Early-career Plans in Engineering: Insights from the Theory of Planned Behavior

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Introduction

Calls to address labor market demands in engineering industry often cite the need to increase engineering degree attainment at postsecondary institutions. However, prior research on engineering students' career decision making indicates that degree attainment in engineering does not guarantee students' plans to pursue engineering careers after graduation [1]. While there are numerous studies of engineering career decision making processes, most researchers study career decisions as students exit college or enter the workforce. In this paper, we suggest engineering students' career plans are a set of evolving attitudes, beliefs, and dispositions over the course of engineering students' college careers. Rather than study engineering students' career plans near, or following, graduation, we examine how students' career plans are shaped by their early college experiences through the lens of Ajzen's theory of planned behavior.

Literature Review

As a result of labor market concerns, students' decisions to pursue engineering in college, as well as their decision to pursue careers in engineering after graduation, have received increased scholarly attention. A particular concern often cited in engineering education scholarship is the consistent finding that many students who pursue and earn college degrees in engineering enter the workforce in fields outside of science, technology, engineering, and mathematics (STEM) altogether [1],[2]. Given that students who earn degrees in engineering often pursue careers outside of engineering, studies of engineering career decision-making processes often focus heavily on engineering students' college-exit strategies and early career decisions. For example, Lichtenstein et al. studied institutional influences, such as curricular design, on engineering students' career decision making by surveying college seniors at two institutions [1]. Similarly, Margolis and Kotys-Schwartz studied graduating college seniors to understand post-graduation attrition in engineering. They found that students who felt more prepared to pursue engineering careers were more likely to pursue such careers after graduation without reservations [2].

Extant literature on attrition in engineering offers various explanations about the alarming number of students who decide to leave engineering after earning a college degree. Scholars have suggested a number of sociocognitive and contextual variables might inform students career decision-making processes. For example, Cech, Rubineau, Silbey, and Seron studied fourth-year engineering students' intentional persistence, operationalized as their reported likelihood of working in engineering in five years [3]. They found that professional role confidence, i.e., individuals' confidence that they could competently fill the role of a professional, was a significant predictor of intentional persistence. Ro studied engineering students' career decision making and found that curricular and co-curricular influences were related to engineering students' post-graduation career plans [4]. Notably, Ro argued that curricular and co-curricular experiences that positively inform students' attitudes and dispositions toward engineering and engineering careers may positively shape students' plans to remain on pathways to the engineering profession [4].

The empirical relationships identified between students' perceptions of their abilities and educational experiences and their plans suggests that students' plans may change in response to their sense of readiness for, and enjoyment of, engineering. Existing research suggests that pathways into the engineering profession are informed by a host of sociocognitive and contextual variables. Still, most empirical evidence on how these variables inform students' career plans are studied as students leave college or enter the workforce. In this study, we examine whether students' degree of certainty about pursuing engineering as a career fluctuates during the first year of college. Guided by Ajzen's theory of planned behavior, we explore a set of variables related to students' academic and social experiences in undergraduate engineering, as well as a set of cognitive and affective variables theoretically linked to career decision making in order to understand how these variables inform engineering students' career thinking [5].

Theoretical Framework: The Theory of Planned Behavior

According to Ajzen's theory of planned behavior, behavioral intentions, such as plans to major in or work in engineering, are informed by three factors: (a) attitude toward the behavior, (b) subjective norms, and (c) perceived behavioral control [5]. Ajzen defined *attitude toward the behavior* as the general disposition toward performing a particular behavior; thus behavioral intentions serve as proxies for motivations. In general, the magnitude of a behavioral intention is theorized to correspond to the likelihood of behavioral performance.

Ajzen recognized that general dispositions toward behaviors alone are poor predictors of behaviors. Thus, he added the concepts of subjective norms and perceived behavioral control to aid in explaining additional variation in behavioral performance [5].

Ajzen defined *perceived behavioral control* as "people's perception of the ease or difficulty of performing the behavior of interest" (p. 183), arguing that Bandura's theory of perceived self-efficacy is most compatible with perceived behavioral control in the theory of planned behavior. Perceived behavioral control is particularly important in the theory of planned behavior because behavioral control is theorized to inform both behavioral intentions and the theorized relationship between intentions and performance. That is, behavioral intentions influence performance only insofar as individuals believe they have behavioral control [5].

Finally, Ajzen defined *subjective norms* as individuals' perceptions regarding the degree to which important referent groups approve, or disapprove, of particular behaviors [5]. Moreover, Ajzen posited that personal norms, i.e., feelings of obligation or responsibility to perform, also play a role in shaping behavioral intentions and, by extension, behavioral performance [5].

The theory of planned behavior is heavily used in empirical studies of career decision-making processes [6],[7]. While most studies utilize behavioral data, we focus on the strength of career intentions, which, according to the theory of planned behavior, should correspond to the likelihood of the behavior. Our research is guided by a single question:

> How are sociocognitive beliefs (e.g., attitudes, dispositions, self-efficacy) related to engineering students' certainty of pursuing a career in engineering during their first year in college?

Methodology

Data and Sample

Data for this study were collected as a part of a larger evaluation study of the Michigan Science, Technology, Engineering, and Mathematics Academies Program (M-STEM) at the University of Michigan. The M-STEM program is a science, technology, engineering, and mathematics (STEM) intervention program designed to provide academic, social, and professional support to a diverse group of undergraduate STEM students. For this study, we focused only on engineering students, collecting data on both program participants and a comparison group of engineering students who were invited to apply for the program but chose not to, or were not selected to, participate. Our analysis included both M-STEM participants and students in the comparison group.

Undergraduates included in this study consisted of engineers in four different cohorts (i.e., 2013 – 2016 cohorts). Cohorts were surveyed at the start of their first-year, as well as at the end of each academic year of their collegiate career. In full, 702 engineers were surveyed at various times over the four years of the study. In the present study, we analyze only those students who submitted survey responses after their first year, rendering a sample size of 323 undergraduate engineering students.

Table 1 presents descriptive statistics for the study sample. Given that the program is designed to support underrepresented groups in STEM, students of color and women are overrepresented in the study sample when compared to National Science Foundation published statistics of engineering demographics across the country.

Table 1
Descriptive Statistics for Sample and National Comparison

	NCES National Statistics (%)	M-STEM Study Sample (N = 323) (%)
Gender		
Male	(81.70)	171 (52.94)
Female	(18.30)	150 (46.44)
Other	-	2 (0.62)
Race		
Africa American/Black	(4.45)	47 (14.55)
American Indian/Native American	(0.53)	1 (.31)
Asian American/Pacific Islander	(12.40)	29 (8.98)
European American/White (non-Hispanic)	(69.45)	131 (40.56)
Hispanic American/Latino/a	(6.94)	43 (13.31)
Other	(7.46)	72 (22.29)

Notes: *Categories of race/ethnicity in this study did not necessarily match the categories provided by the National Center for Education Statistics
Bachelor's degrees conferred by degree-granting institutions, by sex, race/ethnicity, and field of study: 2009-10 https://nces.ed.gov/programs/digest/d11/tables/dt11_301.asp

Measures

In the theory of planned behavior, intentions are "assumed to capture the motivational factors that influence behavior" and the strength of intentions is assumed to correspond with the likelihood of behavior. Thus, the outcome under investigation in this study was engineering students' degree of certainty about their post-graduation career plans at the end of their first year, which served as a proxy for the strength of their intentions. Students were asked how likely they were to change their career plans during college on a scale from 1 (i.e., very likely) to 5 (i.e., very unlikely).

Explanatory variables in the present study operationalize constructs in the theory of planned behavior: (a) attitudes toward the behavior, (b) subjective norms, and (c) perceived behavioral control. Attitudes toward the behavior were operationalized using a scale measuring the Psychological Cost of earning an engineering degree. Measured on a five-point Likert scale (where 1 = Strongly Disagree and 5 = Strongly Agree), the scale asked students to respond to items such as, "Considering what I want to do with my life, having a science or engineering major is just not worth the effort." Cronbach's alpha for this scale was .80, indicating relatively high internal consistency.

The construct of subjective norms is related to the opinions of important referent groups. Our measure of subjective norms is a single item assessing students' perceptions of social pressure to succeed in engineering. Students were asked to respond on a 5-point Likert scale (1=Strongly Disagree and 5=to Strongly Agree)to the survey item that read, "I would be embarrassed if I found out that my work in my science or engineering major was inferior to that of my peers."

Finally, since Ajzen argued that perceived behavioral control is highly compatible with Bandura's concept of perceived self-efficacy, we measured perceived behavioral control using a subscale of our engineering self-efficacy measure. Items in the subscale of Engineering Major Confidence were measured on a five-point Likert scale (i.e., Strongly Disagree to Strongly Agree). Example items included, "I can succeed in an engineering major" and "Someone like me can succeed in an engineering career." Cronbach's alpha for the Engineering Major Confidence subscale was .92, indicating high internal consistency for the subscale.

Table 2 presents descriptive statistics for the outcome of interest, as well as descriptive statistics for each explanatory variable.

Table 2
Descriptive Statistics and Central Tendency for Item Responses (N = 323)

	N (%)	Mean	Std. Dev.	Min	Max
Outcome		-	-	-	-
Very likely	16 (4.9%)				
Somewhat likely	51 (15.8%)	-	-	-	-
Likely	47 (14.6%)	-	-	-	-
Not likely	147 (45.5%)	-	-	-	-
Very unlikely	62 (19.2%)	-	-	-	-
Covariates					
Psychological Cost	323	2.084	.785	1	5
Subjective Norms	323	3.198	1.062	1	5
Self-Efficacy	323	3.988	.637	1	5

Note: The outcome of interest is students' response to the likelihood that they will change their career plans in college.

Analytical Procedure

Since the outcome under investigation was categorical and ordered, a multinomial logistic regression model (MNLM) was estimated in order to understand the relationships between the three explanatory variables and the students' likelihood of changing their career plans. Coefficients in MNLMs represent the change in the log-odds of one outcome occurring relative to a baseline category in the outcome. In this study, students who were "very unlikely" to change their career plans were the baseline outcome. These students were chosen as the base outcome because, according to the theory of planned behavior, they are the most likely to pursue careers in engineering after graduation since the strength of their intentions were greatest.

In MNLMs, the model for the *i*th category (e.g., reporting that one is "somewhat likely" to change career plans), given the baseline category, *j*, is given by Equation 1 below:

$$\ln\left(\frac{P_i}{P_j}\right) = \beta_{i0} + \beta_{i1}x_1 + \beta_{i2}x_2 + \cdots + \beta_i x_i \quad (1)$$

Coefficients in MNLMs may also be interpreted in terms of relative risk ratios. Relative risk ratios represent the change in the odds of a particular outcome (e.g., belief that one is very likely to change career plancs) relative to a baseline outcome. Relative risk ratios are described in terms of Equation 2 below:

$$\frac{P_i}{Pj} = e^{\beta_{i0} + \beta_{i1}x_1 + \cdots + \beta_{ip}x_p} \quad (2)$$

Findings

Descriptive statistics indicated that at the end of their first year, approximately 35% of engineering students were very likely (4.9%), likely (15.8%), or somewhat likely (14.6%) to change their career plans. Conversely, approximately 65% of first-year engineering students in our sample report that they were unlikely (45.5%) or very unlikely (19.2%) to change their career plans.

Table 3 presents results of the estimated MNLM. Since raw coefficients are interpreted in terms of the change in the log-odds of an outcome and the interpretation of log-odds are not straightforward, the results are interpreted in terms of relative risk ratios, whose interpretations are more straightforward. For example, results indicated that increases in Engineering Major Confidence, a self-efficacy measure used to assess perceived behavioral control, were associated with statistically significant decreases in the odds that a student was very likely, somewhat likely, and likely to change their career plans relative to being extremely unlikely to change their career plans. Specifically, holding all other explanatory variables constant, a unit increase in Engineering Major Confidence was related to a 64.9% decrease in the odds that a student would be "very likely" to change their career plans relative to being "very unlikely" to change their career plans, a 49.5% decrease in the odds that students would be "somewhat likely" to change their career plans relative to being "very unlikely" to change their career plans, and a 54% decrease in the odds that that a student would be "likely" to change their career plans related to very unlikely to change their career plans. In addition, our measure of students' attitudes toward the engineering career, Psychological Costs, emerged as a statistically significant explanatory variable in models predicting likelihood of changing career plans. A unit increase in Psychological Cost was associated with a 57.6% decrease in the odds that students would be "very likely" to change their career plans relative to being "very unlikely" to change their career plans.

Table 3
Model 1 Predicting Likelihood of Changing Career Plans

	Raw Coefficient (Std. Err.)	Relative Risk Ratio (Std. Err.)	*z*	*p*
Very Likely				
Psychological Cost	-.858 (.358)	.424 (.152)	-2.4	.017*
Subjective Norms	-.112 (.314)	.894 (.281)	-.36	.721
Self-Efficacy	-1.046 (.417)	.351 (.147)	-2.51	.012*
Somewhat Likely				
Psychological Cost	-.131 (.271)	.877 (.238)	-.48	.629
Subjective Norms	.124 (.183)	1.133 (.207)	.68	.496
Self-Efficacy	-.683 (.340)	.505 (.172)	-2.01	.044*
Likely				
Psychological Cost	-.227 (.234)	.797 (.218)	-.83	.408
Subjective Norms	.098 (.190)	1.103 (.209)	.51	.607
Self-Efficacy	-.776 (.343)	.460 (.158)	-2.26	.024*
Not Likely				
Psychological Cost	-.062 (.217)	.940 (.204)	-.28	.776
Subjective Norms	.075 (.145)	1.078 (.156)	.52	.604
Self-Efficacy	-.504 (.280)	.604 (.169)	-1.80	.072
Total Observations	323			
Null Log Likelihood	-450.864			
Final Log Likelihood	-439.697			
Pseudo R	.0248			

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

Discussion

Results indicate that for the students in this sample, their sense of self-efficacy regarding their engineering major is related to the likelihood of changing their career plans; that is, students who reported greater self efficacy reported stronger intentions to pursue careers in engineering after graduation. This finding is consistent with self-efficacy research indicating a link between greater self-efficacy for task performance and task persistence even in the face of obstacles [8].

Still, our results indicate students' attitudes toward pursuing engineering professionally, which we measure using the Psychological Cost scale, as well as students' perceptions of subjective norms, were not significantly related to their early career plans in college. These findings are not inconsistent with the theory of planned behaviors. For example, Ajzen notes that general attitudes often fail to predict specific behaviors. Moreover, the relative importance of attitudinal beliefs, subjective norms, and perceived behavioral control is said to vary across contexts, behaviors, and situations [5]. Thus, we offer explanations of these findings specific to the context of engineering education.

The absence of a significant relationship between our measure of subjective norms and career plan certainty may be explained by our use of a single-item measure. However, Godfrey's work may also explain the general lack of significance of both this measure of subjective norms and the Psychological Costs scale in relation to career certainty [9]. The subjective norms measure indicates the extent to which students would be embarrassed if their work were inferior to that of their peers. Godfrey suggests that the culture of engineering values hardness and academic rigor, and the ability to overcome academic challenges may contribute to students' sense of pride following their achievements in engineering [9]. In such a culture, we suggest, social comparison to peers may be inconsequential. That is, because the difficulty of the work is well known, encountering academic challenges – including the production of work inferior to ones peers – when working toward the end goal is likely a common experience. As such, engineering students may see academic challenges as a normal part of the engineering experience. Moreover, experiencing and subsequently overcoming these challenges may be a source of pride, rather than embarrassment, for engineering students.

Literature on engineering culture might similarly explain the lack of significance of the Psychological Costs scale, which assesses students' beliefs about whether an engineering major is "worth it" in terms of effort and hard work. As Godfrey explains, "One of the most basic assumptions [of students in Godfrey's sample] was the belief that anything worthwhile was hard" (p. 442) [9]. Describing the disciplinary culture of engineering, Godfrey continues, "The strength and ability to 'take it' and succeed within this paradigm appeared to contribute to the pride and sense of achievement that students spoke of as an outcome of completing the degree. Similar beliefs…have been described as a 'meritocracy of difficulty'" (p. 442). Students belonging to a culture that values difficult work and one's ability to endure may be less deterred by the prospect of a career that requires effort and difficulty. In this way, attitudes about hard work may not be important factors affecting students' certainty about their career plans.

Limitations

This study analyzed data from a sample of engineering undergraduates in a large, selective, research university that is not representative of the national engineering undergraduate population. Thus, it is the theoretical relationships identified that contribute to our growing understanding of students' experiences in engineering programs and how this may affect their decisions to enter the engineering workforce.

Another limitation of this study is related to our use of a single-item scale, rather than a multi-item scale, to measure subjective norms [10]. Within most practical applications of construct measurement, multi-item scales have greater predictive validity than single-item scales. Despite this limitation, the single-item measurement of subjective norms used in this study represented students' beliefs about referent groups (i.e., their peers) in engineering. Still, it is possible that other important referent groups shape students' career intentions. Some scholars have noted the importance of familial pressures in students' academic and professional goals and intentions. Our measure also excludes the potentially important normative pressures exerted by other significant others in the college environment, such as engineering faculty or advisors. The influence of these reference groups potential area for future research on students' career intentions.

Conclusion

This study suggests that engineering students' engineering major self-efficacy, a measure of perceived behavioral control, is negatively associated with intentions to pursue a career outside engineering—particularly for students at the beginning of their college careers. Interestingly, subjective norms did not emerge as a significant predictor of students' intentions to pursue engineering. We suggest that this may have been due to the particular referent group (i.e., engineering peers) investigated in the present study. That is, we may not have been examining students' perceptions of subjective norms within the context of the most appropriate referent group. Research on the important role family and community play in Black and Latinx students' lives [11] provides reason to believe that these referent groups may be more influential than college peers to students in our sample--particularly given that racial and ethnic minority students are overrepresented in our study. Future studies might look beyond the scope of disciplinary culture to investigate the ways in which the norms of other communities to which students belong influence student intentions.

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Acknowledgements

This study was supported by a grant from the National Science Foundation (NSF DUE-1161121). The opinions expressed here do not reflect the opinions of NSF, and no official endorsement should be inferred.

The authors wish to acknowledge the contributions of the members of the research team who participated in various stages of the development of the design, instruments, and databases for this project: Deborah F. Carter, Jennifer Pollard, Christina Morton, Selyna Beverly, and Erika Mosyjowski.