Proactive Behaviors in Engineering: The Role of Pre-College Characteristics, Resources, and Experiences

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***Abstract*—The purpose of this Research Full Paper is to investigate the role of pre-college characteristics, resources, and experiences in shaping engineering students' experiences in college. Previous research has shown that students' pre-college characteristics (e.g., socioeconomic indicators, race/ethnicity, gender) inform their experiences in college, as well as their academic and social outcomes. For example, research suggests that students from low-socioeconomic status (SES) backgrounds participate in co-curricular activities at lower rates than their high-SES counterparts. In this study, we hypothesize that pre-college characteristics (e.g., race, gender, legacy status), resources (e.g., access to college counselors or private tutors), and experiences (e.g., participation in pre-college engineering programs) combine to inform how students are socialized into college broadly, and into engineering specifically. Using survey data collected from 998 undergraduate engineering students, we conducted a set of nested multiple regression models to investigate the relationships between students' pre-college characteristics and both their college experiences and outcomes. Results offer some support for our hypotheses that some pre-college characteristics, resources, and experiences, such as gender and college course taking in high school, are significant predictors of undergraduate engineering students' college experiences, such as students' general socializing experiences and feedback seeking behaviors. However counterintuitive findings suggest a need to further investigate how some characteristics, resources, and experiences inform students' experiences and outcomes in college.**

Keywords—socioeconomic status, pre college preparation, student background, co-curricular, student experience,

I. Introduction

It is widely recognized that pre-college characteristics, including race/ethnicity, gender, family income, and parental education level, influence students' experiences and outcomes in college. The relationships between these precollege characteristics and students' collegiate outcomes (e.g., grade point average, retention, graduation) are well studied in the empirical literature on student success in higher education. Germane to the present study is the consistent finding that students having low socioeconomic status (SES) engage in different activities while in college [1]. Specifically, extant literature suggests students from low-SES backgrounds are less involved in co-curricular activities [1].

This finding is particularly worrisome in engineering contexts where some co-curricular activities, such as engineering professional societies and design teams, are associated with positive academic, social, and even career outcomes. For example, research suggests participation in engineering professional societies is related to students' pursuits of engineering after graduation [2]. More broadly, Ro argued that active participation in engineering-related clubs influences career options, particularly for underrepresented minority students and women [3]. Indeed, as Astin notes, "for certain student outcomes, involvement is more strongly associated with change than either entering freshman characteristics or institutional characteristics" (p. 524), underscoring the need to understand socioeconomic gaps in patterns of student involvement in campus activities [4].

Whereas existing literature considers pre-college characteristics, resources, and experiences, as antecedents of collegiate outcomes, in this study, we sought to understand *how* these pre-college characteristics might inform student behaviors and experiences in college. Specifically, we hypothesize that pre-college characteristics, resources, and experiences combine to inform how students are socialized into college broadly, and engineering specifically, thus informing their patterns of co-curricular involvement and outcomes. For the research presented here, we investigate the relationships between students' pre-college characteristics, resources, and experiences and proactive behaviors (one particular socialization process). These behaviors are defined as actions that newcomers undertake to learn about the values, rules, expectations, and norms of an organization or institution.

II. Literature Review

A. Pre-College Characteristics, Resources, and Experiences

Education research is replete with findings that suggest students' pre-college characteristics, resources, and experiences inform their collegiate experiences, as well as their

academic and social outcomes in college. In research on science, technology, engineering, and mathematics (STEM) education specifically, gender and race/ethnicity have been consistently linked to student success and persistence in STEM majors. In a study of undergraduate students majoring in STEM fields, Bonous-Hammarth found that African American, American Indian, and Latina women experienced the highest rates of attrition from STEM majors; men from these underrepresented racial/ethnic backgrounds experienced the next highest rates of STEM attrition, followed by White and Asian American women [5]. In a study of STEM majors at a Hispanic-serving institution (HSI), Crisp, Nora, and Taggart reported that gender and ethnicity, as well as several measures of pre-college academic achievement, were significantly related to declaring a STEM major, changing to a STEM major from another major, and earning a STEM degree [6]. Specifically, students were more likely to declare, change to, and persist in a STEM major if they were male (compared to female) or if they were Asian (compared to White); in addition, Hispanic students at this HSI were significantly more likely to initially declare a STEM major compared to White students, but were not more likely to change to a STEM major or ultimately earn a STEM degree [6].

Research on first-generation college students and students from low-income backgrounds reveals that these factors may have mixed effects on experiences and outcomes in STEM. In a study comparing college students majoring in science and engineering, Potvin, Tai, and Sadler found that engineering students had significantly lower SES, which they operationalized using the highest level of parental education, than science students [7]. Crisp and colleagues found that first-generation status was not significantly related to the selection of, or persistence in, a STEM major at a Hispanic-serving institution [6]. Verdín and Godwin found significant differences in first-generation engineering students' identities, interests, and beliefs about their own capabilities compared with their non-first-generation peers, as well as differences in academic performance [8].

Recent research suggests a need to more fully explore the pre-college resources available to students from socioeconomically disadvantaged backgrounds in order to understand their differing experiences and outcomes in college. In a qualitative study of students from middle- and low-income backgrounds at an elite university, Jack found that while middle-class undergraduates report feeling comfortable interacting with authority figures such as faculty and staff, lower-income students were not uniform in their experiences, observing two distinct groups: the "privileged poor," who attended boarding schools and other college preparatory high schools, and the "doubly disadvantaged," who remained more closely tied to their home communities and attended local high schools [9].

B. Proactive Behavior

Ashford and Black identified seven types of proactive behaviors in which newcomers to an organization engage in order to gain feelings of personal control: information seeking, feedback seeking, general socializing, networking, relationship-building (with a boss), negotiation of job changes, and positive framing [10]. Proactivity has been widely applied and studied within workplace contexts; for example, Ashforth, Sluss, and Saks found a significant positive relationship between proactive behavior and newcomer learning in the workplace, which was, in turn, positively associated with job performance, job satisfaction, and organizational identification [11]. In addition, the authors found that proactivity was negatively associated with intentions to quit.

Although few in higher education research have adopted the model, proactivity offers a promising way to understand how undergraduate students seek to gain a sense of control over their surroundings as they adjust to their new context, and it may help to explain differences in collegiate outcomes. Sidelinger found that proactivity was a predictor of students' willingness to talk in class and engagement with self-regulated learning (e.g., reading assigned material for class) [12]. Geertshuis, Jung, and Cooper-Thomas corroborated this finding, demonstrating an association between proactivity and self-directed learning, and they also found a strong positive association between confidence to perform proactive behaviors and end-of-semester grades [13].

III. Conceptual Framework: Undergraduate Socialization

This work was guided by a modified version of Weidman's undergraduate socialization framework. Weidman argues that "individual background characteristics that tend to be correlated with specific types of outcomes must be included in any conceptualization of the undergraduate socialization process" (p. 303). In Weidman's framework, pre-college background characteristics, such as socioeconomic status, are said to inform students' collegiate experiences, including the normative contexts they perceive. These, in turn, inform socialization outcomes, such as students' major satisfaction and their post-graduation aspirations.

Still, while Weidman argues that the relationships between background characteristics (e.g., socioeconomic indicators), collegiate experiences, and socialization outcomes are well supported in the literature, the framework lacks an underlying process explaining these relationships. Therefore, we modified Weidman's undergraduate socialization to include two socialization processes--institutional tactics and proactive behaviors--that might explain the relationships. Our resulting conceptual model is presented in Figure 1. Germane to the present study is the role of *proactive behaviors* in college broadly, and engineering contexts specifically.

In this study, we examine the relationships between pre-college characteristics, resources, and experiences and students' proactive behaviors. Our study was guided by the following research question: *What is therelationship between students' pre-college characteristics, resources, and experiences and their proactive behaviors in college?*

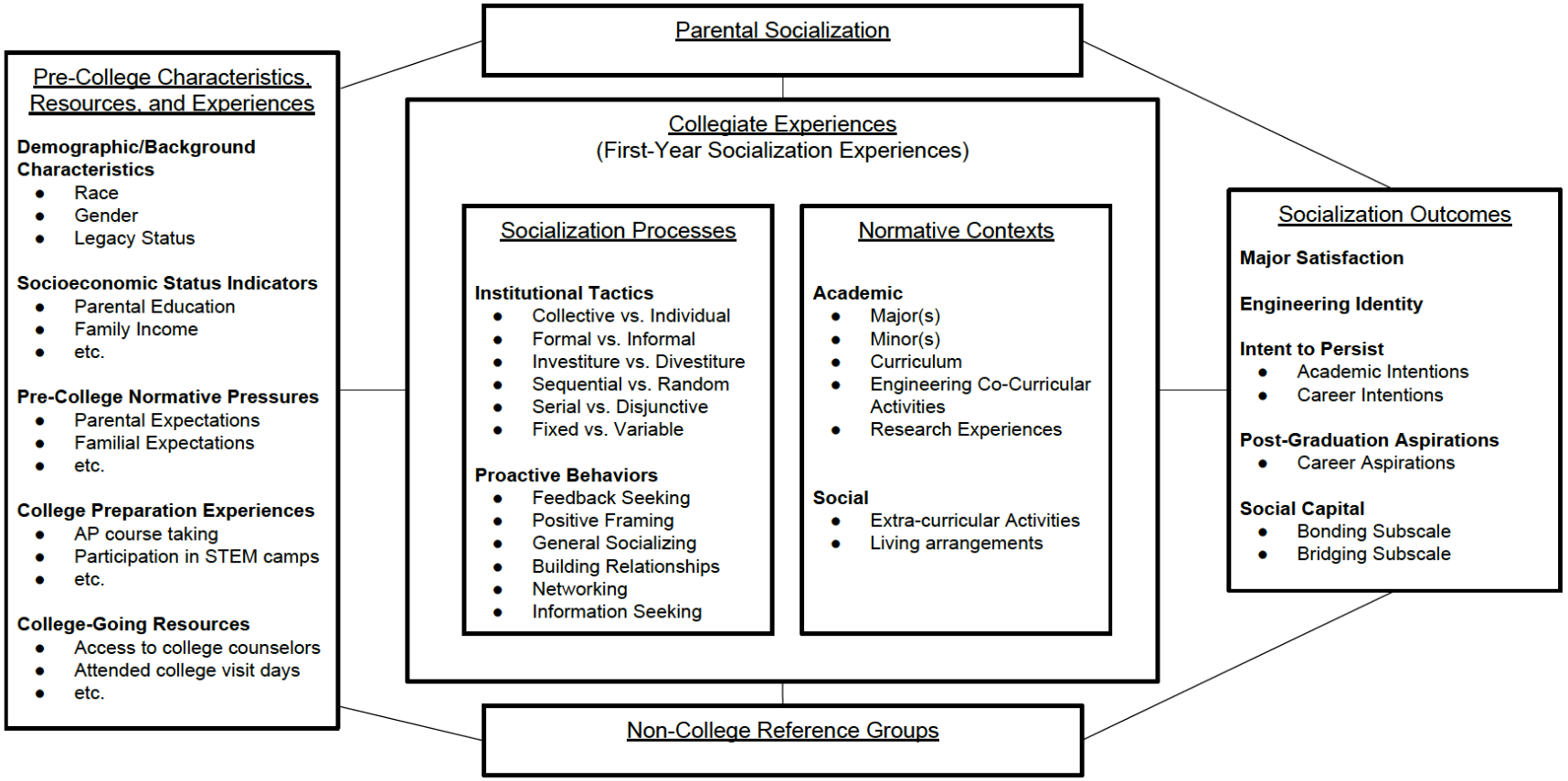

Fig. 1. Modified Conceptual Model for Undergraduate Student Socialization

IV. Methods

A. Sample

This study is part of a larger, NSF-funded project investigating engineering students' socialization experiences in college and their participation in engineering-related co-curricular activities, such as professional societies and design teams. For that project, we invited 4,022 undergraduate engineering students at a large, public, Midwestern university to complete our research instruments. A total of 998 students responded to the survey, yielding a response rate of 24.8%. Of the 998 students who submitted survey responses, 934 students (93.6%) completed the survey.

Undergraduate engineering students included in this study consisted of third- and fourth-year students. Table I presents descriptive statistics for the study sample. The sample was approximately representative along race/ethnicity, parental education level, family income, and legacy status. Women and domestic students were overrepresented in the study sample when compared to the population of engineering students at the university.

TABLE I. Descriptive Statistics for the Study Sample and Sampling Frame

	Study Sample N (%)	***Sampling Frame N (%)***
URM	94 (9.4)	374 (9.3)
Non-URM	904 (90.6)	3648 (90.7)
Men	597 (59.8)	2989 (74.3)
Women	401 (40.2)	1033 (25.7)
Parental Ed < Bachelor's	86 (8.6)	388 (9.7)
>= Bachelor's Degree	912 (91.3)	3634 (90.4)
Family Income <50K	96 (12.68)	395 (12.8)
Family Income 50-150K	343 (45.3)	1393 (45.3)
Family Income > 150K	318 (42.0)	1288 (41.9)
Legacy	322 (32.3)	1252 (31.1)
Non-Legacy	676 (67.8)	2770 (68.9)
Domestic Student	931 (93.3)	3618 (89.0)
International Student	67 (6.7)	404 (10.0)

B. Measures

1) Outcome Variables: Proactive Behaviors

In order to understand engineering students' proactive behaviors during their first year in college, we adapted the scales developed by Ashford and Black [10]. Although Ashford and Black measured proactive behaviors across seven dimensions, given this study's context (i.e., undergraduate engineering education), items related to job change negotiation were not adapted for the present study. We therefore use a total of six dimensions for the present study, each consisting of three or four individual survey items. Responses for each item were collected using a 7-point Likert-type scale, where 1 indicated "strongly disagree" and 7 indicated "strongly agree." Descriptive statistics for each subscale in the proactive behaviors subscale are presented in Table II.

TABLE II. Descriptive Statistics and Central Tendency for Item Responses

Dependent Variable	***Mean***	***Std. Dev.***
Feedback Seeking	4.373	1.106
Positive Framing	3.110	1.378
General Socializing	3.989	1.284
Networking	4.128	1.201
Information Seeking	3.158	1.292
Relationship Building	3.082	1.538
Notes: Items were translated such that the minimum value for each item was 0, and the maximum value for each item was 1.		

In order to establish construct validity for each subscale, we used structural equation modeling. We first examined the relation of observed variables (i.e., survey item responses) to latent constructs (e.g., feedback seeking, positive framing) using confirmatory factor analyses. We examined factor loadings and model fit indices to evaluate how well *a priori* models fit the data and establish construct validity. The test statistics indicated good model fit. Specifically, the comparative fit index (.961), the Tucker-Lewis Index (.952), the root-mean-square error of approximation (.041), and the standardized root mean square residual (.038) each met recommended criteria for good model fit [14,15]. Standardized factor loadings, standard errors, and the construct reliability for each factor are presented in Table III.

2) Explanatory Variables: Pre-College Characteristics, Resources, and Experiences

We obtained data representing students' pre-college characteristics, such as demographic and socioeconomic indicators (e.g., race/ethnicity, gender, international student status), from institutional databases. For analytic purposes, race/ethnicity variable were collapsed into a single dichotomous variable representing underrepresented minority status, with White and Asian students representing one category and Black, Latinx, and Native American/Native Alaskan students representing the second category.

Additionally, family income data was collapsed into three categories according to institutional definitions of low- and high-income status, with a gross family income of less than $50,000 as the cutoff for low-income status, and a gross family income of greater than $150,000 as the cutoff for high-income status. Similarly, parental education was dichotomized according to the highest degree awarded to students' parents. Students who had at least one parent earn at least an undergraduate degree from a 4-year college or university were included in one group, while all other students were included in the second group.

Our survey measured access to a variety of college-going resources by asking students to respond, yes or no, to a series of items related to their pre-college resources and experiences. We developed this list of college-going resources and experiences based on a review of the literature, as well as feedback provided by engineering educators and student affairs practitioners. For example, a focus group of engineering

educators agreed that students' participation in pre-college STEM clubs and camps appeared, at least anecdotally, to shape their academic and social experiences in college. We therefore included the item in our final survey. A complete list of college-going resources from our survey is included in Table IV.

C. Data Analysis

In order to understand the relationships between proactive behaviors and pre-college characteristics, resources, and experiences, we estimated a set of nested multiple regression models. In full, six regression models were estimated using the six proactive behaviors scales (e.g., feedback seeking, positive framing, general socializing) as dependent variables and pre-college characteristics, resources, and experiences as independent variables.

TABLE III. CONFIRMATORY FACTOR ANALYSES ESTIMATES FOR PROACTIVE BEHAVIOR

Latent Variable and Indicators	*Construct Reliability*	*Standardized Estimates*	*Standard Error*
Feedback Seeking	.8847		
I often sought feedback on my performance after assignments.		0.821	0.018
I solicited critiques from my professors/instructors.		0.801	0.022
I often sought out feedback on my performance during assignments.		0.823	0.021
I often asked for professors'/instructors. opinion of my work.		0.798	0.021
Positive Framing	.7788		
I tried to see being an engineering student as an opportunity rather than a threat.		0.812	0.024
I often tried to look on the bright side of things.		0.652	0.030
I tried to see my engineering major as a challenge rather than a problem.		0.763	0.028
General Socializing	.6699		
I attended social gatherings to meet new people.		0.837	0.024
I participated in social events on campus outside of the College of Engineering to meet people.		0.688	0.034
I attended parties with friends I met in engineering.		0.469	0.036
Relationship Building	.8818		
I tried to spend as much time as I could with more senior students.		0.809	0.016
I tried to form a good relationship with more senior students.		0.854	0.016
I worked hard to get to know more senior students.		0.873	0.018
Networking	.7807		
I started conversations with people from different academic majors than my own.		0.740	0.024
I tried to socialize with people (faculty, students, or staff) who are not in engineering.		0.781	0.025
I tried to get to know as many people as possible in non-engineering majors on a personal basis.		0.707	0.027
Information Seeking	.8126		
I tried to learn the important policies and procedures of the University of Michigan.		0.663	0.026
I tried to learn the official organizational structure of the College of Engineering.		0.824	0.020
I tried to learn the politics of the College of Engineering.		0.671	0.024
I tried to learn the unofficial structure of the College of Engineering.		0.728	0.025

TABLE IV. ITEM RESPONSES FOR COLLEGE-GOING RESOURCES

Item	*N (%)*
I took Advanced Placement (AP) courses.	831 (89.0)
I had a private tutor for high school classes.	62 (6.6)
I took SAT/ACT preparation courses (e.g., Kaplan, Princeton Review, etc.).	355 (38.0)
I had a private tutor for SAT/ACT preparation.	148 (15.8)
I took college courses for credit (high school and/or college credit).	328 (35.1)
I took college courses non-credit.	80 (8.6)
I spoke with high school counselor about college.	653 (69.9)
I used a college admissions or educational consultant.	136 (14.6)
I had a family member that graduated from the University.	282 (30.2)
I visited the University's campus.	711 (76.1)
I attended a university-sponsored recruitment visit.	324 (34.7)
I spoke with a representative of the University.	271 (29.0)
I had family ties to the University (e.g., a family member that worked at the University.)	90 (9.6)
I participated in a math, science, or engineering-focused club, organization, or camp.	521 (55.8)

V. RESULTS

Table V presents results of the estimated linear regression models. Results from the multiple regression analyses indicated that various relationships between students' proactive behaviors and pre-college characteristics, such as *socioeconomic indicators,* were statistically significant. Gender (p = .004) and international student status (p = .001) were statistically significant predictors of "feedback seeking" behavior, while international student status (p = .024) was a statistically significant predictor of "positive framing" behavior. Gender (p = .001) and high-income status (relative to low- and middle-income students) (p = .002) were significant predictors of general socializing behaviors. High-income status (p = .006) was also as a significant predictor of networking behaviors. Finally, parental education (p = .025) was a statistically significant predictor of "relationship building" behaviors.

Similarly, analyses indicated that a number of *college-going resources* shared statistically significant relationships

TABLE V. REGRESSION MODELS ESTIMATING PROACTIVE BEHAVIORS

	Feedback Seeking			***Positive Framing***			***General Socializing***			***Networking***			***Information Seeking***			***Relationship Building***		
	N	**R^2**	***p***	**N**	**R^2**	***p***	**N**	**R^2**	***p***	**N**	**R^2**	***p***	**N**	**R^2**	***p***	**N**	**R^2**	***p***
	697	0.08	***	696	0.06	***	698	0.09	***	698	0.08	***	699	0.03		698	0.05	**
	β	***SE***	***p***	**β**	***SE***	***p***	**β**	***SE***	***p***	**β**	***SE***	***p***	**β**	***SE***	***p***	**β**	***SE***	***p***
Pre-College Characteristics																		
URM	0.05	0.16		0.14	0.13		0	0.17		-0.02	0.15		0.06	0.16		-0.13	0.2	
Gender (male)	-0.3	0.11	**	-0.04	0.09		-0.33	0.1	***	-0.17	0.09		-0.03	0.1		0.21	0.12	
Legacy	0.05	0.15		-0.02	0.12		0.13	0.14		-0.1	0.12		-0.01	0.15		0.08	0.17	
International student	0.78	0.22	***	0.48	0.21	*	-0.02	0.27		0.29	0.24		0.14	0.24		0.22	0.29	
Parental education < Bachelor's degree	0.12	0.18		-0.2	0.16		-0.21	0.23		-0.15	0.2		-0.12	0.19		-0.48	0.21	*
Family income <$50K	-0.23	0.17		0.08	0.13		0.03	0.18		0.06	0.16		0.12	0.16		0.05	0.18	
Family income >$150K	0.09	0.11		-0.03	0.09		0.34	0.11	**	0.28	0.1	**	0.04	0.11		-0.1	0.14	
College-Going Resources																		
AP courses	-0.12	0.18		-0.03	0.17		-0.01	0.21		0.3	0.19		-0.21	0.18		-0.16	0.22	
Private tutor for HS courses	-0.32	0.22		-0.7	0.22	***	-0.04	0.2		0.09	0.17		0.07	0.21		-0.09	0.27	
SAT/ACT prep course	0.25	0.11	*	-0.02	0.09		0.03	0.1		0.01	0.1		0.1	0.11		-0.01	0.13	
SAT/ACT prep tutor	0.1	0.16		0.17	0.13		0.18	0.13		0.05	0.12		0.13	0.14		0.11	0.17	
College courses for credit	0.14	0.11		0.04	0.1		0.06	0.11		0.08	0.1		0.11	0.1		0.12	0.13	
College courses for no credit	0.47	0.16	**	0.19	0.14		-0.06	0.17		0.05	0.18		0.03	0.18		0.05	0.21	
Spoke with HS counselor about college	0	0.12		0.2	0.1	*	0.39	0.12	***	0.25	0.11	*	0.21	0.12		0.27	0.13	*
College admissions consultant	-0.04	0.16		-0.12	0.15		0.04	0.13		0.22	0.11		-0.04	0.15		0.11	0.17	
Relative who graduated from University	-0.03	0.16		-0.06	0.12		0	0.14		-0.09	0.13		-0.13	0.15		0.14	0.18	
Visited campus	-0.39	0.14	**	0.24	0.13	*	0.28	0.13	*	0.26	0.12	*	-0.09	0.14		-0.26	0.17	
Attended recruitment event	0.12	0.12		0.18	0.09		0.04	0.11		0.13	0.1		-0.11	0.11		0.29	0.14	*
Spoke with representative of University	0.3	0.13	*	0.02	0.1		-0.12	0.12		0	0.12		0.09	0.12		0.04	0.15	
Family ties to University	0.26	0.19		-0.01	0.13		-0.07	0.18		0.24	0.15		0.18	0.16		-0.06	0.2	
STEM camp	0.12	0.11		0.05	0.09		0.02	0.1		-0.01	0.1		0.1	0.1		0.22	0.12	

Note: * signifies $p < 0.05$, ** signifies $p < 0.01$, *** signifies $p < 0.001$

with engineering students' proactive behaviors. Self-reported participation in SAT preparation course (p =.023), taking college courses for no credit (p = .004), visiting the university campus before college (p = .006), and speaking with university representatives (p = .017) were all statistically significant predictors of "feedback seeking" behaviors in college. Speaking with a high school counselor about college (p = 0.038) and visiting the university campus (p = 0.034) were significant positive predictors of "positive framing", while having a private tutor for high school coursework (p =.001) was negatively related to "positive framing". Speaking with a high school counselor about college (p =.001) and visiting the university campus (p=0.026) were significant predictors of "general socializing behaviors". Speaking with a high school counselor (p=0.025) and visiting the university campus (p=0.031) were also significantly related to "networking behaviors". Finally, speaking with high school counselors about college (p =.045) and participating in university sponsored recruitment events (p =.034) were statistically significant predictors of "relationship building" behaviors.

Interestingly, no socioeconomic indicators or college-going resources emerged as significant predictors of information seeking behaviors. Moreover, the model F statistic indicated that the group of independent variables (i.e., socioeconomic indicators and college-going resources) does not reliably predict information seeking.

VI. Discussion

In this paper, we investigated the hypothesis that pre-college characteristics, resources, and experiences combine to inform how students are socialized into college broadly, and engineering specifically, thus informing their patterns of co-curricular involvement and outcomes. Through our exploratory analyses examining the relationships between pre-college characteristics and proactive behaviors in college, we hoped to better understand the types of background characteristics and college-going resources that are related to proactive behaviors in college.

We interpret our results in light of Ashford and Black's [10] descriptions of proactive behaviors during organizational entry (e.g., a job transition or first year in college). According to Ashford and Black, organizational entry may be associated with feelings of uncertainty and loss of control [10]. Proactive behaviors, then, are an individual's attempt to regain certainty and control in order to maximize performance and satisfaction. In this study, we consider students' transition to college as a form of organizational entry. Thus, students' proactive behaviors in college represent their attempt to regain control, understand the undergraduate context, and maximize academic and social performance and satisfaction.

We attempt to understand the background characteristics, resources, and experiences that result in particular proactive behaviors in college. The results from this study add nuance to the assumption that the relationships between proactive behaviors and pre-college characteristics, resources, and experiences is positive (e.g., higher family income results in higher scores on the proactive behaviors scale). Under this assumption, the finding that high-income status and networking are positively related is intuitive.

Conversely, the finding that male status was significantly, and negatively, related to general socializing behaviors is surprising, and explanations for this finding were wide-ranging. For example, it may be the case that men in a male dominated discipline (i.e., engineering) feel no need to actively socialize with other students. Conversely, women, who often report hostile, chilly climates in engineering, may feel the need to actively socialize within and outside of the College of Engineering in order to make friends, form study groups, or generate other useful social relationships.

The finding that male status is negatively related to general socializing behaviors underscores the need to better understand the relationships between individual student behaviors and the pre-college characteristics, resources, and experiences with which students enter college. Results from this study suggest these relationships are not straightforward or similarly applied across all students, and that understanding how pre-college characteristics, resources, and experiences inform student experiences may be critical to addressing socioeconomic disparities.

VII. Conclusion

This study represents our preliminary effort understand how pre-college characteristics, resources, and experiences are related to gaps in participation in co-curricular activities, such as engineering professional societies and design teams. Results suggest the need to better understand the underlying relationships between pre-college characteristics, resources, and experiences that may preclude students to particular behaviors and experiences in college. Future work in this study will seek to understand the relationships between other socialization processes and pre-college characteristics, resources, and experiences in order develop a more complete understanding of the experiences that inform students' behaviors and outcomes in undergraduate engineering.

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