WIP: Investigating the Impact of Engineering Identity, Belonging and Career Commitment on Early Postsecondary Outcomes

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Abstract

This work in progress paper describes initial findings from a multi-cohort, longitudinal study designed to investigate engineering identity development and the role it plays in postsecondary engineering students' commitment to the field and educational persistence. Although engineering identity is often considered an important contributing factor to educational and occupational persistence, there are few quantitative studies that directly examine this link. This study aims to address this gap and contribute to a better understanding of how we may foster engineering identity and help support students in their educational trajectories.

To capture engineering identity, we use survey questions developed and validated in previous research to measure three scientific identity concepts: interest, recognition by self and others, and perceptions of competence and performance in engineering. Drawing on additional concepts in the literature, we also include measures of sense of belonging and commitment to an engineering career.

In the spring semester 2019, a baseline survey for our first cohort was administered to 179 early career, engineering students across three public postsecondary Hispanic Serving Institutions (HSIs) in the Southwest United States. A little more than half of the respondents (N=93) were attending a traditional 4-year university while the remainder (N=86) were attending community college at the time of the survey. Almost 70% of the respondents identified as Latinx, approximately 30% identified as female, and about one-third reported that they were first-generation college students.

To examine whether students with higher engineering identity, sense of belonging and career commitment are more likely to persist into their second year and have higher college GPAs, institutional enrollment and achievement data were obtained for all survey participants in our first cohort. Logistic and ordinary least squares (OLS) regression were used to test for significant associations, controlling for demographic factors. Preliminary findings suggest that engineering students' sense of belonging to the field may be especially important.

Introduction and Background

This work in progress paper presents initial findings from a multi-cohort, longitudinal study investigating engineering identity development and the role it plays in postsecondary engineering students' commitment to the field and educational persistence. While our longitudinal research design will follow students over time to model changes in social psychological factors, the preliminary analysis presented in this paper is limited to exploring how cross-sectional measures of engineering identity, sense of belonging and career commitment captured early in an engineering student's academic career are related to each other and to early educational success including retention to the next semester and cumulative GPA.

Engineering identity, sense of belonging and commitment to career

Though identity has increasingly been theorized as a predictor of postsecondary STEM students' success and persistence, only recently have researchers begun to directly measure students' engineering identity [1]. Informed by Gee [2], Carlone and Johnson [3] developed a model of scientific identity as a way to better understand the experiences of successful women of color working in science-oriented careers. Researchers expanded upon Carlone and Johnson's insights into the importance of recognition to develop and validate more nuanced and complex measures of general scientific identity, physics identity [4], and mathematics identity [5], [6]. Based off of these diverse foundations, Godwin [7] combined the core concepts of STEM identity - competence, interest, recognition, performance - to create a validated measure of engineering identity.

Godwin's measure of engineering identity is increasingly used in models of engineering education to evaluate how identity contributes to success and persistence of engineering students, and how these processes vary depending on other types of student identity. Researchers are beginning to model, for example, the mechanisms through which engineering identity translates into success for engineering students who are first generation college students, female and/or from underrepresented minority (URM) groups [8].

Another important social psychological factor that has been linked to postsecondary STEM success is sense of belonging [9]. Belongingness is sometimes included as an aspect of identity. For example, Chemers and colleagues include questions on belonging as part of their science identity measure [10]. Although, in a recent article they suggest future research examine belongingness separately and in more depth [11]. Within the engineering education literature, however, sense of belonging and engineering identity are usually considered separate concepts [12]. A number of studies [11], [13] have suggested that students' "sense of fit" within academia has an impact on their success and persistence, and that those who somehow feel outside of the norms of academia have more barriers to success than their counterparts. Measurement of a sense of belonging is a helpful tool in understanding more about what early career engineering students are feeling *right now*; a sense of belonging should stave off the purported "chilly climate" that alienates students from underrepresented groups - be they women, URM students, or first generation college students - new to the field of engineering, who are particularly vulnerable to dropping out of engineering careers.

Career commitment reflects students' intention to work in the field of engineering. Measures of students' self-reported commitment to career have primarily been used by others as outcome variables [10], [11]. In our analysis, we model the possibility that commitment to an engineering career may serve as a motivator to obtain the knowledge and credential often necessary for students to obtain their occupational goals. Because these are early career students, we expect them to have relatively low commitment to the field of engineering in this baseline data, but modeling their expressions of commitment throughout their undergraduate education may help us better understand their confidence that they will be "able to fulfill the expected roles, competencies, and identity features of a successful member of their profession" [14].

The difficulties of obtaining high-quality, detailed longitudinal data on engineering identity, career commitment, and sense of belonging are obvious. Our cross-sectional examination of the relationship between these three variables is a crucial first step in testing the assumption that these factors matter for persistence, and mapping exactly *if* and *how* the process works over time. Understanding the mechanisms by which student identity contributes to STEM persistence broadly, and engineering persistence specifically, will help determine how we can reduce the number of students leaving engineering and/or dropping out of postsecondary education altogether.

Methods

This analysis is part of a larger mixed-methods, longitudinal project examining how college experiences more generally and STEM support experiences in particular impact social psychological factors over time and subsequently influence educational and occupational outcomes. In this paper we focus on modeling the association between our cross-sectional baseline survey measures take in Spring 2019 and achievement data collected one semester later in Fall 2019.

New Mexico STEM Experience Survey

The New Mexico STEM Experience Survey was distributed to more than 4100 early career undergraduate STEM majors during the Spring 2019 semester. Surveyed students attended one of four colleges and universities in New Mexico – two four-year universities and two community colleges. Respondents were recruited both in classrooms and through emails. The response rate for those recruited in classrooms was approximately 95% while the response rate for those students contacted by email was much lower at 10%. While more than 550 valid surveys were completed, this analysis only includes the 179 engineering majors. In fall of 2019, with consent provided by our survey respondents, we requested demographic and high school achievement information, college major, cumulative GPA and enrollment status from students' respective institution. Unfortunately, we have not yet been able to obtain fall institutional data from one of the 4-year universities. Consequently, this analysis will only include data from three of the four institutions being studied in the larger project.

Measures

The two main outcome variables in the analyses presented here are (a) students' reenrollment in the subsequent semester, *persistence* and (b) cumulative Grade Point Average, *GPA*. Both of these measures are obtained from the institutional analysis office or enrollment management office at each of the three participating institutions.

The survey operationalizes the concepts of engineering identity, sense of belonging and commitment to field by asking students how much they agree with a series of statements (developed and validated in previous research), which we then used to develop indices. All variables are calculated by taking the mean across the item responses.

Based on previous work [3], [7], our *engineering identity* measure is composed of three scientific concepts - interest, recognition by self and others, and perceptions of competence and performance in engineering - and is measured by taking the mean score across student responses to the following eleven statements on a seven-point scale (strongly disagree to strongly agree):

My parents see me as an engineer
My instructors see me as an engineer
My peers see me as an engineer
I am interested in learning about engineering
I enjoy learning engineering
I am confident that I can understand engineering in class
I am confident that I can understand engineering outside of class
I can do well on exams in engineering
I understand concepts I have studied in engineering
Others ask me for help in this subject
I have come to think of myself as an engineer

Sense of belonging is measured by having students indicate agreement on a five-point scale (strongly disagree to strongly agree) to the following two questions. These questions are adapted from Chemers et al. [10] identity as a scientist scale, substituting "science" with "field of study."

I have a strong sense of belonging to the community in my field of study
I feel like I belong in my field of study

Our *career commitment* measure is based on a measure of students' commitment to work in the field of science developed by Chemers et al. [10], but was adapted here to measure commitment to the field of engineering. Students were asked to state how much they agreed or disagreed with the following seven statements on a five-point scale (strongly disagree to strongly agree).

I intend to work a job related to my major
I intend to take the next steps in my field
I will work hard as necessary to achieve a career in my field
I expect a career in the field will be very satisfying
I feel that I am on a definite career path in this field
My major is the ideal field of study for my life
I definitely want a career for myself in my field of study

Students were offered an incentive in the form of a chance to win a gift card upon completion of the survey. All who made an attempt to complete the survey were entered to win a gift card regardless of whether or not they eventually entered the study. Those under the age of 18, those who did not consent to participate and allow for the collection of institutional data, and those who did not provide complete responses on key measures were removed prior to analysis.

Analytic Plan and Design

The explanatory analysis includes two measures of academic achievement: cumulative GPA and re-enrollment in fall of 2019. We conduct a series of three regression models for each of the two dependent variables. For GPA we run an ordinal linear regression and for the dichotomous attrition variable we run a logistic regression. Model 1 is a baseline model controlling for race/ethnicity, gender and whether or not the individual is a first-generation college student. Model 2 adds the measure of commitment to an engineering career, *career commitment*, to the control variables and finally, Model 3 adds the three social psychological measure *belonging*, *scientific self-efficacy* and *engineering identity*.

We compare the statistical results of similar models before (Model 2) and after (Model 3) the inclusion of the career commitment variable in order to examine the possibility that career commitment may mediate the relationship between engineering identity and sense of belonging and our academic outcomes. A variable is mediating a relationship when a prior effect between a predictor and outcome variable is significantly reduced when the third variable is included in the model. This indicates the existence of indirect effects [15].

Results

Table 1 provides the averages for the predicator variables as well as disaggregated by institution. There are approximately the same number of respondents who attend 2-year (N=85) and 4-year (N=92) institutions. Consistent with the gender make-up of engineering majors and the institutions' Hispanic Serving Institution (HIS) designation, men and Latinx students comprise a majority of the sample. Men make-up 67% of the sample versus 76% and 72% at the community colleges. Latinx students comprise 73% of the sample at the 4-year university and 52% and 69% at the community colleges. Community college students are more likely to be first generation college students (39% and 36%) compared to 28% of the university sample.

Table 2 explores the zero-order associations between our variables by presenting the bivariate correlations. With regards to our variables of theoretical interest, *career commitment, belonging*, and *engineering identity* are all moderately to highly significantly correlated with one another ($p<.01$). In addition, all these predictor variables are significantly positively correlated with the *GPA* outcome variable: *belonging (*r=.256), *engineering identity (*r=.209) and *career commitment* (r=.177). None of the predictor variables are significantly correlated with the *Retention* outcome variable. University students on average report a higher engineering identity *(*r=.195) and feelings of belonging to their field *(*r=.189) but not commitment to an engineering career, than do their counterparts in the community college. American Indian students reported a higher sense of belonging to the field *(*r=.120), while first generation college students *(*r=.189) reported lower levels of engineering identity.

Table 3 presents the OLS regression results for GPA. In model 1, none of the control variables are significantly associated with college GPA. Model 2 indicates that *belonging* predicts college GPA *(*b = .256; $p<.01$). On average, students who indicate a higher sense of belonging to their field of study have higher GPAs. When *career commitment* is added in Model 3 *the sense of belonging* coefficient only decreases slightly and is still significant (b = .240; $p<05$), suggesting that the effect of *sense of belonging* on GPA is not mediated by career commitment. Overall, the

multivariate analysis finds only sense of belonging to be a significant predictor of GPA. While *engineering identity* and *career commitment* are shown to be positively associated with GPA in the zero-order correlations (Table 2), the associations disappear after controlling for sense of belonging.

Table 4 presents the logistic regression results for the retention variable. None of the control or independent variables significantly predict the likelihood of returning the following Fall semester. However, it is interesting to note that although not significant, we see a similar change in the *career commitment* coefficient when the other three variables are added in Model 3.

Limitations and Future Work

This preliminary analysis of a subset of cross-sectional data from the first cohort of a longitudinal, multi-institution, multi-cohort study has many limitations. Consequently, we view these findings as merely suggestive of directions for further explorations.

Among the limitations are low survey response rates, small sample sizes and inconsistencies in the available data across universities. We will be addressing these issues in the coming months as we work with various college administrators to gain better access and a better understanding of the data. Our second and third cohorts took the survey in Fall 2019 and Spring 2020, and institutional data will be collected in Summer 2020 to produce a more robust longitudinal sample. As we add more cohorts of students to our data, and as each cohort progresses through their postsecondary engineering career, we will have a more robust sample and better statistical power. Regarding the low response rate, we plan to administer the survey in more classrooms which have much higher response rates than online surveys. In some cases, we may need to collect information directly from the students that we thought we would be able to obtain from the institutions. For example, not all institutions were able to provide high school GPA of our respondents, a valuable pre-college achievement control variable.

Some of the limitations are due to being in an early phase of the research. The cross-sectional nature of the predictor variables restricts the interpretation of the causal directions of our effects and the fact that students are early in their engineering academic careers means that concepts such career commitment are relatively undeveloped. For the larger study, the purpose of capturing these measures early is to collect a baseline measure so we can model change through longitudinal surveys that measure the same social psychological variables overtime. The low sample size and missing data from the fourth institution, limits our ability to model differences across institutional environments. We hope to be able to explore these differences and the possibility of modeling institutional level variation through techniques such as Hierarchical Linear Models in the future.

Conclusion

While there are several limitations to this preliminary analysis, these results suggest that student's commitment to an engineering career, engineering identity and experience of belonging are interrelated. Particularly worthy of further study is the preliminary evidence for the importance of students' sense of belonging to their field of engineering study. These are

promising theoretical constructs for helping us better understand how students perceive their engineering learning environments and how those perceptions are related to their academic and eventual career outcomes.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. 1826758. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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Table 1: Descriptive Statistics by Institution

		Northern Community College	Southern Community College	Four-Year University
Variable	Range	Mean	Mean	Mean
Male	0,1	.760 (.431)	.720 (.454)	.670 (.471)
White	0,1	.510 (.505)	.310 (.467)	.300 (.463)
Hispanic	0,1	.520 (.505)	.694 (.467)	.728 (.447)
American Indian	0,1	.0800 (.274)	.056 (.232)	.044 (.205)
First Generation College	0,1	.390 (.492)	.360 (.487)	.280 (.453)
Commitment to Career	1 to 5	4.419 (.576)	4.392 (.827)	4.544 (.617)
Sense of Belonging	1 to 5	3.860 (.932)	3.806 (.920)	4.174 (.833)
Engineering Identity	1 to 7	5.467 (.885)	5.558 (.999)	5.8814 (.972)

Note: Numbers in parentheses are standard errors

Table 2: Correlations among Variables

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) GPA	1.00	---	---	---	---	---	---	---	---	---	---
(2) Retention	.461**	1.00	---	---	---	---	---	---	---	---	---
(3) Male	-.009	.027	1.00	---	---	---	---	---	---	---	---
(4) American Indian	-.047	-.014	-.058	1.00	---	---	---	---	---	---	---
(5) Hispanic	-.095	.040	.065	-.342**	1.00	---	---	---	---	---	---
(6) White	.053	-.067	.011	-.031	-.466**	1.00	---	---	---	---	---
(7) First Gen	-.099	-.047	-.167*	-.014	.111	-.125	1.00	---	---	---	---
(8) University	-.037	.111	-.077	-.057	.143	-.124	-.100	1.00	---	---	---
(9) Career Commitment	.177*	.045	-.100	.126	-.006	.048	.085	.104	1.00	---	---
(10) Sense of Belonging	.256**	.072	.036	.120	-.051	-.058	-.004	.189*	.657**	1.00	---
(11) Engineering Identity	.209**	.101	.007	.011	-.076	.008	-.189*	.195**	.507**	.623**	1.00

** p < .01 (two-tailed tests)

*p< .05 (two-tailed tests)

Table 3: OLS Regression Models Predicting GPA of Engineering Students

	Model 1	Model 2	Model 3
Career Commitment	--	--	.040 (.138)
Sense of Belonging	--	.256** (.094)	.240* (.109)
Engineering Identity	--	.040 (.088)	.034 (.090)
Male	-.040 (.149)	-.075 (.145)	-.069 (.146)
American Indian	-.289 (.316)	-.401 (.308)	-.406 (.309)
Hispanic	-.155 (.173)	-.122 (.167)	-.122 (.168)
Other	.102 (.256)	.110 (.247)	.124 (.253)
First Generation	-.175 (.146)	-.182 (.145)	-.187 (.146)
University	-.062 (.136)	-.170 (.134)	-.168 (.134)
Constant	3.142***	1.955***	1.865***
R^2	.024	.104	.105

Note: Numbers in parentheses are standard errors

*** p < .001 ** p < .01 * p < .05

Table 4: Logistic Coefficients Predicting the Likelihood of Retention

	Model 1		Model 2		Model 3	
Independent Variables	Logistic Coefficient	Odds Ratio	Logistic Coefficient	Odds Ratio	Logistic Coefficient	Odds Ratio
Career Commitment	--	--	--	--	-.001 (.583)	.999
Sense of Belonging	--	--	.041 (.380)	1.042	.042 (.447)	1.042
Engineering Identity	--	--	.262 (.328)	1.299	.262 (.342)	1.299
Male	.261 (.595)	1.298	.259 (.603)	1.296	.259 (.614)	1.296
American Indian	.210 (1.185)	1.234	.251 (1.212)	1.285	.251 (1.217)	1.285
Hispanic	.378 (.642)	1.460	.486 (.656)	1.625	.486 (.656)	1.625
Other	.640 (1.151)	1.897	.680 (1.160)	1.975	.680 (1.169)	1.974
First Generation	-.225 (.574)	.798	-.142 (.595)	.868	-.141 (.602)	.868
University	.795 (.587)	2.214	.698 (.597)	2.010	.698 (.598)	2.010
Constant	1.629	5.097	-.047	.954	-.045	.956

Note: Numbers in parentheses are standard errors

*** $p < .001$ ** $p < .01$ * $p < .05$