of the imposter syndrome” as she navigated being “the only one looking the way I do” in her classes. India believes she would not have persisted in engineering without finding people to march with—“girls who look like me” in engineering through the National Society of Black Engineers (NSBE). She shares:

After I joined NSBE, I think I was really blessed to be in this class. In the class of like 2020, I came in with all these other girls who look like me, and they want to be successful. And I don't see that in like other classes in engineering, you know?

And so even though we're in different majors, we're all succeeding in engineering together, you know. And so, some of my best friends here are in the same major as me, and I'm blessed in that aspect as well, because we're in the same classes and we're doing it together. And I feel like that's that extra push that I need, you know, to just keep going, you know?

Here India paints a picture of marching with her peers in NSBE as they succeed together. India’s predominately white institutional environment shaped her trajectory by pushing her to find the people who looked like her and had similar aspirations, ultimately resulting in her joining NSBE and building a community with her NSBE peers.

Differentiating Oneself.

While some students, like India, looked around their institutional environment and thought “where are the people like me?”, other students looked around their institution and thought, “how

can I make myself different from the people like me?" Several students talked about actively striving to differentiate themselves from their peers upon the realization that many peers at their institution would have similar qualifications upon graduation. Three students, notably all women, shared their strategies to focus on honing their professional and leadership skills in order to distinguish themselves from their peers. For example, Rita, an industrial engineering student, reflects on her epiphany of how to "separate herself" from her peers by leveraging her professional skills:

So my freshman year was when I went to Convention, NSBE Convention, and that's when I noticed the importance of working on my communication skills with recruiters... I wasn't even in engineering then and I had like three offers to do like an engineering job. And I was like when I had my ah-ha moment, I was like, I was so hyper-focused on grades. Because I thought only the best, the people with the highest GPAs get the best internships. And so, I got GE which is like a huge company... and I was like, oh wow, this is what will separate me from the other people is how I can talk to the recruiters and how I can communicate with them.

Rita recalls her epiphany to focus her efforts on developing her professional skills, such as her communication with industry recruiters, as a way to differentiate herself from her engineering peers on the job market. In a similar way, Rachel reflects on her efforts to differentiate herself from her peers by focusing on her leadership skills:

when I got into college, I kind of, another big thing that I realized was there's a lot of the people that are super technically smart. Very book smart, really good, the numbers and the figures and everything like that. And I realized I was kind of not on that level. I mean I'm doing fine, absolutely fine academically, but I kind of realized it was like "Eh, I'm never going to be like one of these super geniuses that solves the problem to everything or cracks the code." So I kind of realized early on what my, I guess my challenge was compared to others academically and I was like, "Well I'm going to turn that into a strength." And so ever since then I've really focused on getting more professional development.

Joining my sorority helped me meet, helped me network and meet people and I realized it was like, "Hey, I'd be, I'd probably be really good as, in a manager role at some point in my life." So that's kind of where my whole thing of turning into a manager would go. That kind of thinking I did, I probably did that a lot of my own just 'cause I've always recognized myself as, I always feel like I have a good group leader and especially an engineer that first year of engineering, you do a lot of group projects and I was like, "Yeah, I definitely am a leader in this group. So I'm gonna, I should probably aim maybe towards that path rather than being the super genius on like the computer or whatever. Which is also, I mean, I wish I had those skills, but I just, I don't, and so I recognize that, but, I'm using that as my, as my path forward and I've, and so every step that I've taken

along the way, I've kind of aimed more towards, how can I be a better leader? How can I be a better, I guess, how can I prepare myself better for the future? So that's kind of where I got into always looking into internships and all of that.

In this narrative segment, Rachel reflects on assessing her institutional environment and, more specifically, the skills of her peers. Her evaluation of her peers leads her to conclude that she should hone her leadership strengths as she pursues a career in chemical engineering. She recalls recognizing the importance of developing her leadership strengths as early as her first year in her engineering program and subsequently building a dossier of experiences that would position her strengths in leadership to a future employer. One other student, Peony, discusses her experiences leveraging her leadership skills in her engineering group projects. She advises other students to “learn their strengths” within group settings. She shares in detail about her strategies to navigate her engineering group project and leverage her strengths:

...something I think I was the strongest point within my groups was recognizing what I wasn't good at. Not being I denial that, oh, I'm not amazing at code, but being able to recognize your weaknesses and what you are not good at versus what you are good at... I ended up being the main group leader coordinator for both of my engineering group projects. We did extremely well, got everything done on time...

We did the drone project, so we had to do construction, some prototyping... you have to do some coding, have to do some writing. All of the other people in my group were pretty much CS computer related major. So I was like, if you guys can talk all that code, I'll do all the prototyping and then we can work together on the paper. And that's exactly what we did.

In this narrative excerpt, Peony reflects on her self-assessment that she was “not amazing at code” and determining that she should focus on her leadership skills instead. This excerpt suggests that strategies to differentiate oneself should not be interpreted as inherently positive, as Peony and Rachel both reflect lower self-efficacy in technical aspects of engineering. Peony refers to a specific technical engineering skill, coding, while Rachel extrapolates her self-assessment to a broader level of not being as “super technically smart” as her peers.

While Rita, Rachel, and Peony discuss strategies to differentiate themselves through professional skills, another three students—notably, all men, strategized to differentiate themselves through extracurricular projects and activities. Examples shared by these three students included joining design teams, seeking internship experiences, and conducting projects

outside of class to build their resume. While many students in this study were involved in design teams or extracurricular engagements, only three students—Charlie, Naz, and Azad—mentioned specifically engaging in these activities in order to distinguish themselves from their peers. For example, Charlie shares:

I knew to be successful in engineering or physics you need to be more than just a student. You can't just have good grades. So I wanted to start getting more involved in extracurriculars, projects, things like that, than I was in high school.

Similarly, Naz reflects on his efforts to gain technical project experience outside of his classes as a way for him to distinguish himself from his peers. He shares:

So on my resume I have a lot of experience, so I have certificates from high school. I have a personal goal website, and I have things of PC repair and working for a PC repair company, things like that. I have experience in the field that a lot of people don't.

Like Naz, Azad reflects on the imperative to build technical experience outside of his class work in order to secure an internship with a company. As a community college student, Azad shared that opportunities to network with companies were almost nonexistent. He discusses his strategy to develop technical project experience before transferring to a four-year university, where he knew opportunities to connect to companies would be more accessible:

when you're in community college, you can't get interviewed as easily. Right? You don't have the career fair. You don't have professors you can talk to and say, "Hey, do you need any research assistants or do you know any companies?" ... When people see you don't have any sort of education, well, the only alternative, at least in [computer science] and I'm sure it's probably even worse in other engineering majors is building projects. I did a lot of iOS app development starting off. I really didn't know what I was doing initially, but just getting in the ropes early on helped me a lot in building a project base where when I came to [four year institution] I was already a leg ahead of most people here simply because most people here, they were firmly focused on academics just trying to survive the major. Whereas for me to even get my foot in the door anywhere, I had to bring something else to the table.

In summary, students' narratives highlighted the impact of institutional environments on their educational trajectories. Students of color tended to reflect on the 'culture shock' of transitioning from high school to college at a predominately white institution. Several students navigated this transition by finding people who looked like them to march with, or move through

their engineering program with. While some students assessed their institutional environments and determined they needed to seek out the people who looked like them, other students determined they needed to differentiate themselves from their peers in order to be competitive for engineering internships and jobs. Common strategies for differentiation included honing in on personal strengths, focusing on professional development, and seeking out opportunities to build engineering technical skills, such as personal projects. It is interesting to note that the strategy to differentiate oneself by focusing on professional development was highly gendered in this study, only emerging in three women's narratives.

4.3.5 Political Environments

Finally, the national political environment—and, in particular, the nexus of U.S. media and executive leadership at the time of this study—emerged in two students' trajectories. Rob, an aerospace engineering, discussed how the national level political rhetoric impacted his day to day interactions as a Hispanic man navigating a PWI:

with everything that, I guess with certain things that I hear over the news, with like the President trying to say you know all these racisms and things like that, and they'll show negative things on the news. Like white people basically saying, "Go home we don't want you," or "build this wall, you're rapists, criminals." Well I'm just like, well I never raped anybody. I've never committed a crime. Do you guys really think that stuff about it? And I feel that's also another thing that played a role in trying to make friends, because I also hear that the South is a bit more conservative, and I'm just afraid of saying like, I'm literally going to a conservative field.

It is striking here that Rob uses the verbatim words of the executive leadership at the time of this study, who released public statements that included slurs about persons from Mexico, from where Rob's family had immigrated. He elaborates on how the national political narrative impacted his everyday life at college, making him question how he would be treated by his peers:

One thing though that I did find a little bit challenging at first was like, because I came here and I don't know anybody. I live four hours away from here. So I guess just trying to make friends and things like that. I feel like was definitely somewhat difficult for me, trying to just go up to people, random people, and say, "Hey," introduce myself. So at first I just went up to random tried to talk to them, just say, "Yeah I don't really know anybody, I'm just trying to meet people." And everybody here was friendly. The majority of people were friendly, they'd say, "Yeah you know, let's exchange contact information, we'll go hang out or whatever." And so that was good...

...it was a fear of being rejected and then having them say like, because the majority of the people that I've seen here, I guess maybe not that it matters, but they're White, right? But I'm Hispanic. So I guess I was kind of afraid that if I came they were going to see me as something different. Like, "Oh you're Hispanic, you're not part of us, you're probably here because, and plus you went to NOVA, so we're here since freshman year, so I'm above you, better than you," things like that. I guess I was kind of afraid of that criticism.

Rob's narrative highlights the tangible, day-to-day impact of the national political environment on his educational trajectory. As evidenced by Rob's reflection, the political environment was not a distant set of ideological debates. Instead, the political environment—and, in particular, the violent language perpetuated towards people of color by politicians—had a palpable impact on Rob's day-to-day interactions.

The other emergence of a political environment influencing a student's educational trajectory was shared in the narrative of Marie. Marie noted that the national political debate about transgender bathroom accessibility influenced her day-to-day decisions and feelings of inclusion at her university. She also discussed political environments at the institutional level, noting that the university president, who sometimes sent out emails to the university community condemning violence against marginalized groups, failed to comment on acts of violence perpetrated against the LGBTQ+ community. The university president's silence on LGBTQ+ discrimination made her question whether she was supported at her university. Similar to Rob's narrative, Marie's narrative highlights the influence of political rhetoric—or the lack thereof—on students' educational trajectories.

4.3.6 Summary

My second research question explored the influence of social environments on students' educational trajectories. From student narratives emerge five types of social environments that significantly shape students' trajectories, including collective agency in family environments, community level rhetoric about higher education environments, economic environments (e.g., the Great Recession), peer and institutional environments, and political environments.

4.4 Critical Incidents and Changes in Trajectories (RQ3)

In RQ2, I explored the role of social environments in students' educational trajectories. In my discussion of results for RQ2, I largely treated social environments as static entities that remain unchanging. However, social environments are subject to change—change that is

unexpected and volatile in nature. In the following sections, I complicate my exploration of influences on students' trajectories by exploring the following question: *what critical incidents do underserved engineering students perceive to alter their educational trajectories?* My exploration here focuses on the dramatic changes in students' trajectories and the critical incidents that led to them. I discuss three types of critical incidents that emerged in students' narratives: 1) translocation (shifting fields); 2) unanticipated revaluation of capital without changing physical location, and 3) re-authoring habitus, often evoked by a social interaction.

4.4.1 Translocation: Shifting Fields

First, many of the critical incidents that students discussed were directly tied to a geographic move. As student navigated changes in location, a pivotal transition occurred that was typically associated with learning to access, activate, and/or develop capital in new set of fields, or social spaces. Many students referred to moving physical locations as one of the most critical time periods of their educational trajectory. Three types of changes in physical locations emerged as salient in students' journeys, including moving to a new country, transitioning directly from high school to a 4-year institution, and transitioning from community college to a 4-year institution. I describe each of these below.

Moving Countries: First Generation Immigrants

Students who were first generation immigrants tended to reflect extensively on their journeys navigating from their home country to the United States, citing their move to the United States as one of the single most important events of their lives (Figure 27). As students discussed this critical incident in their lives, a common theme across students' narratives was the importance of activating—and, in some cases, developing—navigational capital. Through the development and activation of navigational capital, first generation immigrant students discussed developing a new set of linguistic capital. As students enacted navigational capital, they reflected on drawing from funds of linguistic capital from their home country as they navigated situations on behalf of their families. For many students, the development of linguistic capital resulted in them become default representatives for their families as they often served as interpreters in legal, medical, and social situations.

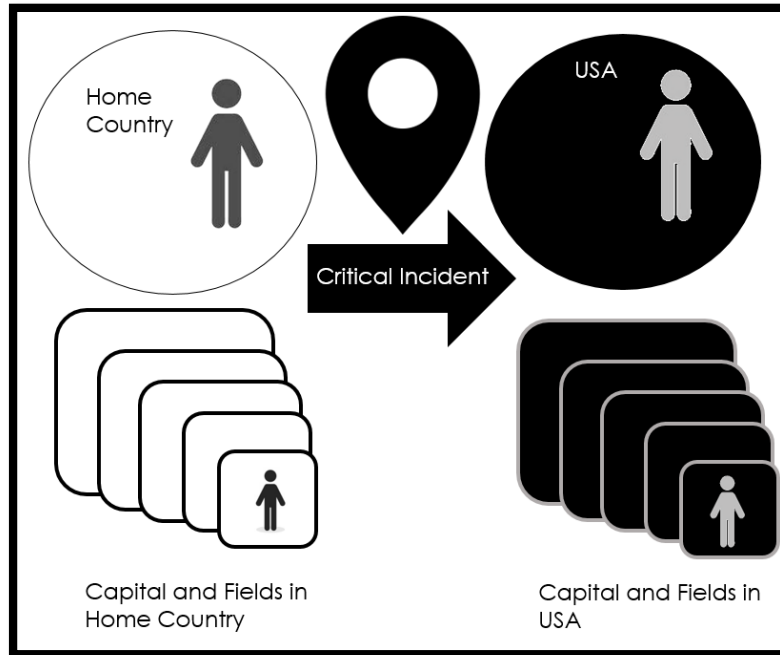


Figure 27. Visualization of students' reflections on moving countries as a critical incident in their trajectory

For example, Danny reflects in her narrative on her process of enacting navigational and linguistic capital when her family moved from the Caribbean to the United States during her childhood. She shares:

I remember back in eighth grade, like out of my entire family I, well there's only four of us, but out of the four of us I have the most, the strongest American accent if you would say and, at that came from eighth grade that came from going back into eighth grade probably because of the maturity level of the students that I was with, you know, they, I wouldn't say they bullied me because I didn't, I didn't necessarily feel threatened in a way, but they definitely brought on that insecurity of how I sound and, being that throughout eighth grade I was, I was the only one that was from the Caribbean.

So I was literally standing alone by myself, had no support and stuff and so, I obviously, I automatically felt the need to change and so eighth grade I adapted this American accent trying to fit in and I didn't become necessarily a follower rather than a leader but, I fell back rather than being the person that I usually was, which is when I was in my groups back home I, was confident enough, you know, to speak out.

Danny recalls actively working to develop an American accent so that her middle school peers would relent their bullying.

Miru, whose family also immigrated to the United States when she was a child, also reflects on navigating this critical incident in her trajectory:

When I first got here, I was about seven, and we lived in an apartment in [state]. I wasn't fluent in English at all when I first came to America. I only knew a little bit of alphabets, I didn't even know all of them. I knew a little bit of alphabets and that was about it. I remember when I first came, I knew how to say like, "Oh, my name is blah, blah, blah," but when someone actually asked me what's your name, I couldn't speak because I was scared, although I knew what to say. So, transitioning was difficult, but like I said, in [state], there weren't any Asians or Koreans because I'm Korean.

I mean I have to go to school and I was in third grade, no Asians. No one I can really speak to. I just sat in class. Did what I can do, just picked up stuff, just listening to other conversations. But I was good at math, and math is a universal language so you don't really have to speak English to do math. Yeah, for a long time, we didn't meet any Korean people around. And although I was no way close to fluent, I was still better than my parents because I was young and I picked up a lot faster than them. So, even since when I was in elementary school, I just remember having to translate a lot for my parents like this one time, we got internet at our house but it was so slow. So, I have to call them and tell them that it's slow and we don't like this.

Miru reflects on using math as a “universal language” as she worked to navigate the new fields she was in when her family immigrated. Like Danny, she shares that she undertook additional responsibilities for her family after they immigrated to the U.S., developing navigational capital not just for herself but for her entire family. Though I omit specifics here to protect Miru’s anonymity, Miru shared intimate details in her interview about navigating serious financial and health situations on behalf of her family—acts of advocacy that she undertook as early as elementary school. Miru posits that developing navigational capital “made me mature a lot faster than other people.”

Nabou’s journey offers another salient example of immigrating to the United States as a “critical incident” that shifted her educational trajectory. In fact, it was a critical incident that led Nabou’s family to immigrate to the United States in the first place:

Yeah. Everyone knows I was born in [home country]. I lived there for 11 years. I went to a private Catholic school. Honestly, when I was there I thought I wanted to be a secretary because the thought of being in the United States was out of reach. I didn't think I was going to make it to the United States. I thought I was going to spend most of my time in [home country]. My first instance was to be a secretary. Then I thought about being a lawyer because my father's brother, my uncle, was a lawyer and that looked pretty good. That was one of the most respectable positions you could have...

Here, Nabou reflects on her aspirational capital and its development in her home country. She originally desired to be a secretary, and later, a lawyer. Both of these career paths were well

respected in her home country. However, then a critical incident happened that changed her family's lives, and as a result, Nabou's educational trajectory:

... but then the [natural disaster in home country] happened and I moved to the United States. I had to learn the whole language in the span of a year pretty much just to be able to take regular classes. I ended up learning it pretty quickly so in 7th grade they moved me to regular classes and in 8th grade I got into honor's classes. In high school I started taking honor's classes as a freshman because they didn't have AP classes for 9th grade. In 10th grade I took my first AP course which was AP English, like everyone AP literacy. Then I took AP history and the AP classes just kept coming. I was like, "I guess this is regular. I can't go back now. It would look weird if I did." I started going into the AP math and AP sciences. I took honor's bio and then I took honor's chem then I took honor's physics and then I took AP chemistry. I had the same professor for AP chemistry and honor's chemistry. He knew me by name. He knew who I was. He always came to me like I said and that's when I was applying to colleges. He basically just out of nowhere said, "I think you would be a really good chemical engineer. You should think about that."

Though Nabou had originally aspired to be a secretary or lawyer in her home country, her family's move to the United States became a life-altering critical incident that ultimately exposed her to new social capital and aspirational capital in her new fields.

Nabou, Danny, Miru, and other students in this study whose families had immigrated to the United States each reflected on their family's immigration as a critical incident on their educational journey. Common elements across students' narratives of these critical incidents including accessing, activating, or developing navigational and linguistic capital and serving new roles as navigators for their entire families in the United States.

Changing Institutions: First Time in College and Transfer Students

A second type of physical move that students pointed to as a critical incident in their educational journeys was their transition from high school to college. Students noted that transitioning from high school in their home community to college in a different community was a critical incident and required significant navigational capital, learning new rules and norms of their social environment and working to build social capital. One student, Danny, compared her process of transitioning from high school to college to her process of immigrating to the United States. She shared:

I guess in my confidence level and I feel like that affected me throughout the move as well to [university] to where I did the same thing to where I was out of my environment that I got used to... so coming to [university] it was just starting all over again and, it

didn't seem like a long enough time to where I was comfortable with who I was to basically be who I left off to be in senior year. So it basically came like I was starting middle school all over again and I had to revamp myself to match these American college kids you know?

Danny says that transitioning to college was like “starting middle school all over again” after her family immigrated to the United States. She reflects on actively working, again, to learn new social norms and “rules of the game” during her high school to college transition, just as she had done when her family immigrated.

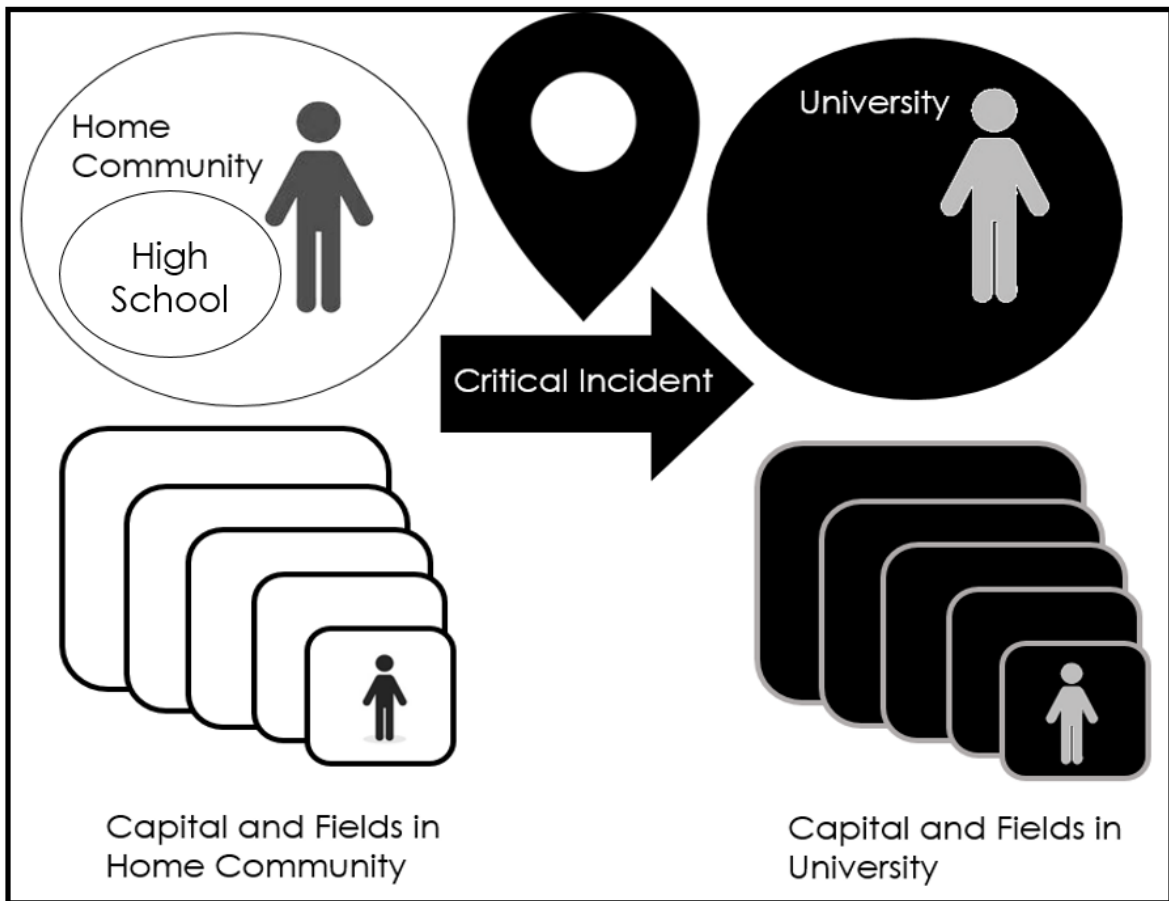


Figure 28. Visualization of critical incident of transition from high school to college

While some students, like Danny, reflected on their process of transitioning directly from high school to a 4-year university, some students said the most critical incident in their journey was navigating from a 2-year university (i.e., community college) to a 4-year university. Students’ highlighted that community colleges were typically located within their home communities, so learning the expectations and cultural norms was less of a challenge. However,

when these students transferred from their local community college to a 4-year institution, the change in physical location was accompanied by a need for different types of capital in their new social spaces. Charlie, a student who transferred from his local community college, reflects on transferring institutions as a critical incident in his journey:

But since getting here first semester, it's ... First thing I would notice it's just really different coming from a two-year school... But I did notice that it was just, the atmosphere was really different from anything that I experienced, high school, [community college], even just like what I grew up around. It's just being around this many people your age that are all academically motivated and intelligent was just a really weird feeling, to just be around so many similar people, and like-minded people. So it just kinda ... Even now, just walking around campus sometimes, it's just gives me a weird feeling, cause it's just so wildly different from anything that I've ever really been a part of.

Alex echoes Charlie's sentiments about transferring institutions as a critical event on his trajectory. Though he calls his transition "tough," Alex performed well academically in spite of the challenges associated with navigating a new social space:

So I got here, first semester went really well, I surprised myself. It was a little discouraging actually coming to [4-year institution] because when I was at community college, the classes were tough but I felt like there was a lot of ... it was a smaller environment and it was easier to find support. So then, they had ... they would pay for tutors and they would have specific work zones that people would go and work on certain subjects. Which is obviously more easier to do on a smaller scale and then when I came here, I didn't know anyone and some of the professors seemed like they were there more for research more than teaching.

I didn't really ... they were talking a million miles a hour and there wasn't any actual explanation, it was all theory. And then there's this huge disconnect with the actual material. So it was really challenging. I actually sort of hit a wall with a couple of my classes, I'm like, "I don't know if I can do this, it's very difficult." I ended up sticking with it obviously and stayed with the class. I did not end up doing well in that class, but no one did well in that class, so I wasn't used to a 30-some point curve on the final grade but apparently that's a thing. So, I ended up doing fine in all my classes the first semester even though it was a hard transition.

Though Alex managed to excel academically after his critical incident of transferring, he also shares that his mental health suffered during this time period. He reflects authentically on his transition to a 4-yr institution:

Yeah, so a pretty tough time. The ... It wasn't ... I would say I get into modes where I just focus a lot on work. It's honestly I've come to the point where I realize it's unhealthy, I've

tried to tone my intensity back a bit. But I was really intense, I was really focused. I had a lot of perspective from the two years that I wasn't in college. How tough the world could be if you really don't have much to ... Anyways, this degree meant a lot to me, so having that goal in mind and having perspective of what happens if I don't get this degree, really put things in perspective.

So, I mean I was working my first year, I was putting probably 60 hours a week in. I was pretty exhausted. It was really a lot of self ... especially the first semester, it was just staying ... I didn't know anyone, so I would just read my textbooks and just work through every problem in the textbook. It was a little ... like I said, it was obsessive, but I felt like if I didn't do that, it would be very difficult. I just felt so much pressure.

Also, the fact that if I didn't get a certain GPA, bad things could happen regarding my staying in the College of Engineering or not getting in my major. So, there was just a lot of pressure in that season. It wasn't healthy, but I got through it.

Really that semester was probably the worst for ... regarding mental health and ... but also the following semester, just because I was working even harder the next semester, even though I knew people. But the course requirements that we had to take ... there was just so many heavy classes, it was a little too much work. I'd say ... actually those two semesters definitely low on mental health and that was a big struggle.

Chris shared similar experiences to Alex when navigating his transition from community college to a 4-yr institution in engineering, noting that he managed to perform academically but his health suffered greatly. He shares:

Showed up at [4-year institution]. Took 15 credits my first semester. Took a lot to acclimate to the campus... I started getting into the core engineering classes and it really bogged me down...I've always had like test anxiety and generalized social anxiety and my mother's bipolar so I guess, I don't know if that genetically went anywhere. I really suffered from depression that second semester. Like it got really bad. [Fiance] was telling me, "Hey, maybe you should go see counseling." I ended up going to [counseling center] for a few weeks, but I could only get an appointment every two or three weeks because they're booked. I ended up finally seeing a doctor, I went to [medical center] to get evaluated and they told me I have social anxiety and depression. So I became medicated into [medicine]...That was, it was a really weird transition because I went from being so stressed and everything to the medication working and it actually made where I didn't care at all. I stopped caring completely. So classes were hard, but at the same, not. That was a struggle. That was a real big struggle...

It is noteworthy that several of the transfer students in this study reflect on the critical incident of transferring to a 4-yr institution as detrimental to their health and well-being, whether physical, mental, or both. Also of note is that transfer students reflected on challenges enduring throughout

their first and second years at the 4-year institution, showing the longitudinal impact of transferring—a critical incident—on their trajectory.

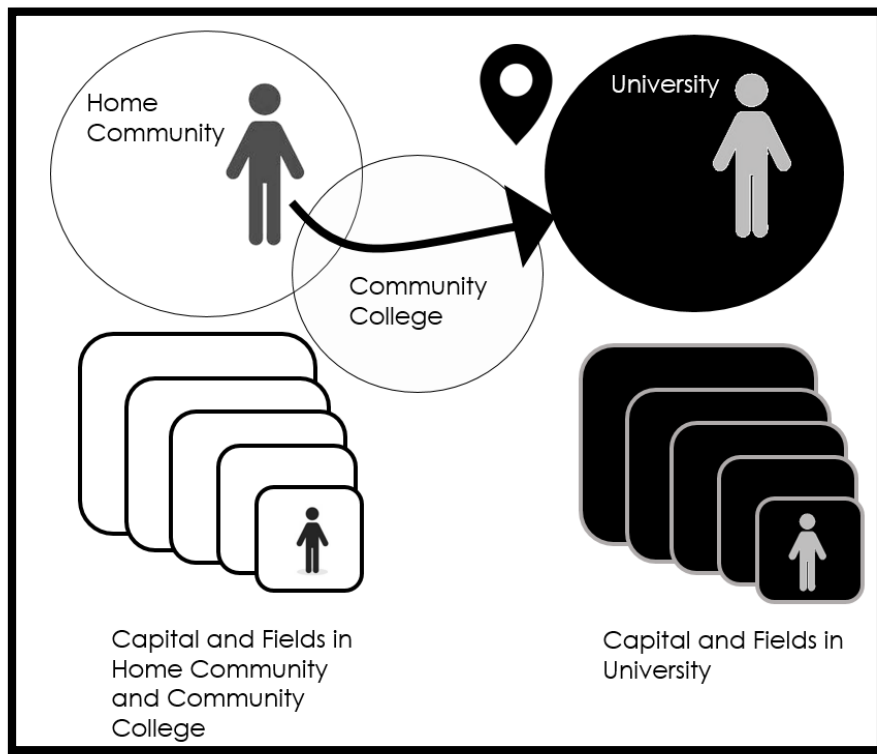


Figure 29. Visualization of critical incident of transitioning from community college to four-year institution

4.4.2 Unanticipated Revaluation of Capital

Another type of critical incident that emerged in students’ narratives was a sudden and drastic change in capital *without* moving physical locations. In these incidents, students’ discussed their worlds entirely changing though their physical locations stayed the same. Students reflected on these critical incidents leading to an unanticipated, dramatic change in economic or family capital, and these events emerged in students’ narratives as early as childhood and as late as university. For example, Andy, a chemical engineering student, shared in his narrative interview that his parents’ divorce remained the most life-altering incident of his life. Before his parents’ divorce, Andy says, his family was financially stable:

I guess, growing up I was part of a family that was pretty well off, I would say. My dad came here when he was around eight. My mom came here when she was around 19, I would say. My dad made enough money to sustain our family. I have two other siblings, so three kids. He made enough money to sustain our family just working by himself, and I

guess we lived an upper middle class lifestyle. So growing up I had my mom to stay at home and care for me. We lived in a pretty good neighborhood, I would say, in [state].

However, he says, everything changed when his parents divorced in his childhood:

I guess when I just started middle school, when I think I would say I was 11, 10 or 11, my parents got divorced. I think that was a really big shock. Obviously, now that my dad can't provide for us anymore, I had to go through the whole divorce.

My mom spoke no English, so basically, I was the one at 11, 10, 11, 12 years old, whatever, that had to help her go through the whole proceedings. So I mean, I witnessed everything from how two people can be so in love with each other and all of a sudden, after 10 years of marriage or 11 years of marriage, it just all gets destroyed. So I went with her to the lawyers. I was the one who contacted with the lawyers. I didn't know anything at that point, so I helped her go through that.

So yeah, after they got divorced, we had to sell the house. My mom lived off of my dad's payments, which were decent, but I mean it was definitely a significant drop in income after that. So throughout middle school and high school we lived on less income. My mom was never home, because she obviously had to go out and work to make some money to help us. I don't think I would say our income at that point was low. I would just say it was definitely, not low compared to a lot of other people in the United States. But definitely for the area that we lived in, northern Virginia, it was where the average income is around definitely in the six figures, ours was definitely, I would consider it low income for that area.

Andy highlights his parents' divorce as a critical incident that led him to develop navigational capital, supporting his mother as the primary English language speaker in the household at 11 years old. In addition, the divorce incident significantly changed his economic capital, and—as a result—his family capital. He notes that, due to his mother's increased work hours after the divorce, he had to learn to independently and focus his efforts on school:

So yeah, growing up through middle school and high school, I never really had someone to care for me. I was really used to being independent all the time, doing my work, going through school by myself. There was no one really there for me. So then I think I did pretty well in school.

The impact of this incident on Andy's life was felt for decades. Andy shared that spending so much time alone during his childhood, as a result of the divorce, helped him navigate the transition from high school to college:

I mean, I was home alone, like I said, all the time through middle school and high school. When I got to college, it was a big ... I mean, it was nothing different. You're on your own. I liked being alone. I think it was a big freedom. A lot of freedom, because in high

school I couldn't really do anything because I was home alone all the time. My mom wasn't home. I don't have a car like everyone else, so I couldn't do anything.

But in college it was a really big change. You're on campus and there's a lot of stuff to do that you can walk to and do a lot of stuff. I would say [my transition] was smooth because I mean I've been used to being alone ever since my parents got divorced.

Reiterating the importance of this incident on his educational trajectory, Andy closed his narrative interview with the following:

Definitely, when my parents got divorced. Probably the biggest point in my life that everything changed. The reason I said that is, I guess it gave me a lot of adversity to face, and I think it really helped me become who I am today. I mean, who knows? If I have my dad there, or my mom there, both father and mother figures there, maybe I wouldn't be as adjusted to the transition to college.

Here, we see again that critical incidents can lead to enduring changes to students' trajectories.

While some students, such as Andy, discussed critical incidents in childhood that led to a sudden change in capital, other students reflected on situations that occurred during their time in university. For some students, the critical incidents they shared were recent in their journeys at the time of their interview and often painful to narrate. Marie, a mechanical engineering student, anchored much of her narrative on the critical incident of coming out to her parents as transgender and a lesbian. Before this critical incident, she notes, she was excelling academically and was accepted into her first choice major in engineering:

Freshman year was relatively easy for me. That kind of goes back to not really having any general problems with the prerequisites. I was walking in with chemistry. I was walking in with almost all of my math, and the only things that I really had to do were finish up that last math class for freshman year. Then, I had a couple of CLEs and then I also had obviously my physics classes. All of that went off without a hitch. I had Bs in all of my classes. I made the 3.0 cut off for the College of Engineering for mechanical, to get my first pick.

The critical incident in Marie's journey was coming out to her family during her sophomore year, which she says led to growing tensions with her family:

Then going into sophomore year, that's when things started to get a little bit difficult for me in terms of ... I wouldn't say, stomaching the engineering curriculum, but just classes were becoming more difficult, and then there were also some tensions that were developing between myself and my parents at the time. That's more or less related to me coming out to them as both transgender and as a lesbian. They weren't necessarily supportive, or at least my father wasn't necessarily supportive. I had told my mother at

the time that I was questioning, and it had taken me a full year to actually come out to them and during that process, my mental health in general just started to go down. With that, my grades started to suffer. In addition to all of that stress of worrying about whether or not I'm going to be able to still have this relationship with my parents, and worrying about grades, I was also worrying about being able to obviously afford tuition.

Freshman year seemed to work out okay, because I was walking in with scholarships. I had a renewable scholarship through the [grant program], and then I also had a separate one year, two semester scholarship that applied for \$1,500.00 a semester. So all told, the cost had gotten brought down to about 12 and then that got split evenly between myself, my mother and my father when we were all on good terms. Sophomore year, when things were starting to degrade with my relationship with them, my mother kind of came out and said ... Her excuse was that she needed to start putting more towards her retirement, and it was kind of coded in such a way that ... Regardless of the reason, she started to withdraw support. She wasn't doing anything except cosigning loans. At that point, that \$12,000.00 figure was already with me signing federal student loans.

As Marie's mother began to withdraw support after Marie came out to her family, tensions mounted with Marie's father, even as she needed his financial support and communication to be able to persist in her degree. She continues:

With her only signing private loans at that point, it came down to myself and my father to split the cost. I had never really had this. As I had gotten older, the relationship with my dad just seemed to kind of degrade. Me being out of state and not being able to stay in direct contact with him and with my mother ... it kind of put me in a situation where ... I had support from my friends at the time, but my family was kind of despondent. They weren't really talking to me. I wasn't really talking to them.

So, roll around junior year, this was about a year ago at this point and I finally go in for the semester. I move off campus. I'm going through my junior year classes. I pass all my sophomore year classes. I'm going through junior year. I'm doing okay at first, and then again the mental stress of not being out to them just kind of built and built to the point where I was depressed. I couldn't get out of bed, and physically go to my classes, and it's really hard to describe that kind of a feeling to someone who's never actually gone through depression before. It drastically affected me, to the point where I had to take academic relief. I was also working for an engineering company at the time, locally in [university town], a manufacturing company, [company name]. That was fine. There was a requirement for me to be enrolled, at least part time in order to maintain the job, but they ended up waiving the requirement after I had withdrawn. They let me continue to work there at least for the next couple of months.

Marie decides to contact her family, writing both parents a letter:

After coming out to both my parents in a letter and telling them what exactly was going on with me, because I had essentially cut off contact with them for the most part. I got two different responses. My mom was mostly accepting, partly because she had already known that I was questioning and I had told her that information. But I was so afraid of what my father would think, that I didn't give him that heads up of what was going through my head. I don't know if it was just a big shock to him or anything like that, but after coming out and sending that letter I had made preparations to go home back to [home state], and live with my mom and work for a bit before I had decided to go back to school.

At that point it was just me trying to figure out what exactly his reaction would be, because he still wasn't talking to me. So, a month after I come back ... I moved back to [home state], he finally reaches out to me, and essentially tells me that he doesn't understand where any of this is coming from, thinks that it's a phase, flat out refuses to accept it. He puts the option on the table of me going to see his therapist, and then he starts sending me all of this information that he's been doing research on, apparently. The majority of it is extremely trans-phobic, and homophobic stuff that he's sending me. Stories of other trans women that have transitioned and then decided that it wasn't necessarily for them, and de-transitioning. Sending me stuff about how I'm apparently going to go to hell for my "lifestyle choices."

I finally got him into a room with my therapist. I didn't feel comfortable going to his, because I didn't know ... My mom wasn't necessarily willing at the time to be in a therapy session, and my father didn't feel comfortable with that either. So, I didn't feel comfortable walking into a situation where I had someone that my father was familiar with, that I wasn't familiar with. I just didn't want that conflict. So, I had convinced him to go and see my therapist, and he sat down and the first words out of his mouth were, "I don't necessarily see this going anywhere." Which, kind of set the tone for the whole session in which he went over the points of information that he had sent me before about what research he was doing, what things he was doing. Essentially trying to undermine my ability to make a decision about who I was as a person, and me being mentally sound to make this decision to go on hormones and stuff like that.

Leaving that therapy session, Marie says, would become a second critical incident on her educational trajectory, as her father cut off all support—emotional and financial—to Marie:

It was at that point that he had essentially cut off any kind of resources for me entirely. He stopped talking to me. He stopped ... I can't obviously go to him to fill out any FAFSA information at this point, and he is the person that I was using at the time to fill out FAFSA information and scholarship information. He was no longer contributing to college. So, that full cost, the \$12,000.00 plus ended up falling to me. Through conversations with my mother about how exactly I was going to be able to afford it, because I knew that I had to go back to be able to afford to do the things that I wanted to do with my life and my transition. Just to have a fulfilling career, I knew that I had to go back to school.

So, I had kind of talked with her and she reluctantly said she would cosign ... Again, loans, but wouldn't necessarily give me any money because she had plans for retirement, plans for building additions to her house, and she didn't feel comfortable giving me that money. It was this double edged sword, or this irony because in me filling out applications to go and get housing off campus, she had to submit guarantor information and I was able to see how much that she actually made. It was significantly more than what my father made, which scared me for two reasons. Number one, because I was afraid of losing need based scholarships, and number two, it kind of put me off because there's absolutely no reason in my opinion, that she can't save for her retirement, do the things that she needs to do ...

...Then, come to find out as I'm going through that application process, my mother goes out and starts a lease on a new car, has all of these credit card bills coming in. So in doing all of that, I end up finding out that she is not able to cosign loans for me. She doesn't pass any of the guarantor checks for me to even get housing near campus, whatsoever. She certainly would not have passed any of the checks required for me to get a low interest rate on any kind of privatized loans. So, I end up having to, of my own volition, go and talk to my grandparents, get them to help me out in terms of cosigning for things, guaranteeing things as far as housing goes. From that, I'm able to go back to school, but there's still deficits on my account. Again, it puts me in a situation where I have to go to the financial aid office to go and talk to them about what exactly my options are.

Marie enacts her agency to seek support from her institution's financial aid office, who assisted her in developing a portfolio of financial aid to supplement what she could pay out of pocket from her savings. During this time, Marie met her partner, who served as a source of emotional and financial support as she navigated her loss of economic and family capital. At the time of her interview, Marie shared that she and her partner were "making things work financially." Still, the trauma of such a volatile change in family and economic capital persisted, impacting Marie's day to day thoughts about her ability to persist in her degree program:

One of the more upsetting things for me is, is that it almost feels like there's this consistent fear that I'm not going to be able to come back next semester. I try and put it out of my head and just focus on my classes, because of the fact that I know that I need to do well to continue to even attend [university] and be a part of the College of Engineering. But there's this inherent fear that, I know I'm not going to have support from my father at this point in my life. I know that my mom is only going to be able to cosign loans, and given the way that her credit is, she might not even be able to do that. So, it puts me in a really tough position financially, to figure out how exactly I'm going to be able to afford things.

For Marie, the drastic loss in capital hangs over her, particularly as she works to navigate how she will finance her higher education. Throughout her narrative, Marie quantifies her loss of

economic capital, and she strategizes about how she can compensate for her sudden loss. What looms large, however, is the loss of family capital- and this loss, in Marie's perspective, cannot be quantified.

For some students, critical illness of a family member ignited a change in economic capital changed even as family capital grew stronger. Fen, a chemical engineering student, shares his family's story navigating his dad's sudden and unexpected illness. Before that, Fen reflects that he would not call himself "underserved," noting that "in the earlier part of my childhood, we never had to struggle with money." Things changed for his family, however, in high school with two critical incidents: 1) his dad losing his job, and later, 2) his dad being diagnosed with a "baseball sized tumor." He elaborates on the former event:

"...my dad had lost his job at some point during all of this. We went through six months of him not having a job, and he's still paying for my older sister to go to college. My other sister's is getting to go to college right then. I'm just now going back to high school, so it's just this huge stressor on my family. Luckily he got a job. But as soon as he gets this job his old job reopens and decides they want to rehire him, but he has to take a pretty large pay cut to do so."

Things were trying during this time for Fen's family, he explains, but his dad found another job and his family worked together to navigate the situation. Largely influenced by his dad's encouragement, Fen—a first generation student—decides to attend university to study engineering. Flash forward to Fen's junior year, and he secures two co-ops "back-to-back." While the co-op experiences were positive, Fen's family was hit hard with grief and unexpected loss:

This, I think, is just ... I don't even know how to put it. I had an aunt die a month into my co-op. Then two months into my co-op my grandfather died. Then three months into my co-op my grandmother died, all in just a span. I was just like, "This is crazy." I didn't want to even be on co-op. I wanted to be done with school, so I could go home or just be done with the situation.

As Fen's family mourned the loss of three loved ones, his mother became concerned about his father's wellness, noticing that something seemed off. While Fen was away for his second co-op, his mother called to see if he had noticed anything during his recent father-son cross-country motorcycle trip. Fen shared:

I had moved to [city]. I was starting my new job... But I got a call from my mother, and she had asked if my dad had been acting weird the past time I saw him. I was like, "No." I got to give you some back story. I went on a cross country motorcycle trip in the summer in between my two co-ops. I saved all my money from my co-op, all of it, as much as I could. Then I rode a bike that the bank owns across the country and back with my dad, and it was great. It was just amazing. It put so many things into perspective...

But my dad was really off the whole time. He's usually sharp as a tack and just very ... I'd say sharp as a tack, but he's really quiet. He holds his words until he knows what he needs to say. Usually when he speaks, he's right. But he was just off. He was missing a lot of turns and just being really weird. He had come home from something. They had gone on a trip or something by himself for like a weekend, him and his friends, and one of his friends told my mom he was acting weird. He was missing turns, riding really slow, wasn't even doing the speed limit. She was asking me if I thought anything of weird of it and I was like, "No. I don't think so."

Well, he had fell earlier in the day and hit his head really hard, and it had given him a concussion. He went to the doctor and come to find out he had a brain tumor the size of a baseball that he had no vision in his left eye. He couldn't even tell. All he could see out of his left eye was like you put your hand here, he could see this, but he couldn't see anything over.

His father's health team acts quickly, removing the tumor, and Fen's family hoped "everything was good." The doctors recommend "[running] some tests on it," but told Fen's family "I think that you're gonna be good. It's just gonna be a benign tumor." The testing results, however, revealed a nightmare:

We get the results back, and it's like the deadliest brain tumor ever. It's like a grade 4 glioblastoma, just like the brain tumor ... Usually, people do not live past like six, seven months with this kind of brain tumor with treatment and with surgery. My dad goes out of work for like seven months. He's getting paid, but you got to think, "Now we're going through you have to pay all these hospital bills." I don't know. It's just like I came home from my co-op when it was all said and done. He's spending his times with your family when you're like, "Wow. This is crazy." You just don't expect that kind of thing to happen to you. Even when it does, you don't expect for it to ... You see your dad as Superman, nothing could ever hurt him.

This critical incident resulted in re-prioritization of economic capital for Fen's family, as they fervently worked to access health care for Fen's father. This critical incident also shaped Fen's thoughts about what to prioritize—seeking his degree or working to immediately financially support his family. He looked to his father for advice in a conversation about whether he should continue at university given the family circumstances:

I remember so he had to have a checkup scan to make sure everything was good. I'd asked him, I was like, "Look, if this comes back bad, do you want me to stay home from college? I won't get my degree. I will stay at home, and I'll work, and I'll get a job." Because he has good enough connections where he works, I could get a job...He's like, "No. Then you're doing what I did. You had enough to go and do that, but then you're gonna choose not to. That's not a good decision. That's just a poor decision on your part. If you want to screw up your future ..." Not screw it up but, "The world is your oyster right now, and you have all of these opportunities and chances to further your education and further your career and do so much better than I did." Because my dad worked for 35 plus years to get what engineers now start making. I just felt like he's so right. Why would I? I don't know how to put it. I think your emotional side kicks in, and you're like, "Wow, I should stay and make sure everything's okay." But I guess my dad has been alive for 30 more years than I have. He knows that that would not be the best choice. But I don't know.

When Fen's father becomes critically ill, his trajectory—and the collective trajectory of his family—drastically changes. This critical incident sparked intense questioning for Fen about where he should place his priorities, and thus, whether to continue at university. Ultimately, Fen's family encouraged him to persist, and at the time of his interview, Fen was negotiating how he could best support his family even while continuing at university.

4.4.3 Re-authoring Habitus

Finally, students often reflected on critical incidents that caused them to re-author their habitus, and consequently, their aspirations to pursue or not pursue engineering. Stahl (2015) and Yang (2014) posit that Bourdieusian theory provides unique insights into how students' aspirations are formed by considering the following:

- 1) Students' volume and composition of capital
- 2) Students' perception of a field, shaped by habitus, and
- 3) Social reproduction in their field(s)

These three lenses, Stahl (2015) suggests, allow us to examine how aspirations are formed and negotiated, with habitus serving as the primary mechanism for negotiation. Put another way, habitus is constantly evolving, re-authored within constrained socioeconomic conditions. All of these factors shape students' aspirations (Stahl, 2015).

In this section, I discuss critical events in students' trajectories where students' habitus was re-authored. In particular, I highlight the salience of social interactions (i.e., exchanges of

social capital) with trusted mentors in students' lives that resulted in students' change in habitus and, ultimately, changes in aspirations. Students' reflect on this category of critical incidents with striking vividness and clarity, often recalling the exact details of the interaction that changed their disposition (habitus) toward engineering. Students' commonly reflected on these incidents as "shifting their ceiling" so to speak, where a social interaction changed their view of "available paths" on their life trajectory. Often, students reflected on a critical incident that shifted their aspirations by revealing previously unseen paths for themselves (i.e., "moving their ceiling up"). In some cases, however, students reflected painfully on interactions that constrained their paths, or—in other words—said "that path is not available to you." I discuss both of these below.

Habitus Re-Authored, Paths Constrained.

Some critical incidents in students' lives resulted in seeing their paths as more constrained after a negotiation of habitus. In these incidents, students reflected on an interaction with a trusted mentor and having a path they saw for themselves "shut down" by their mentor. For example, Fen was interested in pursuing engineering at the state's flagship engineering institution. He went to his guidance counselor to mobilize toward these aspirations by finding out what steps he should take to get there. This interaction, however, negotiated his habitus and led him to discern that this path was not available to him. He discusses this interaction:

I went to my guidance counselor. We're sitting there and talking and she was asking me what I wanted to do. I was like, "I think I want to do mechanical engineering." She looked at me in the face, and it has to be like the most shut-down feeling on the face of the Earth is when your guidance counselor who's supposed to hype you up and get you excited tells you like, "Oh, well, you're 20th in the class." I was like, "Yeah. I know it's not great." She was like, "The kid that was third in the class last year applied and he didn't get in, so I wouldn't get your hopes up." I was like, "All right." I just decided then I was like, "I don't think I'm gonna go to [flagship institution]. I should just take, in my mind, the easy way out and go to [other institution]," because I had an offer there.

This interaction with his guidance counselor was a critical moment in Fen's negotiation of habitus, leading him to change his aspirations due to his guidance counselor's advice. Another student, Rita, talks about her longer-term negotiation of habitus, largely shaped by interactions with a high school teacher. She reflects on how these social interactions shaped her dispositions toward engineering, and more broadly, toward her own self-efficacy:

With the self doubt, it's always been, no it's not always been something I struggled with. It was something that I struggled with my junior and senior year of high school because I had a teacher who straight up made me feel like I was stupid. So it was a math class and [classmate] had also the same exact teacher that I did and had the exact same experience. And me and [classmate] share something which is our color. And there was also another student that he had before us. She was a Black female and the same experience. He never treated anyone else in that class. Me and [classmate] would joke about how we were like, he would treat us like clowns. He would, I remember once he, I was like asking him a question on the test just for clarification and somebody got a little too close to us, like while I was asking him. And he was like, are you cheating? And then the kid was like, no I'm not cheating. And he was like, good, you wouldn't want to cheat off her paper anyways.

Though Rita resisted her teacher's assessment of her abilities, these interactions—where she was systematically belittled along with her classmates of color—heavily shaped her disposition toward her own abilities. She says that she entered university “already beaten down from that,” making her time at university even more challenging and leading her to feel “so uncomfortable in [her] skin.’ Ultimately, Rita developed powerful resistant capital, actively working to navigate racist systems and all the while renegotiating her own disposition toward her ability to pursue engineering. Still, like Fen, she acknowledges that these critical interactions with a high school power figure significantly shaped her dispositions and aspirations toward engineering.

Habitus Re-authored, Paths Expanded.

In contrast to the experiences of Rita and Fen, other students reflected on critical incidents that renegotiated their habitus and expanded their paths, rather than constrained them. For example, Azad had never considered applying to the flagship engineering institution for this state until a critical interaction with his community college advisor. During this interaction, his advisor encouraged him to apply to the flagship engineering institution, surprising Azad. This interaction, Azad shares, “affected me and how I saw my ceiling.” Another student, Connor, reflects on a similar experience with his 8th teacher who he describes as “not the nicest man... but he would never lie to you or tell you anything that would mislead you.” It was his teacher's direct, “upfront” nature that made Connor actually trust his teacher's recommendation that he apply to the regional STEM school. Prior to Connor's application, no one from Connor's community had been accepted to the school, but Connor trusted that his teacher would not recommend him unless he truly believed that Connor could succeed there. Connor reflected on the power of this incident on his trajectory and formation of aspirations, sharing:

it kind of gave me a sense of meaning and it was so powerful that someone thought ... Saw me as smart enough that I could do this and I could be good at this, that he wrote me that recommendation, and that's kind of sparked and that's still there and that's why I'm gonna finish out the four years.

Perhaps the most striking example of a single interaction that renegotiated habitus and, therefore, aspirations, is found in the narrative of Payleigh, a mechanical engineering student who grew up thinking “I was just going to be a plumber, like my dad.” Her father had advised her, “You don’t got to go to college, it’s fine. College isn’t for everyone, it wasn’t for me, wasn’t for your mom.” In her narrative, Payleigh clearly describes how her habitus and disposition toward higher education was shaped by her family. Her formative childhood years had led her to believe she would never be “college type of person.” However, in 8th grade, a critical interaction with an engineer who visited her math class led her to renegotiate her disposition toward higher education, and more specifically, toward engineering:

In eighth grade we had this civil engineer come in and talk to my algebra one class...he worked for the company that makes traffic lights, he specifically wrote the software for the timing of everything, all the lights, the cycle time. He came in and basically said, "What do engineers do?" He's like, "They solve problems." I remember that, and then he was like, "So I'm going to give you a problem to solve." ... Pretty much, we all worked on it individually, and he went around and looked at everyone's papers, and he chose four people. He was like, "Okay, put how you did on the board."

It was me and three other people, and I'm putting my answer up there, and the three people got the same thing and I got something different, and I was like, "Oh no, I'm wrong." Then, he was like, "These are all good answers," but then he crossed out the three, and he circled mine. He was like, "But this is the one the engineer would do." At that moment I was like, "What? Me? What?". That was kind of like the turning point where I was like, "Maybe I could do this thing." Then, that was my idea then, I was like, "Oh, I'm going to be a civil engineer!"

Payleigh notes that, while she “doesn’t remember anything else from 8th grade,” she “[remembers] [this interaction] so vividly like it was yesterday.” She says this interaction “flipped the switch” and led her to renegotiate her beliefs on her ability to pursue engineering.

4.4.4 Summary

In this section, I discussed themes in students’ narratives related to critical incidents in their lives that resulted in a change in trajectory. Students—notably, first generation immigrants, first time in college students, and transfer students—reflected on moving physical locations (in Bourdieu’s terms, a change in *fields*) as a critical incident that changed their educational

trajectories. Some students reflected on a critical incident that resulted in a sudden and unexpected change in family, economic, and/or social capital, such as being excommunicated by a family member or navigating the serious illness of a family member. Lastly, students reflected on social encounters that resulted in a re-authoring of habitus and aspirations toward engineering, such as an engineering classroom activity or conversation with an advisor or counselor.

4.5 Beliefs about Agency Provided by Engineering Degree (RQ4)

My final research question explores the beliefs students from underserved backgrounds hold about the agency provided by a bachelor's engineering degree. This exploration revealed three key themes in students' narratives: 1) upward mobility, 2) societal prestige, and 3) freedom to pursue work that is personally meaningful/interesting. I elaborate on each of these themes below.

4.5.1 Upward Mobility

Many students discussed their beliefs that engineering would provide assured upward mobility, where upward mobility refers to financial security and economic intergenerational mobility. Students talked about their engineering degrees as a private *and* collective good—a private good to help them become financially secure, and a collective good to help them financially support their families. For example, Naz talks about the “bar for success” being low for his family and broader community. He believes his engineering degree will provide enable him to make more money than his parents, and “set a new bar” for his family and future generations. He shares:

I can be able to be the new status quo- the bar for success- and be able to teach the people under me how I got there. So like now instead of us all being at a low point, we can all strive to be better than how I was or at least close. So if I can, I want to say make as much money, but the things that I am interested in make a lot of money. So I feel getting to that place in my life where I'm comfortable, and scaling that way, sets a new bar for my family and the generations therein, and then they can strive to be better the same. And that changes the whole mindset of our legacy, which is something that I don't know.

Other students reflected explicitly on their pursuit of engineering for financial security. For many students, the lack of financial security in their childhood led them to pursue a career that would help them be financially secure. Other students talked about choosing engineering knowing that they could quickly pay back their student loans, believing that engineering degrees had a fast return on investment.

As I have discussed, many students expressed expectations that an engineering degree would lead to financial upward mobility, both for themselves as individuals and for their family. However, the financial expectations that accompanied engineering degree choices for students were not always positive. In particular, one student, Carly, discussed how the financial expectations of her engineering made her feel like she could not pursue other career options. She remained in her engineering program (left anonymous at Carly's request) despite feeling "regret" about her major choice. Even once in her major program, she would have preferred to attend graduate school or teach with a teaching non-profit focused in low income school systems. Both of these options, however, would likely lead to financial sacrifices, and she deeply feared letting her family down. She shared:

I have a fear of not being able to provide for my family ... not my family in the future, no. My family currently. I don't care about my future family, they don't exist. Going into [inaudible 00:08:00] I was like, "Yeah, they definitely make money." That's just one of the ... when I came here I was trying to go into computer science, I'm pretty sure that was my main one. That one, or mechanical...

being an engineering major, you're expected to make a certain amount after you come out of college. If I'm making teacher salary, that's not a bad thing, it's just not preferable for spending five years in an institution that takes so much money from you. So, that's another thing. If I were to move somewhere else and teach. My parents would be like, "What the heck? Why did you even go for that?" I could've probably finished earlier, for doing teaching. Because I have friends who are already out that have been doing teaching. I have friends who are ... acquaintances, that are already out, who have already gotten their Masters. I'm like, I've been here five years and I haven't got my undergrad. The expectation of what [salary] you should be getting when you come out of college is also scaring me. Because I don't know if I'm actually gonna get it, and if I don't get it, I'm worried that I'll let down my parents. That's a big thing. You know how they're like, "You shouldn't beat your kids, you should day you're disappointed in them because that hurts more", it does, it really does.

She elaborates on the pressure she feels to secure a high engineering salary out of college, and her fear that she will not meet her family's expectation of her engineering salary. She shares that earning money has been her family's priority for her, and she wrestles with the two often competing desires to be happy with her career choice and make money. She shares:

That's kind of the mentality I grew up, as a kid. Money's really important, and that you should always be making money. I feel like that's how ... at least [my mom]. She equates money to stability. That's fine, because it's true, in all honesty. It's true. But I don't think it's healthy to do that. I don't think that's the only way you can judge it. If I'm happy doing

what I do, I think it should be okay. That's my end goal, because like I said if I get stuck in a job that I don't like, I will just be stuck. I won't move on from that, probably. It will just be a miserable life where I go to work, and then I come back, and I'm like, "Got to go work again tomorrow." Endless cycle of suckiness that I don't want to partake in.

At the time of her interview, Carly expressed regrets about her degree choice and was wrestling with deciding what steps to take after she completed her degree. As she shared in this narrative excerpt, her decision to pursue engineering was rooted largely in financial upward mobility perceptions of an engineering degree. However, her true passion was to “help people,” an aspiration which she did not feel like her degree was allowing her to engage in. She would have liked to join a teaching nonprofit, but recognized that she would need to take a pay cut to do so and could not bear the thought of disappointing her family with her lower salary. At the time of her interview, Carly was looking for an engineering job after graduation. Like Naz and other students, Carly believed an engineering degree would afford her upward mobility; however, unlike Naz and others, for Carly, the expectations of upward mobility associated with an engineering degree constrained her career choices instead of broadening them.

4.5.2 Societal Prestige

Other students talked about gaining societal prestige from their engineering degree, alluding to financial wealth but explicitly valuing how society would view their “success” upon earning an engineering degree. For these students, the agency afforded by an engineering degree was less about the direct financial incentives and more about being respected by society. The most salient example of this belief is found in the narrative of Hao, an international student from a coal town in China who was the first in his family to pursue college. Hao, who was pursuing a chemical engineering degree, shared that he “[does not] like chemical engineering at all.” However, he was persisting toward the degree in an effort to achieve societal prestige, and ultimately, be able to come out to his family as gay. Engineers are well respected in China, he says, and he believes if he can attain his engineering degree, he will be successful enough to come out to his family. He elaborates on why he works so relentlessly to attain a degree that does not align with his personal interests:

My engineering journey, I study hard during college. That's kind of related to my sexual identity. ...Because the Chinese society, they don't accept gay people, only three or four came out, gay people. They are really outstanding. They're like a big company CEO, and

that, I think, that kind of ... These people affect me a lot. I think right now the only way I can come out is just be successful. You have to be outstanding and then you can come out because you're successful. You got money, you got, you know, social status, whatever.

So when I got in college at [university], I study really hard. That's because I want to get these things to come out with my family ... So this kind of a thing is pushing me to work hard, because I think Chinese people, they love putting tags on people. For me, how they put tags like on gay ... Because I don't want that tag. I want like a normal tag. It's normal I call it. I don't want people reminds me like oh, how, "He's a gay." I don't want ... I'm not ashamed of that, but I don't think that's quite right, because sexual identity is part of me. It's not a tag. You cannot ... It's like, if we are Chinese, I cannot say my Chinese friend like, "Oh, he's a Chinese," so if we are both Chinese, that's not a tag. So I want to study really hard. I got like 4.0 GPA ... So I can change out the rest of my ... It's like, oh when people say to me, "Oh he's a good student." That's another part of the reason I want to study hard. Yeah.

Hao believes as he attains an engineering degree he will simultaneously attain social status. He does not want to be “tagged” as “gay,” but instead wants to be tagged as successful. He believes if he earns the respect of society, he can come out to his family and still have their respect, too, despite a lack of cultural acceptance of a core part of his identity.

4.5.3 Freedom to Pursue

Notably, not all students referenced economic mobility or societal prestige in their narratives. Some students were pursuing engineering degrees because they believed attaining an engineering degree would provide freedom—freedom to pursue work they found personally meaningful and/or interesting. One student, Elizabeth, says that she initially wanted to be a lawyer because she wanted to earn money for her family. However, she realized she did not find a law career personally meaningful, so she switched to engineering—a career she could pursue with passion while still providing a stable income. She shared:

So I knew I wanted to do something that I enjoyed, but also enough so where I can not worry about financial troubles 'cause I grew up with financial troubles. I don't want to be in financial troubles. So I chose, I wanted, that's why when I was younger, I was like I'm gonna be a lawyer. Because I wanted to earn money for them. I wanted to earn money for them. But then I obviously wasn't interested in it. It wasn't a thing I was interested in or passionate about so I switched to engineering 'cause I love science. I love math. And it just so happens to work out so that it does make a lot more money than what my parents make. But it's also something I'm passionate about and I want to learn more about ... I knew it when I was younger that I wanted to do something that made money. But it wasn't the driving force of engineering 'cause there's a lot of other majors that make money.

Another example of a student pursuing work he found personally meaningful is found in the narrative of Fen. Fen discusses his learning during his co-op experience, and says his “biggest learning experience was to make sure whatever you’re doing, you like it.” Fen realized the value of doing work that one enjoys, and his pursuit of an engineering degree was largely grounded in that understanding. Another student, Azad, discussed the freedom he believed his computer science (CS) degree would provide:

For me, CS just gives you that ability to really be free. That's how I see it. More so than I'd say any other major right now. At the end of the day, if I want to build an app, put on the app store or I study a certain language or framework for three, four months, I'll have a skillset to just go out and seek work. Monetarily, it does make sense. Passion-wise, you can do anything with it, I'd say. If you love let's say art or design, or you love writing or whatever, you can always join these different companies that ... or launch your own initiative to take on those passions.

Like Azad, many students discussed the broad foundation they believed their engineering degree would provide, allowing to pursue a variety of meaningful careers. Similarly, students discussed their personal interests and passions as a core reason for pursuing engineering degrees, with a strong desire to work in careers they found personally interesting.

Several students discussed altruistic motivations for pursuing an engineering bachelor’s degree. Hannah, an industrial engineering student who transferred from a community college, also believed a career in engineering would enable her to effect positive change in the world. Hannah’s trajectory to engineering, and her rooted perspectives are altruism, are particularly striking as she started her college journey in graphic design at a local community college. While at her community college, she traveled with a community group on a “mission trip” to “[distribute] food packs” abroad. On that trip abroad, she decided to pursue engineering:

So [on that trip] I kind of realized the world is so much bigger than I originally thought. This is my first time being oout fo the country and really even travelling a whole lot. And so it was a big step... And I was like, wow, the world's huge, it's amazing. I want to make a different. And so I realized that as much as I love math and solving problems and helping people, engineering was kind of the thing for me.

Similar to Hannah, some students believed that an engineering career would provide a stable income while also allowing them to help people. Genesis discussed her desire to work for a

disaster relief agency, envisioning herself working closely with communities. Similarly, Kyle discusses his belief that an engineering career will help him make a “better world:”

I mean it allows me to help improve the world as a whole too, because I'll be making people happier... then that'll improve, make the world happier one person at a time, and then happier world the results in a better world essentially.

Unlike some students who believed that engineering was a career that would enable them to make money *and* simultaneously make the world a better place, Peony—a civil engineering student—argued that other degree paths, such as business, offered a more direct path to making “ridiculous gross amounts of money.” She shared:

So if you want to make money, go [be a business major]. But the reason I wanted to be an engineer, specifically, so it's 'cause I wanted to make the world a better place. I wanted to work on structures, help with climate change and doing green infrastructure, implementing this all into society. I had ideas, for my senior year I wanted to try and do some underground watering system for farms in California to try and water fields without wasting water from evaporation.... Having that want to make things and change things and find solutions to problems. That curiosity is something that I think you need, not the curiosity for money for just having money.

For Peony, pursuing engineering was less about money and more about altruism—a desire to pursue work that was personally meaningful to her. Like Peony, many students discussed pursuing engineering as a mechanism to pursue work they found meaningful, which often intersected with altruistic goals.

4.6 Summary

In this chapter, I presented the results from this study, whose purpose was study was to explore how students from low income and/or first generation (underserved) backgrounds navigate their educational trajectories in pursuit of a bachelor’s engineering degree. In my first research question, I examine students’ navigation strategies in pursuit of an engineering degree, finding that students enact agency to plan, optimize, and—at times—redirect their educational trajectories (RQ1). Next, I examine how social environments shape students’ trajectories to and through engineering degree programs. I find that family, community, institutional, economic, and political environments significantly influence students’ trajectories (RQ2). Furthermore, my results emphasize the dynamic nature of students’ trajectories, which often change based on critical incidents (RQ3) such as moving to a new social context (e.g., first generation immigrants) or a change in economic situation (e.g., loss of job). Lastly, students have varying

beliefs about the agency provided by an engineering degree. Upward mobility, societal prestige, and freedom to pursue work that is personally meaningful and interesting emerging as three key beliefs about the agency provided by an engineering degree.

Chapter 5: Discussions and Conclusions

5.1. Introduction: Interrogating the Interplay Between Structure and Agency in Engineering Education

In this study, I explore the trajectories, as shared through narratives, of 32 engineering students from underserved backgrounds. My overarching research question was: *In their narratives, how do students from underserved backgrounds describe navigating their educational trajectories towards a bachelor's engineering degree?* Using a Bourdieusian lens, I explore this question with particular focus on the interplay between individual agency and societal structures. My examination is rooted in an anti-deficit approach, acknowledging that underserved students develop, activate, and enact agency and draw from unique funds of capital. However, using Bourdieusian logic, I acknowledge that agency is also constrained by societal structures, though not deterministically so (Stahl, 2015). Doing so is imperative because, as Major, Godwin, and Sonnert (2018) argue, to not critically examine the societal structures students are navigating is to “[absolve] current institutions of education and systems of engineering of dealing with a real problem (p. 3).” Therefore, I examine both agency and structures herein.

By critically examining the interplay between agency and structures in underserved engineering students' trajectories, I build on a growing conversation on the sociology of engineering education. Xie, Fang, and Shauman (2015) argue that STEM education research, more broadly, lies “at the border between the sociologies of science and of education” (p. 333). I similarly argue that engineering is a unique social institution that students navigate at the nexus of social influences. This study, accordingly, was aimed at understanding those influences and enlightening the agentic and social forces that shape underserved students' trajectories in engineering. Though the literature on underserved students' trajectories into higher education broadly is rich (Yue Xie et al., 2015), scholars have argued that the processes and social determinants shaping engineering pathways are distinct from general education (Yu Xie & Shauman, 2009; Yue Xie & Killewald, 2012). We understand less about agentic and social determinants unique to engineering career pathways, particularly for students from socioeconomically disadvantaged backgrounds (M. Strutz et al., 2012). This gap in literature served as the underpinning motivation for my dissertation.

In the following sections, I discuss my findings and connect them to the broader conversation in literature on underserved students' experiences in engineering. It is notable that much of the narrative shared by underserved students focused on getting to the door of higher education (i.e., *college access*); however, ever present in students' narratives were experiences navigating university settings, speaking to the importance of distinguishing college access from college persistence. Where possible, I connect my findings to engineering and/or STEM education literature, specifically connecting to broader literature on access to engineering education as much of students' narratives were focused here. I conclude this chapter with implications and suggestions for practice, policy, and future research.

5.2 Agency of Underserved Engineering Students

In the following sections, I will situate my study's exploration of agency in the broader literature. I first highlight what students were enacting agency toward, which—importantly—often extended beyond private goods. I then discuss how my study contributes to our understanding of the individual agency enacted by underserved engineering students. To conclude, I discuss the collective agency highlighted in students' narratives, imploring the engineering education community to critically question our popular notions of agency, which are often constrained to the individual level.

5.2.1 Not All About the Money: Beyond Private Goods Approaches to Engineering Education

To set the stage for my discussion of underserved students' agency, it is imperative to note what students were enacting agency *toward*—why they were enacting agency in the pursuit of an engineering degree. I must first and foremost note that, for many students, pursuing a bachelor's degree was not foregrounded entirely in economic rationale. To put it simply, for many of the underserved students in this study, pursuing an engineering degree was not all about the money. To be sure, several participants mentioned economic upward mobility as a main driver for their pursuit of engineering—these were frequently students who discussed experiencing significant material hardship during childhood. Many students, however, pointed to intrinsic interests in their engineering discipline as their driving force. For example, Rob excitedly spoke of his passionate interests in aerospace engineering, never mentioning an economic purpose for his pursuit of his degree. Other students spoke abundantly about their desires for freedom, desiring to have unconstrained agency to pursue work they found personally

interesting and meaningful. Perhaps Azad summarizes this thought best as he reflects on his Computer Science (CS) degree: *“for me, CS just gives you that ability to really be free. That’s how I see it.”* For some students, their pursuit of engineering was grounded in wrestling with their role in the world. In their interviews, many of these students shared how they landed on engineering after grappling with how to help people, as Kyle said, demonstrating a desire to be an active, compassionate citizen in society.

The findings in this study, with rationales that include freedom to pursue meaningful work and becoming an engaged citizen in society, compel us to question pervasive narratives about higher education (and engineering education) as private goods. In economics literature, the dominant narrative surrounding higher education has centered on private goods approaches. Proponents of this idea suggest persons should pursue higher education as a rational economic investment, with eyes-on-the-prize of higher earnings at the finish line of a bachelor’s degree (Becker, 1994; Willis & Rosen, 1979). Rooted in human capital theory, this perspective of higher education argues that the primary purpose of university is to prepare students to more actively participate in the economy (Becker, 1994; Willis & Rosen, 1979). However, as numerous scholars have argued, a private goods view of higher education is too narrow, and we ought to broaden our explorations to consider the public goods of higher education (Case et al., 2018; Marginson, 2011; Nixon, 2011; Walker & McLean, 2013). In actuality, public and private goods are not two ends of a dichotomous spectrum; instead, Drèze and Sen (2002) argue, they are intimately connected.

For the engineering students in this study, the pursuit of an engineering bachelor’s degree was inextricably joined with their grappling of how to contribute positively to society. Walker and McLean (2013) refer to the ideas articulated by students in this study as becoming a “public good professional.” In engineering, some work has suggested that students from low income backgrounds are likely to reflect on using their degree for social good (Conrad, 2009). However, other work has concluded that students from low income backgrounds have stronger economic motivations for seeking an engineering degree than their higher income peers (Donaldson et al., 2008b). Regarding the latter conclusion, my study provides much evidence that, even for students who have experienced significant economic and material hardship, the pursuit of engineering is not all about the money. These findings in the engineering context parallel work

examining low income students' career choice in other STEM fields, such as medicine. When examining medical education, one study found underserved students cited diverse reasons for pursuing medicine; some students pursued medicine for extrinsic motivations (e.g., money, lucrative careers) while others cited intrinsic reasons for their career choice (Greenhalgh et al., 2004). Though literature reveals some similarities between decision making of low income students in engineering and medicine, students' decision-making in engineering may differ from the medical context because the engineering profession does not require a post-baccalaureate degree. This shorter duration of the engineering profession degree (as compared to a medical degree) may be particularly salient in the career decision-making of low income students considering the financial commitment of a post-baccalaureate degree. Still, comparative studies are needed to fully examine the career decision-making of low income students, parsing out what factors may be unique to the engineering context as well as factors that may be shared across career fields. For engineering in particular, the findings in this study suggest the need for a deeper examination of the public and private goods messaging around engineering education. Furthermore, researchers ought to explore underserved students' motivations for pursuing engineering, avoiding drawing oversimplified assumptions about engineering degrees as private goods for students.

5.2.2 Individual Agency of Underserved Engineering Students

From a sociological perspective, my dissertation examines underserved students' experiences through lenses of both individual agency and structures. Most literature exploring the experiences of underserved students in higher education has focused heavily on societal barriers. Prior studies have enlightened our understanding of societal barriers that impede underserved students' trajectories into engineering, including the high cost of higher education (Baum et al., 2010; Kane, 1999; Perna, 2000; Perna & Kurban, 2013); navigating financial aid systems (Coles & Baum, 2005; Heller, 2013; Tierney & Venegas, 2009); lack of information on college access pathways (Grotsky & Jones, 2007); and insufficient academic preparation (Perna & Jones, 2013; Perna & Steele, 2011; Warburton et al., 2001). Scholarship focused on the engineering context—albeit limited—has elaborated many of these same issues. These studies have focused on illuminating student barriers to access and persistence in U.S. undergraduate engineering programs. Barriers to accessing engineering programs persist, as evidenced by the

underrepresentation of underserved students in engineering degree programs (Xingyu Chen & Ohland, 2012; Strutz & Ohland, 2012). In addition, when we examine outcomes such as persistence and time-to-degree in engineering degree programs, significant disparities exist when underserved students are compared to their non-underserved counterparts (Smith & Lucena, 2016b). Prior work has provided a macro-level view of persistent barriers to equity on underserved students' trajectories to engineering. However, much work remains to examine engineering trajectories at the individual level, particularly for underserved students. With a few notable exceptions (e.g., Martin, 2015; Simmons & Martin, 2014; Smith & Lucena, 2016b) little work has explored this area.

My dissertation furthers our knowledge of underserved students' agency along engineering trajectories by viewing these students as "active agents" in their education (Simmons & Martin, 2014). In particular, I diverge from current literature by using an anti-deficit approach to explore the agency of underserved engineering students. By supplementing Bourdieusian notions of cultural, social, and economic capital with Yosso's (2005) community cultural wealth, I focus intentionally on the unique capital of marginalized groups. Though critiques of deficit-based approaches are plentiful (e.g., Smith & Lucena, 2016), deficit-based explorations still constitute the majority of studies in engineering about the experiences of students from underserved backgrounds. Using Yosso's (2005) anti-deficit reconceptualization of capital, this work stands in direct protest to the idea that dominant groups are culturally rich while marginalized groups are culturally poor. By adopting an anti-deficit lens to explore agency in this study, I contribute to a small and growing body of anti-deficit-based literature on the experiences of engineering students from underserved backgrounds.

When examining the agency of underserved engineering students, I found that students enact distinct proactive path-planning strategies as they route and re-route to engineering pathways. Students' agentic strategies are evidenced by the long-term planning recounted in narratives, with many students planning their engineering careers as early as middle school. Students' narratives offer evidence of proactive strategies—a significant departure from the common "reactive" rhetoric in poverty studies literatures. The students in this study were not merely reacting to the barriers on their trajectory, though the barriers were many; instead, students often proactively developed agentic strategies to pursue their long-term goals. This is an

important departure from common narratives about persons experiencing poverty, which tend to focus on “survival strategies of the poor” (Edin & Shaefer, 2015) by positioning persons from low income backgrounds as merely reacting to a poverty minefield.

By zooming in on the agency of underserved engineering students, my study examines the decision-making and navigational processes of students from low income backgrounds. Prior work has suggesting that decision-making processes in STEM careers is different for low income students than for their high-income peers (Niu, 2017). Three main hypotheses have been put forth in literature for why decision making might look different for low income students: 1) access to information, 2) mental load, and 3) focus on immediate stimuli. First, various studies have suggested that information inequalities often result from income inequalities (Hamilton & Morgan, 2018). Put simply, low income students do not have access to the same information as wealthier students. Previous studies suggest that low income students may lack information about engineering career paths (Niu, 2017) as well as exposure to pre-college engineering experiences (Major et al., 2018). Secondly, studies have suggested that low income students carry a higher “mental load;” in addition to navigating decision-making around college, students from low income backgrounds often have other “immediate stressors” that demand time and energy, like contributing financially to family (Mullainathan & Shafir, 2010) or navigating neighborhood violence (Castleman et al., 2015). A third set of hypotheses suggest that students from low income backgrounds tend to focus on immediate stimuli instead of long-term goals (Castleman et al., 2015). Most often, these assertions have been evidenced through the experiences of students from disadvantaged backgrounds who did not pursue higher education. Like the broader literature on experiences of underserved students, the conversation here tends to be focused on exploring why students might struggle to navigate barriers to participation in higher education. Such work is admittedly crucial as educators work to eliminate systemic barriers for underserved students.

However, a sole focus on barriers does not permit a comprehensive sociological view of students’ trajectories, notably lacking an understanding of the role of agency. Understanding the decision-making processes of underserved students who did not participate in higher education is only part of the story; we also need to systematically explore the agentic strategies of underserved students who managed to navigate to higher education—engineering education,

more specifically—despite systemic barriers. Put another way, prior work has helped us understand how barriers make people get “stuck” along educational pathways—but what about those who are “unstuck?” How do these students describe navigating their journeys? I address this gap in literature by analytically focusing on the agency of underserved engineering students.

Results from my dissertation also extend previous work on Bourdieu’s notions of agency. For Bourdieu, agency is about “playing the cards you’re given” (Reed-Danahay, 1990b). Bourdieu views agency as limited by structures of society, with the playing cards a person is dealt serving as Bourdieu’s metaphor for the societal forces that constrain agency. Using a Bourdieusian lens, scholars have suggested that agency is constrained by a lack of capital. This notion is certainly supported by the narratives of some students in this study. For example, Jon noted that everyone in his community lacked the economic capital to attend college, so his community did not see attending college as an option. In this situation, Jon describes, a lack of economic capital constrained perceptions of agency in his community. However, the data are divided in this study.

In my dissertation, some students’ narratives suggest that a lack of capital does not, in fact, constrain agency, but instead may foster the development of resistant and navigational capital. Several students, including Naz and Genesis, reflect on their lack of economic capital as a drive for agency, pushing them to strategically consider how to best navigate “out” of their communities and “out” of a future of poverty. These students did not view their lack of economic capital as a constraint on their agency; instead, they spoke about using their agency to navigate out of their home contexts. Genesis, for instance, talks about her deep dissatisfaction with the future options available to her in her home community—in Bourdieu’s terms, the cards she was dealt. Instead of playing the cards she was given, she decides to change her cards completely, focusing her attention on navigating to new fields with new capital and new rules. In Genesis’s and others’ narratives, strong evidence emerges of underserved students’ strategy to actively challenge “the cards they were dealt” and work to exchange them for different cards, using Bourdieu’s analogy. In my results, I term this strategy “resisting the paved path,” where students openly reflect on rebelling against all of the options available to them in their community.

Through this finding, my study departs from previous literature and expands theoretical notions that view agency as “playing one’s cards.” My findings align with other scholars who

have accused Bourdieu's view of agency of being too limited. Notably, Diego Gambetta (1987), an Italian sociologist who studies educational decision making, asserts that asking "which course of action an individual is likely to choose among those open to him" is the wrong question (p. 21). Instead, he argues, we ought to examine "how and when individuals will take action for changing the available alternatives" (Gambetta, 1987, p. 21). In this study, an analytical focus on individual student agency revealed a strong emergence of students changing their available alternatives, providing new directions for future research on the agency of underserved students.

5.2.3 Role of Collective Agency in Underserved Engineering Students' Trajectories

It is imperative to note that students did not always discuss agency at the individual level. In fact, one of the most striking findings in this study was students' narrative descriptions of their families' *collective agency*. By collective agency, I am referring to the phenomenon of families combining their agency as individuals in a collective effort to push one or more persons toward higher education. With great clarity, students reflected on the importance of their families' collective agency on their educational journeys. Recall the narrative of Naomi, who shared that during the times her family was experiencing homelessness, her mother would take on Naomi's share of chores in the homeless shelter. As Naomi's mother undertook double her share of chores, she would remind Naomi of the importance of achieving a college education. Naomi credits her mother's actions for pushing her toward university, enabling her to focus on her studies as much as possible by relieving her of her required chores at the shelter. Nabou also reflected on her family's collective agency, sharing how her father sold his car and engaged in temporary work abroad to help pay for her university tuition. It was her father's persistent and strategic efforts to support her education, Nabou says, that kept her pursuing her bachelor's degree. Collective agency was also salient in the narrative of Rob, who shared that he had planned to join the military and temporarily forego his opportunity for higher education in order to enable his sisters to pursue higher education, recognizing that his family could only support one person to attend. In the stories of Rob, Nabou, Naomi, and others, *collective agency* emerged as a powerful social force supporting their educational journeys.

These narratives depart from the rhetoric in previous literature on the role of families in the educational trajectories of underserved students. For low income families, the overarching narrative in literature has focused rather exclusively on deficit-based thinking, highlighting how

low income families are unable to provide their children with the same capital (social, cultural, economic, etc.) as high income families (e.g., Xie et. al, 2015). Previous studies have suggested that low income families do not encourage their students to attend college (e.g., Billson & Terry, 1982; Donaldson et al., 2008b), arguing that low income families “lack the experience” to “serve as supports” for their college-bound students (Baillie, Pawley, and Riley, p. 148). In this study, however, underserved students’ descriptions of their families’ roles in their journey sharply contrast the deficit-narrative in literature. Instead, many students in this study emphasized the purposefully strategic agency their families collectively enacted to secure them a place in engineering education.

As Baillie, Pawley, and Riley (2012) highlight, few, if any, researchers have explored the micro-dynamics of low income families as they navigate the college choice and application process. Without carefully exploring students’ own accounts of their families’ impacts on their journeys, we risk making perilous assumptions ridden with class-based biases about the role of families in educational trajectories (Baillie et al., 2012). To be clear, a few students in this study did note a lack of support from their families, triangulating previous literature suggesting a lack of college support in low income families; however, the students who noted a lack of support were few in this study, and many more students emphasized heavily in their narratives the supportive role of their families on the educational journeys. The supportive, familial role described by students was not only emotional in nature; it also included strategic navigational mechanisms (e.g., Naomi’s mother doing her chores in the homeless shelter) and negotiations of economic capital (e.g., Nabou’s father selling his car).

In some ways, the emergence of collective values in students’ narratives is unsurprising. Prior studies have compared the values held by low SES students and their high SES peers, finding that low SES students tend to value community-oriented decision making more than their individualistically-minded high SES peers (Stephens et al., 2012; Tull et al., 2014). We also know that low SES students tend to value interdependent thinking, which can pose a cultural clash as students enter universities that endorse independent thinking, rooted in middle- and upper-class ideologies (Stephens et al., 2012, 2014). Though these studies have focused on higher education broadly, examinations of engineering disciplines more narrowly have

highlighted the deeply held cultural value of individualism (Seron et al., 2018), which poses dissonance with the collective values of many low SES students.

While we know low SES students are more likely to think communally and collectively, we have not fully explored how these collective family values impact engineering trajectories. Perhaps the critical issue here is how we operationalize the idea of family support in engineering education research. In Bourdieusian terms, the issue is largely about capital—what capital has value, in what spaces, and for whom. Prior studies, which have concluded that low income families do not support their students, have rather narrowly examined capital from an academic lens, highlighting how low income students might be lacking capital that is valued in academic settings. The problem with this notion, I argue, is that capital valued in academic settings is anything but neutral, instead reflecting the often raced, gendered, and classed values of higher education. To put it simply, we only see what we look for. If our explorations of family support are deficit based, we are limited to seeing deficits.

However, by expanding our notions of family support—or, better yet, letting students narrate their own notions of support in their journeys—we move towards a more comprehensive exploration of the role families have in student journeys. I argue that we can reimagine our notions of family support by 1) drawing from empirical work in family studies, and 2) expanding our use of Bourdieu's theoretical framework to include collective notions of agency. First, we might reconceptualize our notions of family support by pulling from literature outside engineering education. Notably, the Family Studies literature takes a broader view of family support, exploring ideas such as *family togetherness* and *parent support* distinct from the *home academic environment*. In this literature, studies have found that family togetherness (Gutman et al., 2005) and parent-adolescent emotional closeness (Crosnoe, 2004), to name two examples, support students' academic achievement. Such notions of family support do not narrowly focus on family capital as valued in academic settings. Instead, broader notions of family capital, such as those used in the family studies literature, adopt an asset-based approach to examining family support in students' educational journeys. Future explorations of the role of family support on underserved students' engineering trajectories would benefit from taking a similar approach.

Second, we can build on our exploration of the role of family support in underserved engineering students' trajectories by expanding our use of Bourdieu's theoretical framework to

include collective constructs, including capital and agency. Though Bourdieu's framework has primarily been used to examine capital and agency at the individual level, collective notions of capital and agency are not out-of-sync with Bourdieu's original work. Bourdieu described each person's trajectory as a collective history (Reed-Danahay, 2005). Even in his own life, he discussed the role of his family in "rupturing" him from poverty (Reed-Danahay, 2005). Other scholars, too, have noted that our prevalent conceptions of capital prioritize white, upper-class, individualistic values while ignoring the collective cultural capital of marginalized groups (Yosso, 2005). By broadening our use of Bourdieu's theoretical lens, we may more accurately examine students' trajectories.

To close, this study contributes to a gap in literature by offering asset-based insights on how low income families collectively support their college-bound students on engineering pathways. Students' narratives suggest the need to break from deficit approaches in our research examinations of familial support for low income students. We ought to acknowledge and intentionally explore the collective agency of families, partnering with low income families as they support their engineering-bound students. I also implore educators to consider the nuanced experiences of students from underserved backgrounds, refraining from class-based assumptions about family-level decision making. Assumptions that all low income families do not support their college bound students are not only oversimplified, but directly disputed as universally true by data in this study. By working to reframe our explorations of familial support for low income students, we can dispel harmful deficit-based rhetoric and, instead, collaboratively partner with families to support low income students in engineering.

5.3 Habitus in the Role of Underserved Engineering Students' Educational Journeys

I will now turn to the role of habitus in the educational journeys of underserved engineering students. I begin by discussing how students re-author their habitus through exchanges of social capital. I then discuss the role of community rhetoric on students' journeys, and I conclude with a discussion of the relationship between the national economy and students' aspirations.

5.3.1 Re-Authoring Habitus: A Nuanced Examination of Exchanges of Social Capital

One of the most prevalent trends across student's narratives was the power of social interactions, or exchanges of social capital, to significantly change their engineering goals.

Students recalled specific social interactions with mentors, with particularly striking vividness, that completely changed their disposition—either for better or worse—toward engineering. The unique power of these social exchanges—often lasting no more than an hour in a student’s life—is evidenced by how many students began their narrative interviews by sharing these moments. For example, Payleigh began her narrative with “it all started when...” an engineer visited her math class in 8th grade and told her she would be a great engineer. Many students shared similar encounters, remembering the precise moment that an engineering bachelor’s degree became a goal on their long-term trajectory. On the other hand, some students painfully recalled conversations with trusted mentors where they were pushed away from engineering, often told that they were not capable of such a feat.

Indeed, in this study, there is much evidence that social interactions with mentors are critical influences on students’ trajectories into engineering. Importantly, the notion that social capital matters is not new to the engineering education community. In engineering education literature, a dynamic contemporary conversation persists on the role of social capital in students’ journeys. Though individual scholars tend to define for themselves how to operationalize social, as a field, the engineering education literature converges on the idea that social capital is an “accumulation of resources based on networking and personal relationships” (Foor article, p. 106). In engineering, we have examined how a student’s flow of social capital impacts their experiences and how students form their networks of social capital. We know that students from low income backgrounds are significantly less likely to have someone directly encourage them to pursue STEM (Major et al., 2018). Adding context to this finding, Byun, Irvin, & Bell (2015) find that educators in low income school systems perceive many of their low income students as “failures” early in their educational careers; they do not, therefore, encourage students to seek STEM degrees at the same rate as educators in higher income school systems (Byun et al., 2015). Faced with this lack of encouragement for STEM trajectories, first generation students are more likely to pull from networks of “fictive kin” (i.e., non-blood relations) for support while navigating engineering trajectories (Simmons & Martin, 2014). Therefore, the way that students in this study reflect on the importance of social capital is in some ways unsurprising, aligning with previous research in this space.

Though in engineering education we have tended to conceptualize social capital as an accumulation of resources, recent work on social capital in engineering education argues for a more nuanced investigation. In their work examining “the invisible hand” of social capital, Martin (2015) uses Lin’s (1999) network theory of social capital to delineate how the availability, accessibility, and activation of social capital influences students’ trajectories into engineering. Using Lin’s (1999) lens, Martin’s study (2015) demonstrates that the availability of resources in one’s network is not the full story of the social capital phenomena. Through their narrative inquiry, they find that the availability and accessibility of social capital does not ensure that the capital is activated, or purposefully used towards one’s goals (Martin, 2015). However, they also find that activation of social capital may not be essential in social networks that are especially resource rich (Martin, 2015). When social capital’s “invisible hand” works “backstage” of students’ experiences, availability and accessibility of social capital may be sufficient to reap the benefits of the network (Martin, 2015). As evidenced in Martin’s (2015) work, the exchange of social resources—and the resulting impact on students’ journeys—is complex.

My study provides insights to another layer of complexity by situating social capital in Bourdieu’s broader theory. Apart from some exemplary studies (e.g., Foor et al., 2007; Gopaul, 2015), limited work in engineering education has utilized Bourdieu’s full theory to explore engineering students’ experiences. Therefore, this study is unique, particularly in its interrogations of the relationships between capital and habitus. Using Bourdieu’s full theory, this study provides much evidence for the interconnected relationship between social capital and habitus. When students discussed critical incidents on their trajectory, they often reflected on a negotiation of their habitus as a result of their social interactions. For instance, Azad reflects that he never saw a four-year engineering institution as an option for him until a conversation with his community college advisor, which he said “shifted [his] ceiling,” or changed the options he saw as available to him. From a social capital lens, Azad knew people who were studying engineering (i.e., availability of social capital) and he could have reached out to directly connect with those people (i.e., accessibility of social capital). Still, he never mobilized to activate these resources until a mentor encouraged him to do so. Azad knew studying engineering was an option, but—and this is the crucial caveat—he did not believe engineering was accessible *to him*. Other students reflected on similar examples, where previously unconsidered options (e.g., an

engineering career) suddenly became realizable—not because it was the first time the students’ accessed information about the options, but because it was the first time a mentor said “this option is available to you.” This study suggests, then, that social capital may not always be the direct impetus for pushing students toward STEM; rather, as evidenced in this study, social capital may spark a change in habitus—a re-imagining, of sorts, of one’s dispositions toward engineering. This links to the literature on the connection between social persuasion and self-efficacy (Bandura, 1994), which suggests that students are more likely to believe they will be successful at a task (self-efficacy) if their social environment tells them they will be successful at that task (social persuasion). Viewing social capital as an exchange of resources may be only one part of the story—perhaps it is the change in habitus that leads students to mobilize toward action on their engineering trajectory.

5.3.2 What We Were Told: Influences of Community Rhetoric on Students’ Trajectories

Another contribution of this study is the examination of how students’ home communities influence their engineering trajectories. I drew from mixed-methods approaches to create joint displays of qualitative narrative data with quantitative data on neighborhood contexts (poverty rates and college graduation rates), and found striking similarities in narratives from similar geographic contexts. Three distinct trends emerged in community-level rhetoric about higher education. First, students in areas of high poverty and low college graduation rates were most likely to reflect on strategies to “get out” of their home communities. Some students in areas of low poverty and high graduation rates indicated that their communities thought higher education was nice but unnecessary. In these communities, students reflected on a prevailing rhetoric that they would be “just fine without [higher education].” On the other hand, students in areas of low poverty and low college graduation rates more often reflected tension with their communities around their choice to pursue higher education. Students in these communities were seen as “wasting their time and money” by pursuing higher education, resulting in friction with their communities. This study provides much evidence that geographic context significantly influences students’ trajectories to engineering. Based on the evidence in this study, a more nuanced investigation of students’ trajectories is needed.

However, explorations that link to geographic contexts are underexplored in engineering education and higher education more broadly. To date, most studies that explore persistence in

college examine student decisions independent of geographic contexts (Reyes et al., 2019). Results from this study compel educators to critically reexamine one-size-fits-all approaches to supporting underserved students, particularly in pre-college outreach. The rhetoric heard by underserved students in their home communities is not monolithic, as evidenced by the narratives in this study. While some students' communities are incessantly supportive of higher education as a way to "get out" of poverty, other students face real friction with their communities for their educational decision making. This area of inquiry calls for much further research, as we work to adapt our programming to meet the diverse needs of underserved students.

5.3.3 Relationship between National Economy and Engineering Degree Choice

This study provides new insights into the relationship between the national economy and students' choices to study engineering. Notably, the critical influence of the United States Great Recession emerged in two students narratives—the narratives of Alex and Chris, both students from areas of relatively low poverty. However, when the Great Recession hit in 2007, both Alex and Chris's families experienced loss of work and wages. Alex's family had invested their family savings into a small business just before the Recession, and Chris's parents—who were both truckers—lost their jobs during this time. Both Alex and Chris highlight the Great Recession, and the events that followed for their families, as a critical incident on their trajectories. However, Chris and Alex arrived at different educational decisions based on their families' experiences during the Great Recession. For Chris, the financial instability his family endured left him craving stability. Accordingly, he chose to pursue computer engineering, believing that "computers are the future" and thus would provide him with job security. Alex, on the other hand, concluded that pursuing higher education was not a financially sound investment as he looked around during the Great Recession and saw near peers with college degrees struggling to find jobs. He decided, therefore, to forego higher education, entering the workforce to begin his mining career. Though these two students endured what might be viewed as similar experiences, they drew very different conclusions that pushed them either toward or away from pursuing a bachelor's degree in engineering.

My insights into the impact of the national economy on students' decision making are some of the first of their kind. Scholars have long called for critical examinations of the impact of the Great Recession on students' journeys, which remains the most devastating recession since

the Great Depression in 1930s (J. R. Brown & Hoxby, 2015). Still, little work has examined the relationship between the Great Recession and students' educational decision making, and the work that does exist focuses on quantitative, national data sets to identify population trends in the United States. Interestingly, the small body of literature here is divided on conclusions. One study found that national economic downturns generally tend to push students toward business fields, such as finance (Blom et al., 2015). An important caveat here is that Blom et al.'s (2015) work was not focused on the Great Recession of 2007-2009 specifically, but rather national economic downturns over multiple time periods. Contradictorily to Blom's (2015) more generalized analysis, studies of the Great Recession specifically find that during the Great Recession and economic recovery period that followed, students were less likely to pursue finance in higher education and instead chose STEM majors (Liu et al., 2019). Liu et al.'s (2019) work helps to contextualize the narrative of Chris in the national-level trends, as Chris chose to pursue STEM after his family's financial hardship during the Recession.

Still, the contrasting decisions of Alex and Chris, even after enduring similar circumstances, caution us to avoid making oversimplified conclusions about the influence of the national economy on students' educational trajectories. Economics literature suggests there is a complicated relationship between economic recession and college degree choice (Ersoy, 2019). For example, when labor market effects are examined at the state level, data reflects a decrease in STEM degree seeking in states more severely impacted by the Great Recession (Ersoy, 2019). In other words, during the Great Recession, the number of students who sought STEM degrees decreased significantly more in states whose economies suffered greater losses during the Great Recession (Ersoy, 2019). For example, there was a 127% change in unemployment between January 2007 to December 2010 in Alex's home state, making it the 15th "worst hit" state in the nation during the Great Recession (Ersoy, 2019). This may contextualize Alex's decision to forego pursuing a STEM degree immediately after high school. These quantitative studies, combined with qualitative insights from this study, would suggest that context is crucial when examining the influence of national economic recession on students' journeys.

Also, important to help contextualize the decisions of Alex and Chris is examining which career fields are most "sensitive" to economic recessions or, in other words, which fields experience the most change in unemployment during and after a national recession. This

conversation is linked to Alex's observation in his home community that even his peers with college degrees were experiencing unemployment. To triangulate Alex's observations, zooming out to the national level data set reveals that, in fact, many recent college graduates did struggle to secure employment during and immediately following the Great Recession. Importantly, not all recent college graduates experienced unemployment during this time period, with various graduates of certain university degrees impacted disproportionately. Majors with lowest unemployment rates for recent graduates during and immediately after Great Recession were nursing (4.8% unemployment for recent graduates) and elementary education (5.0% unemployment for recent graduates) (Carnevale & Cheah, 2013). On the other hand, architecture majors (12.8%) and information systems majors (14.7%) were much more likely to experience unemployment during and immediately after the Great Recession, with 12.8% and 14.7% unemployment for recent graduates during this time, respectively (Carnevale & Cheah, 2013). Engineering disciplines fell somewhere in the middle of this spectrum. For example, civil engineering experienced 7.6% unemployment for recent graduates and mechanical engineering experienced 8.1% unemployment for recent graduates (Carnevale & Cheah, 2013). Examinations across all engineering fields find that engineering is a recession-sensitive major (Ersoy, 2019). During the Great Recession, engineering fields experienced a 147% change in unemployment, making it one of the "hardest hit" fields for unemployment of recent graduates (Ersoy, 2019). Again, these national level data analyses begin to contextualize Alex's questioning in high school about whether a college degree would really help him secure a lucrative job.

While these studies help contextualize and enlighten the impact of the national economy on students' educational trajectories, much work remains to fully explore this phenomenon. I am not aware of any studies that have qualitatively examined the influence of national economic recessions on students' journeys, suggesting that this study may be the first to contribute such insights to this important conversation. At the time of this writing, this exploration is increasingly urgent as a significant national recession is predicted in the coming decade (R. Brown, 2019). In order to prepare students, engineering disciplines, and higher education broadly for the impact of economic recessions, we must critically examine how the Great Recession of 2007-2009 impacted students' educational trajectories towards or away from engineering. Organically through the narratives of two students in this study, the Great Recession emerged as a crucial influence on their decisions to pursue—or, importantly, not to pursue—engineering.

These findings should serve as a portal for future inquiry, particularly with qualitative paradigms to help contextualize national quantitative trends uncovered in previous work.

5.4 Complexity of Disadvantage

In the following sections, I will discuss the complexity of economic disadvantage, including the multidimensional, dynamic, and intersectional nature of poverty.

5.4.1 Economic Disadvantage as Multidimensional

In this study, I explored economic disadvantage from multiple dimensions, including individual experiences, household measurements, and community-level data. At the individual level, I explored experiences with material hardship (Appendix E), asking questions about students' lived experiences with housing insecurity, access to healthcare, and food insecurity. At the household level, my data included commonly used measurements of Pell-Grant Eligibility and parental education attainment. At the community level, I explored each student's home context by using their zip code to explore Census Bureau data regarding poverty and educational attainment. The multidimensional exploration of economic disadvantage is unique in my study, as most work in engineering education explores a single facet of economic disadvantage. However, students' narratives highlight the multifaceted, complex nature of economic disadvantage. Approaches to measuring economic disadvantage that consider individual, household, and community measures may more comprehensively examine access and equity disparities in engineering education.

5.4.2 Critical Incidents: Poverty as Dynamic

When socioeconomic status is discussed in higher education, it is often viewed as a static entity. However, the data in this study indisputably highlights the fluid, dynamic, ever-changing nature of socioeconomic status: poverty is not a steady-state system. In the United States, rhetoric about upward mobility is incessantly pitched, with a national optimism attached to the idea that people can climb out of poverty. Rarely, if ever, are other realities of poverty dynamics in our nation discussed, where even a person born wealthy can enter, exit, and re-enter poverty. My dissertation provides much evidence of the dynamic nature of a person's socioeconomic status, with stirring narratives of students' sudden and unanticipated entry into significant material hardship. Situations such as illness of a family member, divorce of parents, a loss of

work, or being financially cut off from parents after “coming out” each instantly changed the trajectories of students in this study. Several students reflected on this change in socioeconomic status explicitly, saying things like “we were middle class” [until the divorce, Andy] or “I wouldn’t say we were underserved” [until the illness of a family member, Fen]. These narratives highlight the reality that socioeconomic status is not a static label, rather a fluid set of experiences that may provide insight about one’s material hardship and wellbeing. Engineering educators ought to think about how we measure socioeconomic status, as what is measured reveals what is valued. A person’s socioeconomic reality cannot simply be “measured” at one time in their journey, as such a snapshot does not capture the essence of one’s lived experience (Cellini et al., 2008). In addition, snapshot measurements are only modestly helpful for understanding how a student’s lived experience might impact their educational journey. Changes in socioeconomic status can and do occur unexpectedly, sometimes as a result of a single adverse life event (Cellini et al., 2008).

Though the conversation on the dynamic nature of poverty is scant in higher education, there is a lively body of economics research that helps contextualize the findings of this study. In economics, the transient nature of socioeconomic status is discussed according to “poverty transitions,” and research shows that young adults are more likely than any other age group to transition into poverty (McKernan & Ratcliffe, 2002; Rank & Hirschl, 1999; Ribar & Hamrick, 2003). When examining entrances into poverty, Rank and Hirschl (2001) find that over one-third of people between ages 20 and 40 will experience poverty. Young people on college campuses are not immune from poverty dynamics. A recent large-scale study of 33,000 students at 70 community colleges found that approximately 50% of students are housing insecure, with 13% - 14% experiencing homelessness (Broton & Goldrick-Rab, 2016). In addition, the study found that food insecurity is on the rise in community colleges, with ~66% of students experiencing food insecurity in 2017, up from ~50% in 2015 (Broton & Goldrick-Rab, 2016). To be clear, though community colleges have higher rates of housing and food insecurity, four-year institutions are not void of these issues. For instance, a 2018 study found that 12% of students in the California State University system experienced housing insecurity and homelessness (Crutchfield et al., 2018). Another recent study of the City University of New York revealed that 40% of students experience housing insecurity (Tsui et al., 2011). A study conducted at the University of Massachusetts Boston similarly found that 45% participants were housing insecure,

with 5.4% experiencing homelessness (Silva & Snellman, 2018). Indeed, material hardship on college campuses is an epidemic, with students seeking their degrees without having basic needs security.

When we examine the dynamic nature of poverty and the impact on students' trajectories, the data clearly points to broader societal, structural dynamics at play. For example, data shows that persons living in households where the primary income earner is a woman are much more likely to enter poverty (Rank & Hirschl, 1999; Ribar & Hamrick, 2003). This trend provides some context to the narrative of Andy, who shared that he transitioned from "upper-middle class" to a much lower income when his parents divorced. After the divorce, his mother became the primary source of wages for the family. Despite working long hours, the family struggled financially. The data also reveals structural dynamics of poverty in findings that people of color are more likely to enter poverty. It is especially troubling that these two findings, which reveal the structural barriers that intersect with the dynamics of poverty, hold true across virtually all known studies (Rank & Hirschl, 1999; Ribar & Hamrick, 2003).

Combined with this prior work, my study's findings on the unstable nature of socioeconomic status suggest a radical reconceptualization of the way socioeconomic status is viewed in higher education. Educators should recognize socioeconomic status as fluid, vulnerable to changing with a single critical incident in a student's journey. As evidenced through several narratives in this study, students of any socioeconomic background can find themselves experiencing material hardship without warning due to an adverse life event, such as a family illness or a volatile parent relationship. Our institutional policies and student support efforts should consider that students' realities can change in unanticipated ways.

5.4.3 Working Way Too Hard: Multiply Marginalized Student Experiences

In my study, I used Bourdieu's framework to examine students' experiences based on their socioeconomic status. However, it is imperative to note the highly salient threads in students' narratives related to intersecting systems of oppression. Many students in my study voiced a keen awareness of being stuck in the crossfires of intersecting systems of oppression in addition to their socioeconomic status, often based on their race, gender, gender identity, and/or sexual orientation. Recall the narrative of Marie, who was cut off from all financial support after she shared her LGBTQ+ identity with her family. For Marie, her socioeconomic status was

inextricably intertwined with her gender identity and sexual orientation, and her experiences in engineering were multiply marginalizing because of the intersecting nature of her identities. In addition to gender identity and sexual orientation, racism emerged as an ever-present oppressive force for most students of color in this study. It is noteworthy that every woman of color in this study discussed their feelings of imposter syndrome in their engineering program, attributing their feelings to not seeing anybody who looked like them in their classes and working to develop the “confidence of a mediocre white guy,” as Rita—a first generation, Pell eligible student—put it. Through numerous threads in students’ narratives, students reflect on their navigation of multiple systems of oppression and—as a result—feeling multiply marginalized in engineering. Nabou, a Pell-eligible woman of color, summarized this phenomenon best, as she discussed navigating multiple systems of oppression: “I’m working way too hard.”

The intersections of these systems of oppression should hardly be surprising in the United States context, where income inequality is inseparably linked to racial inequality. Yet, despite the clear data that racist systems intersect and feed into classist systems in the United States, research has rarely explored student experiences at the intersections of these systems of oppression. Though the literature is scarce, using intersectional analyses is not entirely new to the engineering education community (Secules et al., 2018), with several noteworthy studies exploring engineering students’ experiences at the intersections of systems of oppression. Stitt & Happel-Parkins’ (2019) work examined the experiences of Black women, and Verdin & Godwin’s (2018) work explored the experiences of Latina first generation college students in engineering. Bystydzienski, Eisenhart, and Bruning (2015) examined the impact of intersecting systems of race, class, and gender on women’s interests and persistence in engineering.

Still, there remains a troubling gap in engineering education literature on the experiences of students who are navigating multiple systems of oppression. In particular, few studies examine the intersections of class with race, gender, sexual orientation, and disability (Smith & Lucena, 2016b). The few studies that have examined class using an intersectional lens have concluded that socioeconomic status is a prominent influence on students’ educational experiences (e.g., Foor et al., 2007). Therefore, future work to understand the experiences of students from marginalized groups ought to consider class with an intersectionality lens, examining how class intersects with race, gender, sexual orientation, and disability in the

educational experiences of students. As Slaton and Pawley (2018) point out, these students represent a “small n” (number), and we must design our research inquiries intentionally to better understand the experiences of these groups.

5.5 Implications and Future Work

In the following sections, I outline my study’s implications for practice, policy, and research. I conclude my discussion of implications for research by suggesting directions for future research.

5.5.1 Implications for Engineering Educators

This research has several key implications for engineering student support programs at both the pre-college and undergraduate levels. First, the results of this study make starkly clear that underserved students are diverse and have a diverse range of lived experiences. In student support spaces, underserved students are often discussed as a homogeneous group, and programs are designed accordingly to meet the presumed monolithic student needs. However, this study highlights the diversity of lived experiences within the student label of “underserved.” For instance, for some first generation students, family support was strong and continuous throughout their journey. For other first generation students, palpable family tensions arose based on educational choices. Similarly, there were students in this study who were experiencing material hardship who were not “Pell Grant Eligible.” These insights suggest that targeted support for underserved students must include more broadly defined inclusion criteria in order to truly reach students experiencing economic disadvantage. This study also highlights that student support programming, particularly at the undergraduate student level, should honor and be responsive to diverse experiences of underserved students. There is not a “one size fit all” solution to student support for underserved students, and therefore our programming should adapt and respond to the needs underserved students identify themselves.

Students’ narratives also offer important implications for engineering programming at the pre-college level. The first glaring implication is that exposure to engineering is not sufficient; it is not enough to make students aware of the option of engineering careers. Many of the students in this study were aware of engineering options. However, many students did not consider pursuing engineering until a trusted mentor suggested that engineering career options were

available *to them*. This is a crucial insight, suggesting that our pre-college engineering outreach should partner exposing students to engineering with simultaneously *building engineering self-efficacy*. If we want to encourage students to pursue engineering, we cannot just present engineering career options; instead, we must be student-centered in our discussion of career pathways, highlighting how career options are available to the students we engage with.

This study also highlights the importance of starting early in our pre-college engineering outreach. Many students reflected on developing “ceilings” as early as 6 years old. Pre-college outreach may be more effectively by working longitudinally with students, and working with students starting in early childhood before “ceilings” are formed. Such early interventions should work with communities as powerful partners in the process of re-authoring student habitus. Families and communities should be leveraged in pre-college outreach programs to create comprehensive eco-systems of supports to promote students’ educational success.

5.5.2 Implications for Policy

This research also has important implications for how we (engineering educators) conceptualize and measure socioeconomic status. Students’ narratives reveal the multidimensional and dynamic nature of economic disadvantage, with many students discussing how a single critical incident drastically and unexpectedly caused material hardship. Recognizing that socioeconomic status is dynamic, higher education policies should consider dynamic strategies for measuring and operationalizing students’ economic disadvantage. Commonly used proxies for socioeconomic status, such as parental educational attainment and Pell-Grant eligibility, are limited in their ability to measure students’ lived experiences regarding material hardship. In addition, measurements such as Pell-Grant eligibility draw stark boundaries around who is and is not considered “low income;” such boundaries leave students at the margins of our measurements, and this study suggests that many of the students at the margins are experiencing material hardship. I recommend a multifaceted approach to considering students’ economic disadvantage, including community-level measures, household measures, and individual measures. Moreover, this research suggests that direct measures of material hardship may more accurately reflect students’ lived experiences than commonly used proxies for income, such as parental educational attainment and Pell-Grant eligibility. Regardless of the measurement used, our policies to identify and support underserved students must carefully consider that students’

economic status can change drastically and unexpectedly. Accordingly, we must consider dynamic and iterative approaches to measuring economic status.

5.5.3 Implications for Research and Future Work

Lastly, this work provides a springboard for future research as we work to understand how to best support underserved students in engineering trajectories. First, there is much work remaining to understand how communities shape engineering trajectories. The subsequent phase of this study will interview community members, identified by students in this study, in order to triangulate students' perspectives on community rhetoric around engineering trajectories. In addition, future work should examine how economic trends—particularly economic downturns—shape the engineering aspirations and trajectories for underserved students and students more broadly.

In addition, my analysis was not systematically intersectional. Where observed, I noted trends relating to gender, race, and out-of-state student demographics, but a more nuanced analysis of my data with an intersectionality lens is an immediate next step in this research. An intersectional analysis is particularly imperative considering the intersecting systems of oppression (e.g., racism, sexism, homophobia) directly noted by many participants in this study. Intersectional analyses are an immediate next step in my future work.

Perhaps most importantly, there is tremendous work to be explored regarding the journeys of underserved students who do not enter engineering education and/or higher education more broadly. As I noted in the introduction to this study, the case boundary of this research excludes students experiencing disadvantage who did not navigate to the door of the engineering degree program that served as the context for this study. I somberly acknowledge the absence of their perspectives in this work exploring access and equity in engineering education. There is pressing work to be done to understand the experiences of students who do not enter or persist in engineering education. This student perspective is paramount in order to connect the research-to-practice cycle as we strive to increase access and equity in engineering education.

5.11 Final Thoughts

I designed this research study with the purpose of exploring how engineering students from underserved backgrounds navigate their educational trajectories, focusing on the interplay

between structures and agency. Using a Bourdieusian lens in a single case study design, I conducted narrative interviews with 32 engineering students at a large southeastern university and triangulated narrative interviews with community-level data for each student. This study finds that underserved engineering students describe in their narratives a variety of strategies to enact agency by planning, optimizing, and at time redirecting their educational trajectories. This study also highlights the influence of family, community, economic, and political environments on the educational journeys of underserved engineering students, as students described navigating and adapting to these various social environments. Students also describe their environments as dynamic, with trajectories changing based on critical incidents such as a parent illness or loss of work. Lastly, students' narratives highlight a diverse range of reasons for pursuing engineering, which often extended beyond private goods approaches to engineering education.

Given these results, several critical questions remain. To conclude, I will wrestle with several important questions for the broader engineering and higher education communities. The first pressing question that remains is: what does this research suggest may be unique about the educational trajectories of underserved students? I note here that my study was not comparative in nature, but still it is useful to consider what may be unique about the trajectories of underserved students compared to their non-underserved peers. First, the collective family agency emphasized in so many students' narratives is likely unique to underserved students. This is supported by previous work that suggests underserved students are more likely to make decisions collectively with their families and communities (Stephens et al., 2012). The collective values of underserved students can pose tension with the individualistic values of higher education (Stephens et. al, 2012). In addition, the "get out" navigational perspective, where students recount determining from a young age that they needed to leave their high poverty home community, is likely unique to low income students. In particular, this study found that only students in communities where most people were living in poverty shared "get out" perspectives; on the contrary, students who grew up in a low income household within a more affluent community did not share the same navigational views. This finding suggests that community-level poverty may be a critical factor in shaping students' educational trajectories. On a similar note, the agentic perspective to "resist the paved path" (RQ1) and resist societal forces is likely unique to students who are navigating systems of oppression. While this study focused on the

resistant capital of students navigating classist systems, other work has discussed the resistant capital of students navigating racist systems (e.g., Yosso, 2005). Therefore, while low income students likely possess more resistant capital than their higher income peers, research suggests other marginalized groups also activate resistant capital to navigate educational systems.

Following from above, we must also consider what is unique about low income students in engineering education contexts. Here, looking across research questions at the broader study is particularly useful to consider the nuanced intersection of engineering trajectories for low income students. In research question 3, a salient theme that emerged was students' process of re-authoring their habitus after a critical social encounter, resulting in students viewing engineering as an option available *to them*. One key insight here is that exposure to engineering careers was not sufficient for students to decide to pursue engineering; the critical reauthoring of habitus occurred when exposure was coupled with self-efficacy, and specifically, the building of self-efficacy through social persuasion by a trusted mentor. These findings suggest that engineering carries a particular reputation; as students shared, perceptions of engineering are often rooted in prestige and financial expectations for a high-paying career. These perceptions of engineering may be a heightened barrier for underserved students, particularly in contexts where there is low exposure to engineering careers and low college graduation rates. In addition, perceptions of who an engineer is and the type of work an engineer does are often raced and gendered, in addition to classed. Several students of color and women in this study shared active discouragement from their teachers or communities as they considered engineering careers; these findings suggest that perceptions of engineering disproportionately impact marginalized students.

Related to perceptions of engineering careers, one of the most striking and important findings of this study were the financial expectations that low income students associate with engineering careers. Out-of-state low income students recounted receiving messages from mentors that student debt was a "future problem, not a present one" because they would be earning a high-paying engineering salary. Indeed, the expectation of a high-paying engineering salary was a key factor in out-of-state students' college choice. All 8 out-of-state students in this study cited their top reason for their college choice as the perceived prestige of the engineering program at their university. These perceptions of prestige of the engineering program factored heavily into their cost-benefit analyses, with these 8 out-of-state students ultimately concluding

that the benefits of attending an out of state school outweighed the high out of state tuition costs. For in-state and out-of-state students alike, expectations about engineering salaries were sometimes associated with agency. Many students believed engineering would allow them to climb upwardly in society. These expectations for upward mobility, so intimately and specifically connected with *engineering*, transcended the individual student level and often were rooted in family mobility. Many students believed their own engineering career would afford their broader families a secure and stable future, and this belief was the foundation of their pursuit of an engineering bachelor's degree.

We should heed the narrative of Carly to recognize that financial expectations of engineering careers are not inherently positive. Recall that at the time of her interview, Carly felt regret towards her major choice and was actively searching for a job after graduation. She would have preferred to pursue a career that would allow her to “help people,” such as teaching with a nonprofit or going to graduate school to do research. However, the pressure to earn a high-paying engineering salary to support her family made her feel constrained in her career choices. One of Carly's deepest fears was not earning enough money to support her “family currently... I don't care about my future family, they don't exist.” She noted that “being an engineering major, you're expected to make a certain amount after you come out of college,” and the thought of not securing a high paying job to support her family was “scaring” her. Similar to other students, Carly believed an engineering degree would afford her and her family upward mobility; however, for Carly, the expectations of upward mobility associated with an engineering degree constrained her career choices instead of broadening them. The heavy burden Carly reflects of making career decisions based on the desire to provide upward mobility for an entire family is likely unique to low income students and perhaps heightened in engineering, considering perceptions of engineering salaries.

We also must consider a particularly pressing contemporary question in light of these research results: is engineering education—or even university education more broadly—the right trajectory for everyone? With humility, I note that one person could not possibly ascertain the “right” path for every student. It is my position that each student should be able to decide, with informed agency, what paths to pursue to reach their short- and long-term goals. In light of this dissertation work, I recognize now more keenly than ever that educational trajectories are

incredibly nuanced and context-specific. I therefore urge educators to consider with utmost care the unique circumstances and aspirations of each student before drawing conclusions about the “right” educational trajectories. Perhaps Naz, a computer engineering student in this study, summarizes the grappling that each of us must engage in regarding whether university is the right path for everyone. Naz, a first generation, Pell eligible student of color shares the following:

So, I think there's a generational thing, grandparents, in terms of being Black, saw the importance of being in college because going back 60, 70 years ago... college was the best way of getting the job that will give you the most benefit. And you need a college [degree] to get that job... [my grandparents] not being able to attend college through whatever reasons made them preach the importance of college to their children who did have the opportunity... but because the times have changed.

...Like if I was a master at C++ and Python and stuff, I can go to Google right now and I can apply... Just having, because we have the internet because we have the resources to gain knowledge and do a side thing, we're able to show our skillset in different ways now. So the stipulation is still go to college, get a good job, be successful. But because we're in the times that we are now, college isn't the only route... I just don't think that college is the only route now because we have so many other ways to gain information, gain success, gain experience in our craft. And most of the jobs outside of medical field and a good portion of engineering don't require a degree. It's just the way that the world works is not predicated on just a degree now and most of college really isn't just a piece of paper, it's the internships you got. It's the experience and the side projects that you did throughout that process...

...Me personally, I mean I feel like college is the right route for me. I just don't think it's the only way to success. And like I said, most of my sources of income, what I deem to be success is not technically money, but being able to change the bar set for my family, that doesn't really come solely from having a degree, if you see what I'm saying.

Naz reflects with candor on a sentiment that many of us grapple with—whether university is the “right route,” as Naz says. Whatever conclusions each of us may arrive at regarding this critical question, it is my firm position that we as educators must actively work to ensure that *our educational systems do not make this choice for students*. Instead, we must work to ensure each student has the agency to make such decisions for themselves.

A final question that remains is the following: is it appropriate to focus on the agency of underserved students? In short, no. In this study, I leveraged Bourdieu’s work to simultaneously consider the agency of underserved students in the context of the educational systems

(structures) they are navigating. To consider agency outside of structures is to absolve educational systems of their responsibilities for equity. Even if rooted in anti-deficit approaches, focusing on the agency of underserved students fuels the “bootstrap” meritocracy myth that is all too present in our educational dialogues today. The rhetoric that insists anyone can pull themselves up in our educational systems, despite all the odds stacked against them, is an insidious societal force that continues to marginalize underserved students in the United States. Ideals of meritocracy worship agency while rendering invisible the inequitable structures that persist in our educational systems. At the same time, focusing exclusively on inequitable societal structures renders invisible the lived experiences of marginalized groups and does not honor the agency used to navigate such systems. Therefore, the two—agency and structures—must remain intimately intertwined in our examinations if we wish to truly inform and push towards equitable change in engineering education.

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Appendix A: Student Initial Contact Email

Subject: Your participation is requested! Experiences of Pathmakers in the [Institution Blinded] College of Engineering

You are invited to participate in a research study investigating the pathways of first generation and/or low socioeconomic status (i.e., underserved) students in the Virginia Tech College of Engineering. The purpose of this project is to explore the experiences of students from underserved backgrounds who have been pursuing, navigating, and persisting in engineering. For our study, we invite you to participate in a 60-90 minute interview. All participants will receive a \$20 Amazon Gift Card for the interview.

Your identity will be kept confidential at all times and will be known only to members of the research team. The results of this study may be published in conferences, and will be used to inform the efforts of the [student support center, blinded]. If you have questions please contact [blinded] or the WIRB [800-562-4789, help@wirb.com].

If you are over the age of 18, are an undergraduate student within the VT College of Engineering, and are interested in participating in this study, and have read and understood the information presented in this e-mail, please click the link below to complete a screening survey that will assist us with selecting interview participants:

[survey link]

Appendix B: Screening Survey

The purpose of this study is to understand the pathways of engineering students in bachelor's degree programs. We are interested in understanding challenges that students face as well as resources that students use to navigate engineering degree programs. Please answer the following questions to the extent which you are comfortable.

The following questions have a response scale of 1 (strongly disagree or very dissatisfied) – 5 (strongly agree or very satisfied).

1. I have been strategic in achieving my education and career goals.
2. I seize opportunities when they are presented to me to advance my engineering education and career.
3. I have intentionally made choices to focus my education in ways that are personally meaningful to me.
4. I am in charge of the direction of my engineering education.
5. I feel stuck in my ability to advance in my engineering education.
6. I have little control over whether I advance in my engineering education.
7. What resources were most important to your college pathway? Please check all that apply.
 - Family
 - i. Comments:
 - High school friends
 - i. Comments:
 - High school teachers
 - i. Comments:
 - College friends
 - i. Comments:
 - College teachers
 - i. Comments:
 - University offices
 - i. Comments:
 - Financial resources
 - i. Comments:
 - Other: _____
 - i. Comments:
8. Which of the following were barriers for your access to an engineering bachelor's degree program? Please check all that apply.
 - Lack of support from significant others
 - i. Comments:
 - Lack of financial resources:
 - i. Comments:
 - Lack of information about college resources (e.g., application process, FAFSA, major-specific information, etc.)
 - i. Comments:

- Lack of academic preparation:
 - i. Comments:
- Other: _____
 - i. Comments

9. Is there anything else you would like to share about your pathway to and through [institution's] engineering program?

Please answer the following demographic questions to the extent which you are comfortable.

10. What type of high school did you attend?

- Public
- Private
- Home school
- Charter school
- Other: _____

11. When you entered this institution, were you:

- A first-time college student directly from high school
- A first-time college student not directly from high school
- A transfer student from a community or two-year college
- A transfer student from a four-year institution
- Self-identify: _____

12. How are you funding your education (select all that apply)?

- Help from parents
- Help from other family or friends
- Private Student loans
- Federal student loans
- Scholarships and/or grants
- Working (part time or full time)
- Other (Please describe) _____

13. What is the highest level of formal schooling that your parents/guardians have completed?

Mother/Guardian 1

- Did not finish high school
- High school graduate/GED
- Vocational/technical certificate or diploma
- Some college but did not receive a degree
- Associate or other 2-year degree
- Bachelor's or other 4-year degree

Father/Guardian 2

- Did not finish high school
- High school graduate/GED
- Vocational/technical certificate or diploma
- Some college but did not receive a degree

- Master's degree (M.A., M.S., M.B.A. etc.)
- Doctorate degree (Ph.D., J.D., M.D.)
- Don't know
- Associate or other 2-year degree
- Bachelor's or other 4-year degree
- Master's degree (M.A., M.S., M.B.A. etc.)
- Doctorate degree (Ph.D., J.D., M.D.)
- Don't know

4. Are you currently employed? (Mark all that apply)

- No, I do not currently work for pay
- Yes, in a job not related to my major or career goals
- Yes, in a job that is related to my major or career goals

5. If so, how many hours do you work for pay on a job that is not related to your major or career goals?

- None
- 1-10
- 11-20
- 21-30
- 31-40
- More than 40hrs/week

6. Which of the following describe your citizenship status?

- A U.S. Citizen
- A permanent resident of the U.S.
- An international student
- A status not listed: _____

7. Which was the primary language spoken at your home growing up? Mark all that apply

- Spanish
- English
- Other: _____

8. Please indicate your race. Mark all that apply.

- American Indian or Alaska Native
- Black or African American
- Hispanic or Latino
- South Asian (e.g., Indian, Pakistani, Bangladeshi, Sri Lankan, etc.)
- East Asian (e.g., Chinese, Korean, Japanese, etc.)
- Southeast Asian (e.g., Thai, Vietnamese, Burmese, etc.)
- Middle Eastern or North African
- Native Hawaiian or other Pacific Islander
- White
- Another race not listed (please specify) _____

If there anything else about your identity that should be noted?

As part of this study, we will be conducting one-on-one interviews to better understand the experiences of engineering students and how engineering students navigate bachelor's degree programs. Participation is completely voluntary. Interviews will last no more than one hour. All interview participants will receive \$20 as compensation for their time.

If you are willing to participate in an interview, please provide your name and email address below:

Name:

Email address:

Appendix C: Interview Invitation

Interview Invitation

Subject: Examining Student Pathways – Interview Invitation (\$20 Gift Card)

You recently indicated via an online survey that you would be interested in participating in an interview to discuss your pathway to an engineering degree. As a reminder, each participant will receive a \$20 Amazon gift card. If you are still willing to participate, please contact me at [insert interviewer contact information] to schedule an interview.

This interview will last no more than 90 minutes. During this interview, you will be asked to bring up to 5 photos, pictures, or drawings that best represent your journey as an engineering student. These photos may be shared from your phone or laptop and will NOT be collected during the interview. Rather, these photos are a tool to help you tell your story. Lastly, your identity, and that of any individuals you mention, will be kept confidential at all times and will be known only to members of the research team.

Questions about this study can be directed to the [blinded].

Appendix D: Narrative Interview Protocol

Interview Phase 1: Preparation

Prior to each interview, I will explore the context and participant's survey responses. I will formulate analytical questions specific for each participant for interview questioning phase.

Interview Phase 2: Initiation

The narrative interview will begin by offering the initial topic for narration. *Participants will be asked to bring 5 photos (on their cellular phones, computers, etc.) that they feel help share the story of their journey to an engineering university program.* The narrative interview initiation will begin with participants explaining their story using the photos as visual aids.

“Using these photos, can you tell me about your journey to where you are now-becoming an engineer?”

Interview Phase 3: Main Narration

During participant's main narration, I will not interrupt. Instead, I will offer non-verbal encouragement to encourage participant to continue telling their story. I will note questions to follow up in the next interview phase.

Interview Phase 4: Questioning Phase

Following the participant's main narration, I will follow up on their story and ask additional questions as needed. The questioning phase will also be participant-specific, but some example prompts are provided below.

Narrative Interview: Questioning Phase (Continued).

The following questions are examples of probes that will be used during questioning phase of this narrative interview protocol.

1. Can you tell me a little bit about yourself?

Follow up probes

Where did you grow up?

What is your home community like?

2. Can you tell me the story of how you got here, to university?

Follow up probes

When did you decide you wanted to go to university?

Why did you decide you wanted to go to university?

Can you tell me a little bit about your application process?

What helped you get here?

Were there any resources available that you did not use? Why?

3. Is going to college an expectation for young people in your community?

Follow up probes

After high school, what were the next steps for your friends?

What challenges do young people in your community face?

After high school, what are the other options for young people in your community?

4. How did you decide you wanted to study engineering?

Follow up probes

What did you know about engineering when you chose to study it?

Do you know any engineers in your home community?

Why is engineering meaningful to you?

Would you choose engineering again?

5. I'd like to ask you to think about your path to university, from elementary school to now.
What barriers did you encounter as you navigated here?

Follow up probes

Was there ever a time you felt "stuck"? Unable to move forward?

Did anyone ever discourage you from pursuing engineering? Or from going to college?

How did you/are you responding to those barriers?

6. You've been in college for a few years now. Can you tell me a story about when you faced a challenge in college?

Follow up probes

Why do you think that was such a challenge?

How did you/are you responding to that challenge?

7. Looking back on your journey here, did you have any strategies to help you navigate here?
8. Is there anything you wish you would have known to get to where you are now?
9. If you hadn't come to a four year institution, where do you think you'd be?
10. So we've talked about how you got here. Now I'd love to understand your plans for the future. What's next for you?

Follow up probes

How do you want to use your engineering degree?

11. Imagine yourself ten years from now. In your highest dreams, what do you see yourself doing?
12. What opportunities do you think an engineering degree provides to you? What doors does it open?

Follow up probes

What does an engineering degree give you control over?

How does an engineering degree help you steer your future?

13. Are there any doors that an engineering degree does *not* open?

Follow up probes

Are there things you would like to change but cannot?

14. We talked a little bit about your home community. What advice would you give a young person from your community who wants to study engineering in college?
15. Is there anything else you would like to share or ask?

Appendix E: Exit Survey

Pseudonym _____

Preferred Pronouns _____

1. Have you experienced any of the following on your educational journey? Please check all that apply.

- Experienced difficulty paying rent
- Experienced difficulty paying utilities
- Did not see a doctor or dentist when needed
- Did not have enough food to eat
- Experienced dissatisfaction with my condition of housing
- Had housing related problems
- Experienced a lack of health insurance

2. Please list the name and contact information of anyone from your pre-college context that you would like us to contact in order to help us better understand your story. If you choose to refer us to someone from your pre-college context, the representative will be informed that they were referred by you, but we will NOT disclose any information from the interview. This second stage of the research is completely optional for each participant.

Name: _____

Contact: _____

Anything you'd like to share about your connection with this representative:

Appendix F: Participant Receipt of Reimbursement

I confirm I have received a \$20 Amazon Giftcard for my participation in this research study.

Name:

Signature:

Date:
