Career Calculus: Assessing the Psychological Cost of Pursuing an Engineering Career

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Abstract

Background: Personal characteristics (e.g., race/ethnicity, gender, and pre-college experiences) are known to shape students' pathways to engineering, as well as persistence decisions in college. However, the role of psychological cost in post-graduation intentions has received less scholarly attention.

Purpose: The purpose this study is to examine sociocognitive factors that shape students' post-graduation intentions in the early college years. Guided by Social Cognitive Career Theory and the concept of psychological cost, we examine the role of self-efficacy beliefs, outcome expectations, and psychological cost, as well as key background characteristics, in students' post-graduation intentions.

Method: We analyzed survey responses from four cohorts of undergraduate engineering students at a large public university. Participants responded to items measuring self-efficacy beliefs, outcome expectations, and psychological cost after their first and second years of college. We used structural equation modeling to examine the relationships between the sociocognitive variables and students' graduate school and career intentions.

Results: The sociocognitive variables predicting post-graduation intentions after Year One differed from those predicting intentions after Year Two. After Year One, we found no statistically significant sociocognitive variables predicting graduate school intentions or engineering career plans. After Year Two, both self-efficacy and outcome expectations were significant predictors of post-graduation intentions. Psychological cost was significantly related to both self-efficacy and outcome expectations. Finally, we found significant differences by racial/ethnic identity, sex, and first-generation status.

Conclusion: Examining psychological cost provides additional insights into the factors informing students' post-graduation intentions over the course of their collegiate careers and suggests new directions for research on students' thinking about engineering careers.

Keywords:
career paths; undergraduate education; social cognitive career theory; psychological cost; structural equation modeling

1 Introduction

As policymakers remain concerned about the difficulty of recruiting students into science and engineering fields and educators continue to search for effective strategies for recruiting and retaining women and students of color, researchers seek to understand the antecedents of students' decision-making regarding careers in the science, technology, engineering, and math (STEM) fields. In engineering, the search for effective levers intensified as several national reports (e.g., National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2007; President's Council of Advisors on Science and Technology, 2012) sounded alarms about the threat of unmet workforce needs and the prospect of diminished U.S. competitiveness in global markets. More recently, rising concerns about educational inequities have fueled studies to identify—and potentially ameliorate—cultural and climate-related barriers to engagement in engineering experienced by minoritized students. We use the term *minoritized* rather than "minority" to refer to social groups that are devalued and receive less access to resources. Whereas the term minority has traditionally been used to reference structural diversity—the number of people of a given group represented in a particular setting or context—the term minoritized acknowledges "the active dynamics that create the lower status in society, and also to signal that a group's status is not necessarily related to how many or few of them are in the population at large" (Sensoy & DiAngelo, 2012, p. 32).

To understand how students decide to pursue STEM careers and majors, many scholars have used achievement motivation frameworks (e.g., Perez et al., 2019, Jones et al., 2014; Smith & Gayles, 2017) or Social Cognitive Career Theory (SCCT) (Lent & Brown, 2019) to examine sociocognitive factors that influence engineering students' career plans (e.g., Byars-Winston et al., 2010; Lent et al., 2008). These studies have paid particular attention to the influence of positive motivational factors such as individual interests to explain students' decisions to pursue a particular career; however, this perspective can lead scholars to overlook the negative reasons why students might decide against pursuing a given major or career. In fact, there is empirical evidence to suggest that perceived costs of career choice are related to students' motivational beliefs and persistence in engineering (e.g., Robinson et al., 2019). Yet, as Perez and colleagues (2014) have indicated, scholars have paid much less attention to perceived costs in studies of STEM interest. Understanding the role of negative drivers of decision-making is perhaps more important in a field often characterized as competitive and challenging (Hurtado et al., 2010; Perez et al., 2014), as well as unwelcoming to minoritized students (Cheryan et al., 2017).

Published research (e.g., Lichtenstein et al., 2009; Ro, 2011) as well as our research team's qualitative analyses of interviews from STEM undergraduates (Mosyjowski et al., 2019), further suggest that career thinking is not a decision that occurs at a singular moment in time, but rather an evolving process influenced by a number of factors during the undergraduate years, such as curricular, co-curricular, and non-academic experiences. Relatedly, studies of career intentions have shown that a sizeable percentage of undergraduate students are unsure about pursuing engineering careers or have definitely ruled them out (Margolis & Kotys-Scwartz, 2009; Lichtenstein et al., 2009). Further research is therefore necessary to understand what factors influence students' career thinking at different points during their undergraduate years.

Taken collectively, study findings in engineering and STEM indicate that fostering interest and self-efficacy in engineering might not be sufficient to ensure students pursue engineering careers after graduation. Moreover, given findings that suggest the tenuous and potentially fluid nature of undergraduate engineers' plans to pursue careers in engineering, we sought to understand why, as Lichtenstein and colleagues (2009) noted, "an engineering degree does not (necessarily) an engineer make" (p. 227). Thus, in this study, we examine self-efficacy, outcome expectations, and psychological cost in Years One and Two of college as they relate to students' career intentions. Recognizing that the pursuit of graduate education in engineering may also be a precursor to an engineering career, we also consider whether these same potential antecedents affect graduate study plans in engineering. Our goal is to identify not only positive influences on career and graduate study intentions, but the possible role that negative motivators, specifically perceived psychological costs, play in those intentions in the first two years of college.

We focus our attention on Years One and Two of the undergraduate engineering experience since existing research suggests the sources of attrition in Years One and Two might differ markedly from the sources of attrition during Years Three and Four. First, first-year and second-year attrition appears to be a high point of attrition in engineering (Chen, 2013; Concannon & Barrow, 2009), where coursework may be perceived to be gatekeeper courses for engineering students (Chen, 2013). Moreover, Atman and colleagues (2008) argued students leave engineering because they have "little vision into engineering in the first two years when they are taking math and science courses outside of engineering departments" (p. 3). A focus on these first two years may reveal how sociocognitive factors might shape students' long-term decision-making during the early stages of college. Our research is guided by the following questions:

1. Which sociocognitive factors (i.e., self-efficacy, outcome expectations, psychological cost) are related to engineering students' career plans at the end of Year One and Two of college?

2. How do sociocognitive factors that inform students' career plans differ for students in Year One and Year Two of college?
3. Do sociocognitive factors (i.e., self-efficacy, outcome expectations, psychological cost) differ by personal inputs (e.g., race, sex)?

2 Literature Review

Many studies suggest that students who feel competent in a STEM discipline and view the STEM discipline as interesting, important, or useful are more likely to pursue a major or career in a STEM discipline. Such studies frequently use achievement motivation frameworks, such as Eccles' expectancy-value theory (1983, 2011) or the eMpowerment, Usefulness, Success, Interest, and Caring (MUSIC) framework (Jones, 2009) to demonstrate these relationships in high school settings (e.g., Watt et al., 2012), among college students (e.g., Chow et al., 2012; Perez et al., 2014; Perez, et al., 2019; Robinson et al., 2019), and for engineering undergraduates specifically (e.g., Jones et al. 2010, 2014, 2016). Other studies utilize SCCT, which similarly focuses on the role of individual interests as motivating influences, but which specifically seeks to explain individual's career choice (e.g., Smith & Gayles, 2017). As early as the 1990s, however, studies identified students' negative perceptions of STEM majors as causes of attrition from the field. Strenta and colleagues (1994) and Seymour and Hewitt (1997) identified the deleterious effects of influences such as perceptions of STEM courses as competitive or as characterized by demanding but unmotivating instruction. Eccles' expectancy-value framework (EVT) theoretically incorporates the role of such negative motivational factors, conceptualizing them as perceived costs. In EVT, these perceived or relative costs include anxiety or fear of failure resulting from engaging in an activity (such as majoring in engineering), the social cost of success in a given task, and the loss of time or energy that could be devoted to other activities (Eccles, 2011).

Yet, as Perez and colleagues (2014) noted, there has been relatively little empirical attention to perceived cost factors in EVT or other studies of STEM interest at different levels of schooling. In their study of students in college chemistry courses, Perez and colleagues (2014) found that students' perceptions of costs (i.e., of the effort required, lost opportunities, stress and anxiety) affected students' intentions to leave the sciences. In a study of engineering students in the first two years of college, Robinson and colleagues (2019) found that students' positive expectations for success in engineering declined over time while their negative motivational beliefs, specifically, the perceived costs of lost opportunities, effort, and psychological costs, increased over time. To date, the study by Robinson and colleagues is the only study focused specifically on engineering students that has examined the relationship of costs to other motivational beliefs such as expectancies and valuing in an engineering context and the relationship of these variables to students' persistence in the field.

Although these studies of perceived costs provide needed information about persistence in the field and academic performance (in the form of grades), engineering educators and researchers are also interested in understanding how students' intentions regarding engineering careers may evolve over time. Attention to career intentions is particularly important in engineering because several studies suggest that many students who remain in engineering majors through college graduation are either unsure of whether they will pursue careers in engineering or report certainty that they will *not* enter the engineering workforce after earning their bachelor's degree. Margolis and Kotys-Schwartz (2009) found that 9% of the students in their sample of 169 students had no intentions of pursuing engineering careers, while 34% had reservations about their career choice and planned to leave engineering after graduation. Similarly, Lichtenstein and colleagues (2009) found that between 14% and 36% of undergraduate participants at the two institutions they studied were *definitely not* or *probably not* going to pursue careers in engineering after graduation. Ro's (2011) study of more than 5,000 undergraduate engineers in a 30-institution sample of U.S. institutions similarly concluded that engineering students' post-graduation plans were complex and tentative, with senior engineering majors considering different career options inside and outside the field of engineering.

Qualitative findings from Lichtenstein and colleagues' (2009) study, Ro's (2011) survey findings, and our team's analysis of interview data from STEM undergraduates (Mosyjowski et al., 2019) suggest that career thinking is an evolving process shaped by a variety of undergraduate experiences, including curricular, co-curricular, and non-academic experiences during their undergraduate years. The identification of many different factors empirically linked to students' reports of their intentions regarding further study in engineering or the pursuit of engineering careers after graduation underscores the need to examine whether and why engineers' career intentions and related graduate study plans may be tentative and fluid during the college years. This may be particularly true in engineering and other STEM fields that are perceived to be academically challenging and competitive (e.g., Hurtado et al., 2010; Perez et al., 2014), and in which minoritized students such as women, students of color, and first-generation students encounter unwelcoming program cultures and classroom climates (e.g., Cheryan et al. 2017), experience lack of recognition and/or microaggressions by faculty and peers (e.g., Tonso, 2006; Godwin et al., 2016), and/or do not always see a strong alignment between the values of the field and their own values and career goals (e.g., Seron et al. 2016; Smith et al., 2014; Thoman et al. 2015).

Models of vocational choice such as Holland's (1997) theory of vocations and SCCT (Lent et al., 1994) frame students' career thinking as a complex combination of individual interests and experiences that result in sociocognitive dispositions related to career choice. A National Academy of Engineering (2018) report drew on SCCT to explain that students make the choice to major in engineering by weighing barriers and supports that shape self-efficacy, which in turn influences goals, interests, and ultimately persistence toward earning an engineering major. Indeed, a large body of research guided by SCCT (Lent & Brown, 2019) points to sociocognitive factors, such as students' self-efficacy beliefs and outcome expectations, as important predictors of students' engineering career plans. For example, Borrego and colleagues (2018) found that out of several sociocognitive factors, including outcome expectations, self-efficacy, barriers, and choice actions, self-efficacy was the strongest factor influencing students' graduate school intentions. Yet as the National Academy of Engineering report reminds scholars, barriers and supports are "distinct constructs (not opposite ends of a continuum)" (p. 92). As such, the presence of weak supports does not imply the presence of strong barriers, just as the presence of strong barriers does not imply the presence of weak supports. Therefore, it is important for researchers to attend not just to supports but also examine the presence of barriers. This is especially true given the ways that studies have favored supports, where similar to the body of studies using achievement motivation frameworks discussed above, Lent and Brown (2019) also noted the limited number of studies utilizing SCCT to examine the role of psychological and structural barriers in shaping students' career intentions.

Collectively, extant research in STEM broadly and engineering specifically suggest that students' self-efficacy and interest in engineering do not in themselves ensure major completion or pursuit of a career in engineering. Additionally, the fluid nature of undergraduate engineers' career plans makes understanding the career decision-making process that much more complex. Our study seeks to build on this current body of work by further investigating the ways that perceived barriers, such as psychological cost, influence students' career decision making, and how the factors affecting career thinking may differ at various time points in students' undergraduate careers.

3 Conceptual Framework

For this study, we use SCCT as the basic structure of our conceptual framework, and we include measures of psychological costs to examine engineering undergraduates' career thinking. Lent (2012) explains that SCCT emphasizes characteristics of people and their environments within specific domains relevant to career choice. Characteristics of people include factors such as their behaviors, expectations, and their views of themselves, while characteristics of environments may include social or financial elements that hinder or support the individual. SCCT considers these elements dynamic, particularly over one's lifetime, as well as mutually influential, where people shape their environments and vice versa. Research indicates, however, that perceived cost (Eccles, 2011) also plays an important role in career and educational decisions (Abele & Spurk, 2011), so we include perceived cost in our conceptual framework. In this section, we specify and define constructs we utilize from SCCT and explain how the inclusion of perceived cost in our conceptual framework strengthens the analysis. A graphical representation of the conceptual framework is depicted in Figure 1.

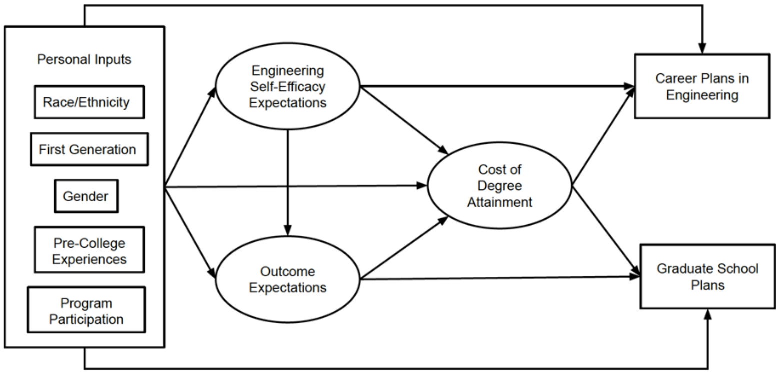

Figure 1. Conceptual model.

3.1 Personal Inputs

Lent (2012) explains that SCCT views personal inputs—e.g., gender, race/ethnicity, disability status—as important not due to their biological or physical elements, but rather to the ways that other individuals in the sociocultural environment respond to these characteristics in ways that influence access and exposure to opportunity structures (e.g., performance expectations, career-relevant models). Access and exposure to opportunity structures includes access to career opportunities, perceived consequences of behavior, and beliefs about one's ability to succeed at a given task in a given context. Lent (2012) explains:

> To a large extent, then, variables like gender and ethnicity may affect interest development and other career outcomes through socially constructed processes that may appear to operate in the background but that nevertheless can powerfully influence the differential learning experiences that give rise to self-efficacy and outcome expectations—leading, at times, to skewed conclusions about what interests or career options are "right" for certain types of persons. (p. 123)

These social influences begin at a young age such that members of a child's social environment may grant greater access to experiences that develop encouraging self-efficacy and outcome expectations in science activities for boys and in helping activities for girls. In fact, women's experiences with gender harassment and discrimination in STEM is well documented in the empirical literature (Alexander & Hermann, 2016). Relatedly, researchers have documented the experiences of marginalization, discrimination, isolation, and hostile climates students of color face in STEM environments (Alexander & Hermann, 2016; McGee, 2013, 2016), contending that these experiences influence both social and academic behaviors (McGee, 2013, 2016). In these ways, personal inputs are important factors in understanding the development of individuals' career plans.

3.2 Self-Efficacy Expectations

The SCCT conceptualization of self-efficacy originates from Bandura's (1986) theory of self-efficacy, where self-efficacy involves "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). That is, self-efficacy expectations are individuals' beliefs about their abilities to successfully perform actions needed to achieve a particular goal. Self-efficacy expectations in SCCT are one of many personal characteristics that can shape career plans, such that positive self-efficacy beliefs regarding a particular career option can encourage an individual to pursue that career option (Lent, 2013). Conversely, negative self-efficacy beliefs can dissuade an individual from pursuing a particular career path. Importantly, self-efficacy expectations are considered both dynamic and domain specific, just as they are in Bandura's theory, such that they should always be understood as changeable and relative to a particular objective. Therefore, just as career plans change over time in response to personal and environmental conditions, so do the self-efficacy expectations that shape them (Lent, 2013).

3.3 Outcome Expectations

Like self-efficacy expectations, Lent and colleagues (1994) derive outcome expectations from Bandura's (1986) theory of self-efficacy, such that outcome expectations concern one's beliefs about consequences of potential career choices. The authors explain the difference between these types of expectations, stating, "whereas self-efficacy beliefs are concerned with one's capabilities (e.g., 'can I do this?'), outcome expectations involve one's beliefs about the consequences of particular courses of action (e.g., 'if I do this, what will happen?')" (p. 118), such as social, self-evaluative, and physical outcomes. Though they are distinct concepts, self-efficacy is directly related to outcome expectations, such that self-efficacy beliefs shape outcome expectations. That is, individuals' beliefs about whether they are capable of successfully completing a task directly influence their expectations of what will happen if they attempt the task.

Positive outcome expectations about a given career path, like positive self-efficacy expectations, encourage individuals to select such career paths, where negative expectations discourage such choices. Importantly, one's self-efficacy expectations and outcome expectations may differ regarding the same career choice. For example, students may have positive outcome expectations regarding a particular engineering career (e.g., "Being a civil engineer would allow me to earn a good living to provide for my family and serve the public in positive ways. . .") that may encourage them to pursue the career, but have negative self-efficacy expectations (e.g., ". . .but I'm not currently so confident in my engineering skills."), which may dissuade them from pursuing such a career.

Importantly, Lent (2012) contend that "self-efficacy and outcome expectations do not arise in a social vacuum, nor do they operate alone in shaping interests or other vocational outcomes. Rather they are forged and function in the context of other aspects of persons and their environments" (p. 122). As explained above, personal inputs, including race and gender, may inform self-efficacy and outcome expectations through influencing the contexts in which they develop. Such personal characteristics may disproportionately open opportunities for experiences that lead to increased self-efficacy for some individuals, while they obstruct these opportunities for others. For example, in a society where engineering roles are viewed as more appropriate career choices for boys than for girls, boys may receive greater access to experiences where they can explore engineering career possibilities and in college gain entry-level experience through internships that offer in turn more opportunities to build both self-efficacy and positive outcome expectations. In this way, a combination of sociocultural forces in the environment and personal characteristics can influence the development of both self-efficacy and outcome expectations in ways that affect future career choices, which the authors explain "help to perpetuate well-entrenched patterns of gender segregation in certain fields" (Lent, 2012, p. 123). Therefore, although personal inputs do not in themselves destine individuals who hold certain gender identities into specific careers, their influences on self-efficacy, outcome expectations, and career choices are important to consider.

3.4 Cost

SCCT posits that self-efficacy expectations and outcome expectations influence individuals' interests, which in turn influence their goals and actions toward career choices (Lent et al., 2016). Thus, interest is an important factor in understanding career choice; however, the strength of the relationship between career interests and career choices theoretically depends on the contextual factors of environmental supports and barriers. Examples of supports include financial supports, emotional supports, and the availability of jobs in one's desired field. Barriers may include financial impediments or socio-structural barriers, such as discrimination. According to SCCT, interests more frequently become goals and goals more frequently become actualized into one's preferred career path in the presence of strong supports and weak barriers. Conversely, environmental conditions of strong barriers and weak supports hinder one's ability to convert interests into goals and goals into career actions. In their examination of the empirical research employing SCCT, Lent and Brown (2019) note that one of the few studies to test the relationship between interests and choice in the presence of barriers confirmed the theory; findings indicated that the relationship between interests and choice was stronger in low-barrier conditions relative to high-barrier conditions.

Though we do not deny the importance of student interest in career decision making, given the fact that interests vary in the degree to which they influence career decisions, we suggest it may not be sufficient as a singular measure of one's incentive to pursue a given career path; that is, interest alone may not capture the complexity of one's inner drive toward or away from a particular career choice based on appeal only. In addition, our participants' commitment to pursue an engineering degree at the university level is already an indicator of interest, as it would be somewhat irrational for a student to pursue an engineering major if they were not at all interested in the topic. For these reasons, we turn instead to the construct of cost from the Eccles Expectancy Value Model of Achievement-Related Task Choices (Eccles, 2011), which models key constructs in individuals' educational and occupational choices.

Eccles (2011) defines relative cost as the cost an individual believes they incur by pursuing a specific educational or occupational path. Cost comprises a range of factors, including fear of failure, anticipated anxiety, loss of energy and time that could have been applied to other activities, and fear of the social consequences associated with success. Cost is one of four components of the subjective task value or relative value of pursuing a career action. A low cost leads to a higher task value, and individuals are more likely to pursue educational or occupational actions with a high task value. For example, a person who attributes a low cost and high task value to pursuing an engineering career is more likely to choose an engineering career. Therefore, cost is a potentially important factor in determining students' career plans.

Recent scholarship on the role of cost in EVT has further developed the conceptualization of the construct and emphasized its importance in influencing motivated behavior (Flake et al., 2015; Barron & Hulleman, 2015; Rosenzweig, Wigfield, & Hulleman, 2019). Barron and Hulleman (2015) position cost as an essential component of EVT that is distinct from, and equally as important as, expectancies and values. The authors argue that asking students if they can do a task (i.e., expectancy) and if they want to do the task (i.e., value) without asking if they have barriers that prevent them from engaging in the task (i.e., cost) provides an incomplete picture of their motivation toward engaging in the task.

Another reason cost is an appropriate measure for this study is because, as Eccles (2011) explains, cost and the other constructs in the model that influence subjective task value shift according to situation and change over time. One aim of our study is to determine what differences in students' career plans, if any, manifest across different time points in their academic careers. Therefore, including a construct that is sensitive to both context and time may aid in identifying differences in our data at different time points as students move through their academic programs.

4 Positionality

Our interest in this topic stems from a commitment to strengths-based approaches to improving engineering education. The tie that binds in our respective research agendas is a belief that structural factors at institutions, rather than students' individual shortcomings or deficiencies, are key factors underlying students' success in higher education and engineering education. Accordingly, we interpret data and findings with an eye toward understanding the conditions that shape students' educational experiences and the form and function of engineering education (e.g., curriculum, pedagogy) that challenge deficit-based evaluations of engineering students.

The research team that collected data for the multi-method study from which this analysis derives brought a range of experiences to the project. It included two faculty members and seven doctoral students at different points in time, including four Black women, one Black man, one Latina, and three White women who all brought significant educational, professional, and/or research engagement in engineering contexts and who worked collaboratively on data collection and data analysis. This particular study represents the collective thinking and efforts of one Black man and two White women who each focus on academic and other cultures—in engineering and beyond—as central elements in their research. Our focus supports the identification of structural explanations of student outcomes in engineering but may also underemphasize the role of individual-level explanations of study findings.

5 Method

5.1 Research Setting and Sample

Data for this study comes from a larger research project assessing the efficacy of a college-level STEM support program at a large, highly selective, research-intensive university. The College of Engineering at the university reports a 3.9 median high school grade point average for admitted undergraduate engineering students, indicating admitted students are high-achieving students prior to their undergraduate careers at the university. The program is intended to support STEM students as they transition into their undergraduate careers in STEM disciplines. The program also provides ongoing academic, social, and professional support and programming to students over the course of their undergraduate careers.

While the program serves students across the STEM disciplines, one branch of the program serves engineering students exclusively. The sample in this study consisted of both program participants and a comparison group of engineering students who met the program's eligibility criteria and who were invited to participate in the program. The program enrolls approximately 60 participants per year. The comparison group students were either not selected by program leadership to participate in the year they were invited or who chose not to participate in the program after invitation. Our sample consists of four cohorts of students who began their undergraduate studies at the university between 2013 and 2016. While data collection for the larger study followed a longitudinal design, this study utilized a cross-sectional analysis of first- and second-year survey responses. Finally, since the 2016 first-year cohort did not submit survey data at the end of their second-year due to the conclusion of the study, the sample size in Year Two declines.

5.2 Measures

Annual surveys to assess the program included measures of a variety of sociocognitive factors that might contribute to persistence, degree attainment, and post-graduation intentions. The survey instrument also included demographic (i.e., race/ethnicity, sex, indicators of socioeconomic status) questions, measures of students' pre-college academic experiences (e.g., high school course taking, pre-college STEM experiences), college experiences, and post-graduation intentions. Consistent with the study's conceptual framework, we include data on students' post-graduation intentions, engineering self-efficacy, outcome expectations, and psychological cost in our analyses.

5.2.1 Post-Graduate Intentions

The outcomes of interest in this research were two post-graduation measures—graduate school and careers in engineering. We measured the outcomes of interest using a set of survey items related to students' plans after graduation. To measure the first outcome, graduate school intentions, we asked students whether they "planned to attend graduate or professional school" as well as the academic field in which they planned to study in graduate or professional school. We coded graduate school intentions dichotomously to indicate students who intended to pursue graduate school (i.e., coded 1) and those who did not (i.e., coded 0). Including both graduate and professional school in a single survey question did not allow respondents' options to indicate both intentions and is thus a limitation of the data.

Since existing research indicates that the intention to complete a degree in engineering is not necessarily an indication that students intend to pursue careers in engineering industry, we also asked students to report their career plans after graduation. This question was asked both of students who intended to pursue graduate school, as well as students who did not intend to attend graduate school. Students selected the career they planned to pursue from a list of career choices, including engineering (any field), physician, attorney/lawyer, statistician, research scientist, business manager, professor, and entrepreneur, to name a few. Like graduate school intentions, career intention was coded dichotomously to indicate students' intentions to pursue careers in engineering (i.e., coded 1) and those who intended to pursue careers outside of engineering (i.e., coded 0).

Descriptive statistics for the outcomes of interest are presented in Table 1. Following their first year in undergraduate engineering, approximately 35% of respondents reported that they planned to pursue graduate school in engineering after earning their degrees, while approximately 27% of respondents reported that they planned to pursue graduate school in engineering after Year Two. Approximately 73% of respondents reported that they planned to pursue careers in engineering after earning their degrees after Year One and after Year Two.

Table 1 Descriptive statistics for post-graduation intentions

	Year 1		Year 2	
	n	(%)	*n*	(%)
Graduate School Intentions				
Yes	121	35.1	75	27.0
No	224	64.9	203	73.0
Engineering Career Intentions				
Yes	248	72.5	167	72.9
No	94	27.5	62	27.1

5.2.2 Background Characteristics and Experiences

Explanatory variables in this study were selected to reflect key demographic characteristics (e.g., sex, race/ethnicity), as well as relevant academic background experiences theorized to be associated with students' academic and post-graduation intentions. For example, Lent and Brown (2019) acknowledged that the "roles of barriers and supports are heightened in contexts where people are most likely to encounter social or financial challenges to their persistence (e.g., first-generation college students, underrepresented racial minorities in STEM fields)" (p. 11). Moreover, extant research indicates that race/ethnicity and sex differences in sociocognitive factors such as engineering self-efficacy and outcome expectations (e.g., Concannon and Barrow, 2009; Sax et al., 2015) are key demographic characteristics since social pressures in the discipline might inform how students respond to various sociocognitive factors. Because of the analysis procedure we describe in the next sections, we coded race/ethnicity dichotomously to indicate minoritized students in engineering, which included Black, Latino(a), and Native American/Native Alaskan students. We did not label the category of Asian and Pacific Islander students "minoritized" due to limitations of our sample. We recognize that this decision blurs the line between "minoritized" and "underrepresented" we previously established and risks essentializing a diverse group of students with diverse experiences in engineering. Finally, we coded parental education dichotomously as a measure of first-generation status, where students were considered first-generation students if the highest level of parental/guardian educational attainment was less than a bachelor's degree.

Table 2 presents descriptive statistics for measures related to background characteristics. We also included related statistics for engineering students nationally. As the program is designed to support minoritized students, Black and Latino(a) students, as well as women, are noticeably overrepresented in the sample of the present study. Moreover, given that the university is a highly selective, research (R1) institution where students' median household income exceeds $100,000, it is possible that some pre-college experiences, such as participating in STEM enrichment programs and advanced course taking, are overrepresented in the study.

Table 2 below compares the study sample (i.e., as measured by students' survey responses) to institutional demographics (i.e., as reported in annual reports) and national statistics. However, we note two details that should inform interpretations of such a comparison. First, our survey included an "Other" category and additional text entry for students to report racial/ethnic information. We used the text entries to further categorize students into the minoritized or non-minoritized category that was included in the analysis. Second, the "Other" category differs across these sources. While the "Other" category in our survey was self-selected by respondents, the "Other" category in the institutional report was a sum of those reported as "Two or More," "Two or More Underrepresented Minority (URM)," "Unknown," and "Nonresident."

Table 2 Descriptive statistics for demographic characteristics

	Year 1 Study Sample *n* (%)	**Year 2 Study Sample** *n* (%)	**University Statistics** *n* (%)
Sex			
Female	164 (47.13)	124 (53.68)	1,937 (28.31)
Male	184 (52.87)	107 (46.32)	4,904 (71.69)
Race/Ethnicity			
Minoritized Student	155 (44.54)	77 (33.33)	856 (12.51)
Non-Minoritized Student	193 (55.46)	154 (66.67)	5,985 (87.49)
First-Generation Status			
First-Generation Student	118 (33.91)	68 (29.44)	-
Non-First-Generation Students	230 (66.09)	163 (70.56)	-

Note: Minoritized students in the survey include students who responded Black, Latino(a), or Native American/Native Alaskan students in the sample, or those who indicated multiple racial categories, including one or more of the aforementioned groups. Minoritized students in the university statistics include Black, Latino(a), Native American/Native Alaskan, and "two or more races—underrepresented minority" students.

Since we were also interested in the role of pre-college educational experiences that might inform students' interests, engineering self-efficacy, and outcome expectations, particularly at the end of Year One, we examined a set of pre-college experiences related to participation in STEM enrichment programs and high school engineering preparation. We asked students whether they participated in STEM enrichment programs during their high school experiences, which we coded dichotomously (i.e., yes = 1 or no = 0). We also asked students the degree to which they believed their high school experiences adequately prepared them for college level mathematics, physics, and engineering courses (which are cornerstones of the first-year engineering experience). We coded each preparation measure (i.e., mathematics, physics, and engineering) dichotomously, where the first category indicated that students either reported that they disagreed or strongly disagreed that their high school coursework had adequately prepared them, or they reported that they did not take relevant coursework in high school.

Finally, we considered a proximal influence during the collegiate experience—participation in the program. Participation was coded dichotomously (i.e., participant = 1, non-participant = 0). However, we wish to note that this participation variable did not capture the degree to which students were engaged in the program, nor did it capture whether students found any or all components of the program beneficial in their first- or second-year experiences. Descriptive statistics for pre-college preparation and college program participation variables can be found in Table 3 below.

Table 3 Descriptive statistics for pre-college preparation and college program participation

	Year 1		Year 2	
	n	(%)	*n*	(%)
STEM Enrichment Participation				
Yes	116	33.33	-	-
No	232	66.67	-	-
High School Prepared for Math				
Yes	277	79.60	-	-
No	71	20.40	-	-
High School Prepared for Physics				
Yes	197	56.61	-	-
No	151	43.39	-	-
High School Prepared for Engineering				
Yes	150	43.10	-	-
No	198	56.90	-	-
Program Participation				
Yes	173	49.71	101	43.72
No	175	50.29	130	56.28

Finally, we selected explanatory variables to operationalize constructs consistent with SCCT (Lent, 2012; Lent, Brown, & Hackett, 1994). In particular, we examined self-efficacy expectations, outcome expectations, and psychological cost. We do not operationalize the construct of interest because we consider it to be an underlying assumption of the study sample. That is, each of the students included in the sample were present only because they expressed initial interest in pursuing engineering degrees during their undergraduate career.

5.2.3 Self-Efficacy Expectations

Several instruments measuring engineering students' self-efficacy exist in the scholarly literature. We used Concannon and Barrow's (2009) adaptation of the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) scales developed by Marra and Bogue (2006). Unlike Concannon and Barrow (2009), who used a seven-point Likert scale to measure engineering self-efficacy, we measured self-efficacy using a five-point Likert scale (i.e., 1 = strongly disagree, 5 = strongly agree). Moreover, while Concannon and Barrow measured engineering self-efficacy across two subscales (i.e., engineering self-efficacy I and engineering self-efficacy II), our analysis of data in this study, which consisted of exploratory and confirmatory factor analyses for scale validation, indicated a single factor structure consisting of seven items. The retained items can be found in Table 3. In our sample, Cronbach's alpha for the self-efficacy expectations subscale was .90, indicating excellent internal consistency.

5.2.4 Outcome Expectations

We adapted the engineering career outcomes expectations subscale of the LAESE to measure outcome expectations. Our measure differs from the factor as described by Concannon and Barrow by a single item. The item "I expect to feel 'part of the group' on my job if I enter engineering" was removed as a result of a low factor loading in our analysis, indicating a relatively weak relationship with the outcome expectations construct. Cronbach's alpha for the outcome expectations subscale was .90, indicating excellent internal consistency.

5.2.5 Psychological Cost

Finally, we utilized an adaptation of the Value of Education (VOE) scale described by Battle and Wigfield (2003). The VOE is a 51-item scale designed to measure various aspects related to the value students place on pursuing graduate education. Since we were primarily interested in psychological cost as it relates to students' long-term, post-graduate career and educational pursuits, we drew on the cost subscale, defined as the personal sacrifice students associated with the pursuit an engineering degree (Battle & Wigfield, 2003, p. 61). See Table 3 for survey items. Cronbach's alpha for the utility value subscale was .82, indicating good internal consistency. Descriptive statistics for the items utilized in this study for Year One are presented in Table 4.

Table 4 Descriptive statistics for survey item responses (Year 1)

Engineering Self-Efficacy $(Cronbach's\ \alpha = .90)$	Mean	Standard Deviation
I can succeed in an engineering major.	4.22	.74
I can complete the math requirements for most engineering majors.	4.26	.71
I can excel in an engineering major during the current academic year.	3.93	.84
I can succeed (earn either an A or B) in an advanced physics course.	3.52	1.06
I can succeed (earn either an A or B) in an advanced math course.	3.84	.89
I can complete the physics requirements for most engineering majors.	4.14	.70
I can succeed (earn either an A or B) in an advanced engineering course.	4.01	.78
Outcome Expectations $(Cronbach's\ \alpha = .90)$		
A degree in engineering will give me the kind of lifestyle I want.	4.16	.81
A degree in engineering will allow me to obtain a job that I like.	4.23	.76
A degree in engineering will allow me to get a job where I can use my talents and creativity.	4.21	.72
Psychological Cost $(Cronbach's\ \alpha = .82)$		
When I think about the hard work needed to get through a science or engineering major, I am not sure that getting a science or engineering degree is going to be worth it in the end.	2.19	1.14
Considering what I want to do with my life, having a science or engineering major is just not worth the effort.	1.88	.89
I think getting a science or engineering degree requires more effort than I'm willing to put into it.	1.93	.93

We established construct validity by examining factor loadings for each construct (i.e., self-efficacy, outcome expectations, and psychological cost). Since variables measuring self-efficacy, outcome expectations, and psychological cost were continuous, we used the maximum likelihood with robust standard error (MLR) estimator to fit the initial measurement model. The test statistics provided evidence for good model fit. For example, absolute fit indices, which measure how well an *a priori* model fits the data, indicated good model fit (Kline, 2016). Specifically, the root mean squared error of approximation (RMSEA) was 0.057, with the lower bound of the 90% confidence interval at .044 and the upper bound at .071, indicating good model fit. Moreover, the standardized room mean squared residual (SRMR) was 0.040, indicating good model fit (Hu & Bentler, 1999). Additionally, incremental fit indices, which measure the relative improvement in fit of the model over a baseline (i.e., null) model, indicated good model fit. The Comparative Fit Index (CFI; .961) and the Tucker-Lewis Index (TLI; .951) indicated the model was a good fit to the data (Hu & Bentler, 1999).

Since we were also interested in the ways that students' responses might evolve over the course of their first two years in college, we also examined the loadings of observed variables onto their specified latent constructs (i.e., self-efficacy, outcome expectations, and psychological cost) at Year Two. Initially, results indicated room for improvement in model fit (RMSEA = .065, SRMR = .058, CFI = .925, TLI = .911). After examining the factor loadings on each latent construct, we modified the factor structure to mirror the year-one model. This resulted in an improvement in both absolute and incremental fit indices (RMSEA = .061, SRMR = .059, CFI = .942, TLI = .925). Table 5 presents the factor loadings for the Year One and Year Two models.

Table 5 Measurement model for sociocognitive variables at Year 1 and Year 2

	Year 1		Year 2	
	Standardized Estimate	Standard Error	Standardized Estimate	Standard Error
Engineering Self-Efficacy ($Cronbach's\ \alpha = .90$)				
I can succeed in an engineering major.	.82	.03	.79	.04
I can complete the math requirements for most engineering majors.	.77	.04	.68	.05
I can excel in an engineering major during the current academic year.	.79	.03	.79	.03
I can succeed (earn either an A or B) in an advanced physics course.	.68	.03	.65	.06
I can succeed (earn either an A or B) in an advanced math course.	.68	.04	.68	.04
I can complete the physics requirements for most engineering majors.	.81	.03	.72	.04
I can succeed (earn either an A or B) in an advanced engineering course.	.80	.03	.75	.04
Outcome Expectations ($Cronbach's\ \alpha = .90$)				
A degree in engineering will give me the kind of lifestyle I want.	.81	.05	.77	.04
A degree in engineering will allow me to obtain a job that I like.	.92	.03	.91	.04
A degree in engineering will allow me to get a job where I can use my talents and creativity.	.88	.04	.85	.04
Psychological Cost ($Cronbach's\ \alpha = .82$)				
When I think about the hard work needed to get through a science or engineering major, I am not sure that getting a science or engineering degree is going to be worth it in the end.	.61	.03	.71	.05
Considering what I want to do with my life, having a science or engineering major is just not worth the effort.	.89	.02	.91	.04
I think getting a science or engineering degree requires more effort than I'm willing to put into it.	.84	.02	.88	.03

5.3 Analytical Procedure

The analytical procedure in this study proceeded in two stages. First, we estimated a set of multiple indicator and multiple causes (MIMIC) models to examine the relationships between pre-college background characteristics (e.g., demographic characteristics, high school educational experiences), and the three sociocognitive constructs examined in the measurement model. Demographic characteristics (i.e., race/ethnicity, sex, first-generation status) were regressed on self-efficacy, outcome expectations, and psychological cost at both Years One and Two. However, since self-efficacy is thought to be malleable with relation to its sources (Bong & Skaalvik, 2003), the variables related to high school preparation for engineering and participation in summer STEM enrichment programs were regressed only on self-efficacy, outcome expectations, and psychological cost at Year One.

Finally, since the two outcomes of interest (i.e., graduate school and career intentions in engineering) were dichotomous (e.g., coded 0 for those who did not intend to go to graduate school/pursue engineering careers and 1 for students who intended to pursue graduate school/pursue engineering careers), we estimated a set of logit models in order to understand the relationships between latent constructs (i.e., self-efficacy, outcome expectations, and psychological cost) and post-graduation intentions (i.e., graduate school and career intentions) in structural regression models. Logistic regression results are presented in terms of odds ratios, where, where odds ratios less than 1 indicate a decrease in the odds that one will report an intention to pursue graduate school or careers in engineering, and odds ratios greater that 1 indicate an increase in the likelihood one will report intentions to pursue graduate school or careers in engineering (Rodriguez et al., 2018).

All models were estimated in Mplus Version 8.4, which uses full information maximum likelihood (FIML) estimation by default. While the demographic characteristics presented in Tables 2 and 3 represent the full sample of 348 and 231 respondents for Year 1 and 2 respectively, the number of cases per variable varied from 344 to 348 (Year 1) and 230 to 231 (Year 2).

6 Results

6.1 MIMIC Models

First, we examined differences in mean self-efficacy, outcome expectations, and psychological cost by regressing dichotomized exogenous covariates representing background characteristics and experiences (e.g., race/ethnicity, sex, STEM enrichment participation) on each latent construct in MIMIC models at both Years One and Two. At Year One, we included both demographic characteristics as well as proximal high school experience (i.e., STEM enrichment program participation; engineering, mathematics, and physics preparation variables). We also included a dichotomous variable representing program participation. However, in Year Two, only demographic characteristics and the program participation variable were included.

Model fit indices for the MIMIC models at both Years One and Two are presented in Table 6. We examined modification indices to determine if measured variables in the measurement model were significantly predicted by pre-college preparation variables, an indication of differential item functioning (Kline, 2016). Modification indices indicated that no measured variables were significantly predicted by participation variables in the model at Year One.

Table 6 Model fit indices for multiple indicator and multiple causes (MIMIC) models

	Year 1	Year 2
RMSEA	.052	.056
SRMR	.042	.051
Tucker-Lewis Index	.927	.927
Comparative Fit Index	.943	.943

Notes: RMSEA = root mean squared error of approximation; SRMR = standardized root mean squared residual

Results from the MIMIC model, which are presented in terms of standardized coefficients (β), indicated that sex (male = 1, female = 0) was a statistically significant predictor of engineering self-efficacy beliefs following Year One ($\beta = .16, p = .004$), suggesting male students end their first year of undergraduate engineering studies more confident in their ability to earn high grades in the advanced engineering curriculum, as well as to eventually earn their degrees. Additionally, high school preparation was a statistically significant predictor of self-efficacy beliefs following Year One. Students' perceptions of their engineering preparation ($\beta = .12, p = .016$) and physics preparation ($\beta = .19, p = .001$) were significant predictors of self-efficacy at the end of Year One. Finally, program participation was a statistically significant predictor of self-efficacy beliefs at the end of Year One ($\beta = .12, p = .028$). Finally, students' perceptions of their engineering preparation were also a positive predictor of outcome expectations ($\beta = .12, p = .036$).

After Year Two, with pre-college high school preparation variables removed, sex differences in self-efficacy beliefs ($\beta = .051, p = .483$) were no longer statistically significant. However, program participation was statistically significant predictor of psychological cost ($\beta = -.141, p = .029$) and outcome expectancy ($\beta = .178, p = .019$). Our results indicated that students who participated in the program viewed the psychological cost of degree attainment more favorably than non-participants. Moreover, students who participated in the program had higher mean expectations that an engineering degree would be worth the work required to attain the degree than non-participants.

6.2 Logistic Regression Models

The next step in the analysis process was to examine the relationships between demographic and background characteristics, as well as sociocognitive variables consistent with our theoretical framework (i.e., self-efficacy beliefs, outcomes expectations, psychological cost), and our outcomes of interest—post-graduation graduate school and career intentions. Since the outcomes of interest were dichotomous, we estimated a set of logistic regression models predicting students' intentions to pursue graduate school or careers in engineering after Years One and Two. Results of the logistics regression models are presented in terms of odds ratios in Table 7 below.

Table 7 Logistic regression results predicting graduate school and career intentions

	Year 1 Odds Ratio	Year 2 Odds Ratio
Graduate School Plans		
Male	0.79	1.07
Minoritized Student	1.02	1.71
First-Generation	0.73	0.51**
Engineering Preparation	1.25	-
Physics Preparation	1.05	-
Math Preparation	0.63	-
Pre-College STEM Enrichment	1.04	-
University Program Participation	1.33	0.57*
Engineering Self-Efficacy	1.31	3.15*
Outcome Expectations	1.05	1.42
Cost of Degree Attainment	0.92	0.70*
Engineering Career Plans		
Male	1.87	0.82
Minoritized Student	1.35	0.40***
First-Generation	1.26	1.43
Engineering Preparation	0.98	-
Physics Preparation	0.75	-
Math Preparation	1.51	-
Pre-College STEM Enrichment	2.22	-
University Program Participation	0.78	1.27
Engineering Self-Efficacy	1.11	0.59*

Outcome Expectations	0.78	0.77
Cost of Degree Attainment	1.29	1.59

Note: ***$p < .001$, **$p < .01$, *$p < .05$

At the end of Year One (Figure 2), there were no statistically significant sociocognitive variables in the model. We also examined the relationships between the sociocognitive variables by regressing outcome expectations on engineering self-efficacy, as well as psychological cost on self-efficacy and outcome expectations, to be consistent with the conceptual model presented in Figure 1 above. Our results offered support for the conceptual model. After Year One, we found significant relationships between outcome expectations and self-efficacy ($\beta = .74, p < .001$), outcome expectations and psychological cost ($\beta = -.35, p = .001$), and self-efficacy and psychological cost ($\beta = -.22, p = .039$).

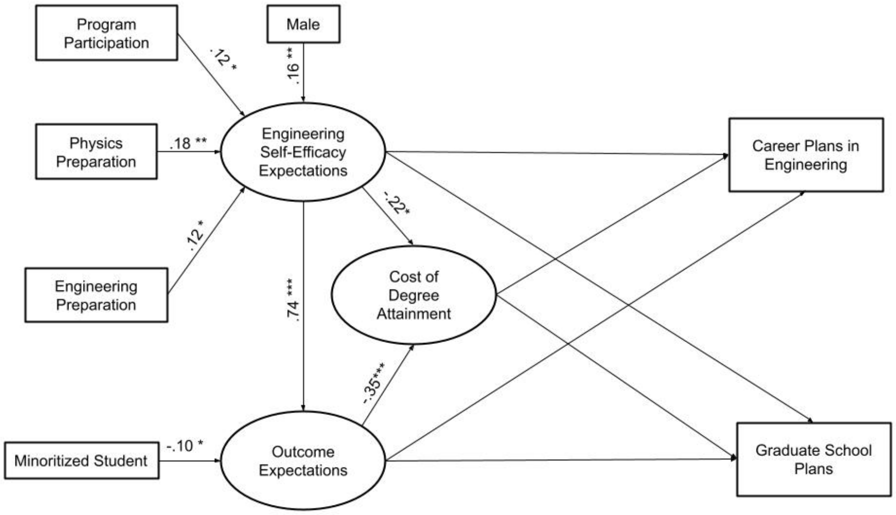

Figure 2 Structural model after Year 1
Note: Arrows on sociocognitive variables are standardized coefficients. Only statistically significant covariates are shown in the model. Odds ratios for the relationships between sociocognitive variables and career plans and graduate school intentions can be found in Table 6.
***$p < .001$, **$p < .01$, *$p < .05$

At the end of Year Two (Figure 3), results indicated that self-efficacy beliefs were a significant predictor of both career plans ($odds\ ratio = .59, p = .038$) and graduate school intentions $(odds\ ratio = 3.15, p = .034)$, indicating that as students' self-efficacy beliefs increased, they became less likely to report intentions to pursue careers in engineering and more likely to indicate plans to attend graduate school. Additionally, outcome expectations were a statistically significant predictor of graduate school intentions $(odds\ ratio = .70, p = .038)$, indicated that as students' outcome expectations increased, they became less likely to report intentions to pursue graduate school.

Several demographic characteristics were significant predictors of post-graduation intentions following Year Two. For example, minoritized student status was also a statistically significant predictor of career plans $(odds\ ratio = .40, p < .001)$. This indicated that engineering students from minoritized student populations were less likely than others to report plans to pursue careers in engineering following their second year in the discipline. Moreover, first-generation status was a negative predictor of graduate school intentions $(odds\ ratio = .51, p = .006)$. Finally, program participation was a negative predictor of graduate school intentions $(odds\ ratio = .57, p = .024)$. We noted that programming emphasized pathways into careers, which might explain students' responses about both career plans and graduate school.

We found three significant predictors of graduate school intentions after Year Two (see Figure 3 below). First, first generation status $(odds\ ratio = .51, p = .013)$ was a statistically significant predictor of graduate school intentions, with first-generation students less likely than others to report intentions to pursue graduate school. Significant sociocognitive predictors of graduate school intentions after Year Two included self-efficacy beliefs and outcome expectations. As self-efficacy beliefs increased, so too did the likelihood that students would report graduate school plans $(odds\ ratio = 3.15, p = .034)$. Additionally, outcome expectations was a significant predictor of graduate school intentions $(odds\ ratio = .70, p = .038)$.

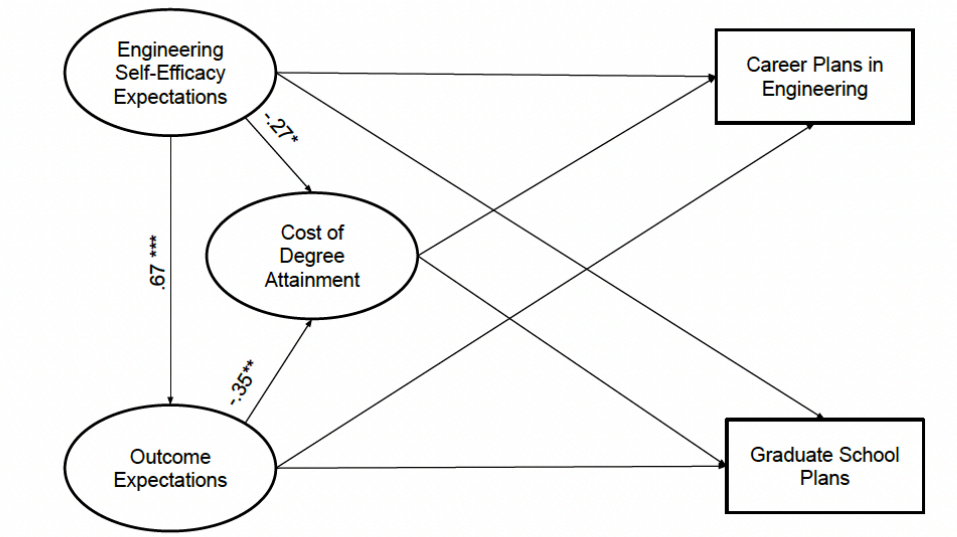

Figure 3 Structural model after Year 2
Note: Arrows on sociocognitive variables are standardized coefficients. Only statistically significant covariates are shown in the model. Odds ratios for the relationships between sociocognitive variables and career plans and graduate school intentions can be found in Table 7.
***$p < .001$, **$p<.01$, *$p< .01$.

As in the Year One model, we also examined the relationships between the sociocognitive variables by regressing outcome expectations on engineering self-efficacy, as well as psychological cost on self-efficacy and outcome expectations. Our results offered additional support for the conceptual model (see Figure 2), which was consistent with the first year model. After Year Two, we found significant relationships between outcome expectations and self-efficacy $(\beta = .67, p < .001)$, outcome expectations and psychological cost $(\beta = -.35, p < .001)$, and self-efficacy and psychological cost $(\beta = -.27, p = .039)$.

7 Discussion

The purpose of this study was to examine the role of three sociocognitive variables—self-efficacy, outcome expectations, and psychological cost—on students' engineering career and graduate school intentions and how these influences might differ between the first and second year of students' undergraduate engineering careers. We also examined the role of pre-college inputs, such as pre-college course taking and engineering-related experiences, as well as demographic predictors such as race/ethnicity, sex, and first-generation status. This effort was designed to understand the relative importance of the concept of psychological cost in modelling engineering students' post-graduation intentions.

7.1 Self-efficacy

Our results suggest the factors that inform students' career thinking after Year One differ from those that inform students' career thinking after Year Two. Specifically, whereas self-efficacy was not a factor informing students' post-graduation intentions to pursue graduate school after Year One, self-efficacy was a statistically significant predictor of graduate school intentions after Year Two. This may reflect our sample; whereas the Year One sample includes all students with undergraduate engineering interests, the Year Two sample might have been affected by attrition. Still, the finding that self-efficacy is positively related to graduate school intentions after Year Two might suggest that confidence-building experiences over the undergraduate engineering years might be a pathway forward for improving students' graduate school intentions. Eagan and colleagues (2013) for example found undergraduate research experiences increased students' intentions to enroll in graduate school.

Other sociocognitive factors studied in this research offered insight about the state of the literature on students' self-beliefs in engineering. For example, the literature on sex differences in self-efficacy beliefs has been fairly inconsistent. Concannon and Barrow (2009) found no sex differences in engineering students' self-efficacy beliefs. However, they did not study their participants over time, choosing instead to compare students' self-efficacy beliefs across years (i.e., comparing Year Four students' beliefs to those of Year Five students). This is important since our study suggests sex differences in engineering self-efficacy at Year One may narrow after Year Two. This supports the idea that the factors informing students' post-graduation intentions evolve over the course of their undergraduate career. In contrast, however, Schar and colleagues (2017) found significant differences in engineering task self-efficacy and innovation self-efficacy by sex among third-, fourth-, and fifth-year students. Although the direction of these differences differs between these studies, the overall findings may suggest that sex differences in self-efficacy beliefs might not only persist but vary in response to the kinds of experiences that students have during their undergraduate engineering programs.

7.2 Outcomes Expectations

In both Years One and Two, self-efficacy is a significant predictor of outcomes expectations, specifically, of students' expectations that an engineering degree will lead to a desirable job and lifestyle. However, outcome expectations were not significantly related to engineering career intentions and were negatively related to graduate school intentions (i.e., the odds-ratio less than one) – findings which appear counterintuitive in light of the theoretical framework guiding this study (i.e., SCCT) and previous meta-analyses that link outcomes expectations to dependent variables measuring career choice (see Lent & Brown, 2019). In this study, we found that the inclusion of psychological cost resulted in similar counterintuitive relationships between outcome expectations and our dependent variables of engineering career and graduate school intentions arose.

The negative relationship between outcome expectations, which we measured using items related to expectations about using skills for engineering jobs, and graduate school intentions might suggest that as students' beliefs that their engineering degree will lead to a desirable job and lifestyle increase, their desire to enter careers, rather than continue in school, increases. This might also explain the small positive, though not statistically significant, relationship between outcome expectations and career intentions. Future research might examine the changing relationship between students' expectations of the outcomes associated with degree attainment and their career and graduate school intentions, particularly considering the cost students appear to associate with earning a degree in engineering.

This finding, however, may provide greater insight into post-graduate choices in engineering, suggesting that students' career calculus changes in light of the costs they associate with pursuing and attaining their undergraduate degrees in engineering. That is, whereas positive outcome expectations are thought to foster students' intentions to pursue careers or graduate school in engineering, our findings suggest, holding psychological cost constant, self-efficacy and outcome expectations continue to shape students' career and graduate school intentions. Psychological cost's role as a mediator in students' career intentions is thus an area for future research.

7.3 Psychological Cost

Our findings regarding the role of psychological cost in shaping students' career decisions over time are a key contribution of our study. While limited, existing research indicates psychological cost is a significant factor in persistence for STEM and engineering students' persistence. In the single study conducted with engineering students, Robinson and colleagues (2018) found that perceptions of cost in engineering increased over time, but those students whose perceptions of cost increased more slowly were more likely to persist in engineering majors. While not a significant predictor of the outcomes of interest, our findings suggest psychological cost is significantly related to other important sociocognitive variables, such as self-efficacy beliefs and outcome expectations, which are in turn predictors of career and graduate school intentions. These findings suggest that promoting interest and retention in engineering majors alone may be insufficient for ensuring students will continue in engineering after deciding to pursue and graduate with degrees in engineering.

Unsurprisingly, psychological cost was negatively related to the other sociocognitive variables in the models (i.e., engineering self-efficacy and outcome expectations) at both Year One and Year Two. These findings indicate that as students' confidence in their ability to succeed in undergraduate engineering increased, their beliefs that the effort required to attain an engineering degree would not be worth it in the end decreased. Similarly, as students' perceptions of the cost of pursuing an engineering degree increased, their beliefs that engineering careers would provide positive post-graduation benefits (e.g., a job or lifestyle they liked) decreased. It follows that cost was negatively related to graduate school intentions—as students believed the cost of degree attainment increased, their intentions to pursue further engineering education decreased. However, while cost was positively related to career intentions after Years One and Two, the relationship was not statistically significant.

Our study findings, while framed as a collection of individual values, beliefs, and dispositions, must be understood as the result of individual experiences in a particular social, cultural, and historical context. For example, rather than judging students who agreed with statements in the psychological cost scale that the effort needed to complete an engineering degree might not be worth it, educators should ask how and why self-efficacy beliefs and outcome expectations appear to be significantly related to psychological cost in this sample of high-achieving students in a highly selective university. Rather than focusing on the student as the cause, educators and researchers must continue to examine the educational conditions that make such findings possible.

For example, while Godfrey (2014) noted that some engineering students find a sense of pride and achievement resulting from their ability to persist through challenging coursework in engineering, Chen (2013) noted that introductory "gatekeeper" courses might be barriers to student persistence. That is, while some students value the challenge of demanding engineering courses, others consider leaving the discipline precisely because the coursework is perceived to be unnecessarily onerous (see also Seymour & Hewitt, 1997; Strenta et al., 1994). In this study, students who expressed enough interest in engineering to pursue the degree perceived the effort cost of degree attainment after their first years in college to be high and were less likely report intentions of pursuing engineering careers. Our findings suggest perceived cost is related to students' self-efficacy beliefs and outcome expectations, as well as their post-graduation intentions.

We also note that the challenging nature of early engineering work alone may not fully explain the role that cost appears to play in students' self-efficacy and outcome expectations. Considerable research points to practices that appear to support students' post-graduation plans. For example, Ro and colleagues (2017) point to undergraduate research experiences and engineering clubs as significant predictors of graduate school attendance both in- and outside of engineering. Yet research also suggests that inequitable access to, and participation in, such practices might shape the degree to which they effect positive academic outcomes for students in higher education (Greenman et al., 2022; Stewart & Nicolazzo, 2018) and in engineering fields (e.g., Simmons et al. 2018). Here, again, we suggest engineering educators turn their attention to institutional practices, rather than individual student outcomes, to understand the role of the structure and delivery of engineering education in students' outcomes.

In this study, we examined only one type of psychological cost related to the effort required to attain a degree in engineering and its relation to long-term, post-graduation outcomes. Prior research (e.g., Robinson et al., 2019, Perez et al., 2014) has examined additional forms of cost in retention in engineering and STEM. Our measure is most similar to the measures of effort cost that Robinson and colleagues (2019) and Perez and colleagues (2014) found to be most strongly related to major persistence. To extend this body of research, studies of career decision making should explore the role of effort and other kinds of psychological costs in shaping students' decisions to pursue graduate study and/or careers in engineering.

A particularly concerning result of our study is the finding that minoritized and first-generation students were less likely to see graduate school and careers in their futures, even after Year Two, when students have persisted past the challenges of first-year courses they might perceive as gatekeeper courses. Lent and colleagues (2018) pointed to the role of contextual supports and barriers, such as family support and economic need, as potential factors moderating the role of sociocognitive variables (e.g., outcome expectations and self-efficacy) in students' goals and outcomes. However, unlike Lent et al. (2018), in this study, we conceptualize psychological cost as a potential barrier and find that cost is a significant predictor of students' intentions after earning their degrees. If, as Lent and Brown (2019) suggest, some barriers weigh differently on particular groups (men vs. women, minoritized students vs. racial/ethnic majority students, first-generation vs. continuing generation students), future research should specifically examine how the role of cost might vary for minoritized and first-generation students in their academic and career decision-making.

Perez and colleagues (2019) observe that minoritized students are more likely to encounter challenges in STEM fields due to structural inequalities such as less robust STEM preparation programs at the secondary level in as well as implicit or explicit racism or sexism (see, for example, McGee & Bentley, 2017), which can diminish students' motivation to pursue STEM.

Similarly, our findings found significant differences in sociocognitive variables by minoritized student status, as well as significant differences by students' perceptions of their high school preparation for engineering and physics after Year One. Future research should examine the interaction between minoritized student status and sociocognitive variables in engineering—particularly psychological cost. These findings, in conjunction with extant literature that indicates changes in perceived cost over the course of the undergraduate engineering experience shape retention intentions, suggest the need for future research to examine how racialized experiences may shape the role of psychological cost in students' decisions. While existing literature has examined students' experiences with racialized and gendered hostility in STEM broadly, and engineering more specifically (e.g., Byars-Winston & Rogers, 2019; Dewsbury et al., 2019; Lent et al., 2016; Tonso, 2006), there is less research examining how racialized experiences might contribute to differences in the evolution of expectancies, values, and costs across racial/ethnic groups, or comparing first-generation college students to their continuing generation college students.

Additionally, our sample included students who persisted past the challenges of first-year engineering to their second year, but still reported lower likelihood that they would actually pursue careers in engineering after earning their degrees. These findings suggest interest, effort, and commitment are not necessarily the leading reasons students leave engineering following their first year. Instead, other factors, such as their views about the cost of the effort needed to earn the degree separate those students who decide to stay from those who eventually leave. For researchers and educators aiming to promote retention in college and beyond, these findings suggest it is important that understanding students' values and perceived costs guide intervention efforts.

We do not argue that engineering educators must or should pursue retaining those students who have decided to leave. Instead, educators and student affairs practitioners should offer resources that help students effectively transition out of engineering into post-graduation academic and professional opportunities consistent with their goals. That minoritized students and first-generation students are less likely to see graduate school and careers in their futures means that efforts to support students' post-graduation transitions out of engineering are consistent with diversity, equity, and inclusion initiatives designed to support minoritized students in college.

8 Conclusions

In this work, we drew upon both person and environmental elements from two models of SCCT to examine the sociocognitive factors that shape students' career thinking after Years One and Two in undergraduate engineering. Our findings suggest the factors shaping students' decisions after Year One differ from those that shape students' thinking after Year Two. For example, while we found no relationship between sociocognitive variables and post-graduation plans after Year One, both self-efficacy and outcome expectations were significant predictors of career plans and graduate school intentions after Year Two. This suggests a need for future research to examine the various factors that students draw on at various times to make their career decisions, rather than study career decisions at a single point in student's undergraduate career.

Importantly, this work expanded on SCCT by including a measure of psychological cost in models predicting students' post-graduate intentions in engineering. We found that psychological cost was significantly related to both self-efficacy and outcome expectations during both Year One and Year Two in undergraduate engineering, which themselves appeared to shape students' post-graduation plans during the early years of undergraduate engineering. Still, our work suggests that co-curricular programs, such as the program examined in this study, might play a pivotal role in shaping students' post-graduation intentions. However, how these programs shape students' intentions and whether these benefits are shared among participants from diverse backgrounds are areas for future research.

This is particularly important given our findings that minoritized students and first-generation students are less likely to plan for graduate school or careers are consistent with the idea that different students experience the academic challenges of the discipline differently. Future work might examine ways to support students so that the academic challenges of engineering are viewed not as gatekeepers meant to "weed students out," but as academically useful experiences, supplemented by timely and useful support, meant to prepare students for post-graduation work in engineering.

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