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# Predicting Persistence in Engineering through an Engineering Identity Scale*

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Identity is emerging as an underlying explanation for persistence in engineering, but few prior studies have directly measured the engineering identity of engineering students, nor compared it with observed persistence. Of these studies, there are connections between (a) students' math, physics, and science reported interest, performance, competence, and recognition and (b) their identification and persistence in these domains and engineering. This study expands on that research by adapting previously validated scales of math and science identity to predict engineering identity and persistence. Data used in this study were drawn from a cross-sectional sample of undergraduate engineering students in mechanical and civil engineering (n = 474). We used exploratory factor analysis to analyze engineering identity items adapted from prior survey studies. We used logistic regression to predict engineering identity and one-year persistence after controlling for gender, major, students classification, and mother's education. The engineering identity factors align well with previously validated math and physics identity factors as evidenced by the factor loadings and Cronbach's alpha. Results from logistic regression models indicate that engineering interest, recognition, and performance/competence significantly predict engineering identity after controlling for student classification, major, and mother's education. Moreover, males and females report approximately the same attitudes on these predictors. Major, classification, and engineering interest were significant predictors of persistence in engineering. Gender was neither a significant predictor of engineering identity nor persistence in engineering. This study is the first step in using an engineering identity scale to directly measure engineering identity in undergraduate students beyond the first-year.

**Keywords:** identity; persistence; retention; survey; undergraduate

## 1. Introduction

Engineering is often perceived as exclusive, cold, and highly demanding, pushing many students away early on in their undergraduate studies and resulting in dropout rates approaching 50% [1]. In her review of engineering identity, Tonso [2] suggested that this results from engineering students failing to identify with the field of engineering. Additionally, engineering disciplines tend to have low female and minority representation [3–6]. Though the attrition rate for men and women in engineering is approximately equal, women have been found to leave at an earlier stage than men [7, 8] and only around 20% of all engineering degrees are awarded to women [1]. Similarly, underrepresented racial and ethnic minorities make up fewer than 20% of engineering student populations in the United States [3]. Therefore, improving the recruitment, retention, and diversity within engineering is the focus of many researchers and practitioners.

Most of the engineering career choice research conducted thus far has focused on high school students considering pursuing an engineering degree or those who are at an early stage of their college engineering experience; this includes, predicting student interest in engineering careers, fostering early interest in engineering in P-12 students [9], and determining what influences students to switch out of engineering [10]. Few studies consider the persistors: engineering students who continue to pursue engineering in college and beyond as they define themselves within the context of engineering. However, by understanding how students form engineering identities over time and what factors influence this development, additional research in this area may be able to combat issues of recruitment and retention.

Engineering identity provides researchers with a relatively new lens through which to study these two issues. However, this lens is still developing, as our current methods of measuring engineering identity are primarily indirect and rely heavily on surveys [e.g., 11, 12] that measure such factors as engineer-

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ing interest and recognition. The factors that comprise engineering identity have been explored more extensively in the context of math and physics identity in which the identity framework for this study was previously developed [13]. Thus, as an extension of previous work, one of the aims of this study was to further polish the engineering identity lens by testing a new scale containing items to directly measure engineering identity using engineering factors distinct from math and science identity factors. More recent quantitative studies of engineering identity tend to focus on first-year engineering undergraduates [14, 15] and do not yet link identity measures to persistence. Another aim of this work was to understand the relationship between engineering identity and persistence for students across undergraduate levels. Three research questions motivate this work:

1. How do these engineering identity items, adapted from prior math and physics identity studies, align with one another in factor analysis?
2. To what extent do these engineering factors predict engineering identity in engineering undergraduates?
3. To what extent do these engineering factors predict persistence in engineering undergraduates?

By examining how factors that influence engineering identity development and change over time in the students who persist through engineering, researchers can better inform retention-related interventions. Providing students with programs and support that foster the development of an engineering identity at an early stage in their undergraduate careers could improve retention rates and enhance diversity.

## 2. Theoretical framework

Identity is defined, used in theory and practice, constructed, and measured variously and with limited connections both within and between academic disciplines. Science, technology, engineering, and math (STEM) disciplines have turned to identity theories as a relatively new perspective on understanding why students persist through or leave STEM majors. In engineering education, prior studies have combined identity with other motivation and retention constructs. For example, Sheppard et al. [16] incorporated confidence and academic persistence in constructs separate from identity. Jones et al. [17] used the MUSIC Model of Academic Motivation to show the relationship between first-year engineering students' course perception and other constructs. This model found perceived empowerment by graduate teaching assistants and group members; usefulness, competence, and interest in the course; and perceived support by graduate teaching assistants significantly relate to engineering identification and program belonging.

A wide variety of theories have been used to guide studies of engineering student identities including multiple identity theory [18–20], identity stage theory [5, 9], communities of practice [21, 22], and figured worlds [23]. This variety of theoretical frameworks and terminology has meant that studies do not necessarily build on each other, and engineering identity is not as well theorized as math and science identities. As applied to STEM disciplines, identity has been variously defined as "being recognized as a 'certain type' of person" [20]; an integration of multiple identities including social, personal and academic [5]; how students see themselves in respect to a content area, based on their perceptions and navigation of everyday experiences in that area [24]; as well as a composite of students' performance, competence, and recognition in a domain [13] among other definitions.

The most cited framework on identity in STEM originates from Carlone and Johnson's [13] qualitative grounded theory study on science identity as the triangulation of performance, competence, and recognition in science. These three components interact with other identities such as racial, ethnic, and gender to establish science identity in the individual. Hazari et al. [25] built upon this model in their quantitative analysis of physics identity by adding interest to the theoretical framework. Their work identifies relationships between physics identity and physics career choice through the relationships between performance, competence, interest, and recognition in physics. From these theories, many have sought to define what it means to have a science identity [5, 26, 27], have a math identity [24, 28], be a physics person [25], or be a math person [29]. Hazari and colleagues have further examined the extent to which math identity, science identity, and physics identity contribute to choices in engineering [24, 28–31]. Specifically, Godwin is extending this work into developing measures of engineering identity similar to those used in the current study [13].

The theoretical framework for the current study builds on science identity work by Carlone and Johnson [13] and Hazari et al. [25]. From these two studies, four basic factors arose in relation to identity: performance, competence, interest, and recognition. However, in this and subsequent work by Hazari and others [e.g., 24, 29, 30], performance and competence were found to be theoretically equivalent constructs. A representation of this framework can be found in Fig. 1. *Performance* describes a student's belief in their ability to perform in their classes or when conducting engineering tasks. If a student performs poorly in class, they are less likely to identify themselves as an engineer. Similarly, *competence* describes a student's belief in their ability to understand engineering material. Performance and competence are closely linked, as students' self-perception of ability is often reflected in actual performance. Over time this may lead to the formation or erosion of engineering identity due to the development of a sense belonging in engineering or preparedness to succeed engineering. *Interest* describes how motivated a student is in the content and career they are pursuing; often encompassing the motives a student has for pursuing engineering. Interest encompasses not only affinity towards engineering tasks such as tinkering or design (which may fuel a student's initial pursuit) but also the ongoing reasons students identify with and persist in engineering. *Recognition* describes how parents, relatives, friends, and instructors see the student in the context of engineering. How that message is transferred to the student often affects their self-recognition. For example, engineering is often framed as a "for male" discipline which may lead females to receive less recognition as potential engineers. Collectively, we used these anticipated factors as well as measures for gender, socioeconomic status, student classification, and engineering major to measure engineering identity and persistence in engineering.

### 2.1 Predicting engineering identity

There are few prior studies that treat engineering identity as an outcome to be modeled. Methodologically, identity has been studied both qualitatively and quantitatively in a relatively equal number of studies. Many of the quantitative studies treat science, math, or engineering identity as a predictor variable for outcomes such as STEM career interest [11] or choice of engineering career [16, 24, 31–33]. One study worth noting is Meyers et al. [9], which used logistic regression to model engineering identity in undergraduate engineering majors at a large public institution. The predictors they explored included experience with engineering through work, research, and student organizations but this work was not based on identity theories used in other studies of engineering identity. Engineering related future plans, gender, and students' classification (freshmen vs. sophomores, juniors, and seniors) were the only significant variables in their model. Gender was also found to be significant in relation to identity and career choice by Cribbs et al. [24]. They found both math interest and recognition to be positive predictors of engineering career choice where the same increase in recognition boosts the likelihood females aspire to an engineering career more than males. In this study, the authors also controlled for student classification and socioeconomic status, which are important to model specification and generalizability of findings.

### 2.2 Predicting engineering persistence

Engineering persistence, defined as an individual staying in an engineering major or completing an engineering degree, is an outcome of particular interest in engineering education [e.g., 34–37]. Both cognitive and non-cognitive factors that contribute to persistence or intent to persist have been heavily examined from various perspectives. Yet there have not been studies that link actual persistence in engineering to engineering identity. Some studies do relate identity to self-reported persistence. For example, Matusovich et al. [38] sought to address persistence by investigating the motiva-

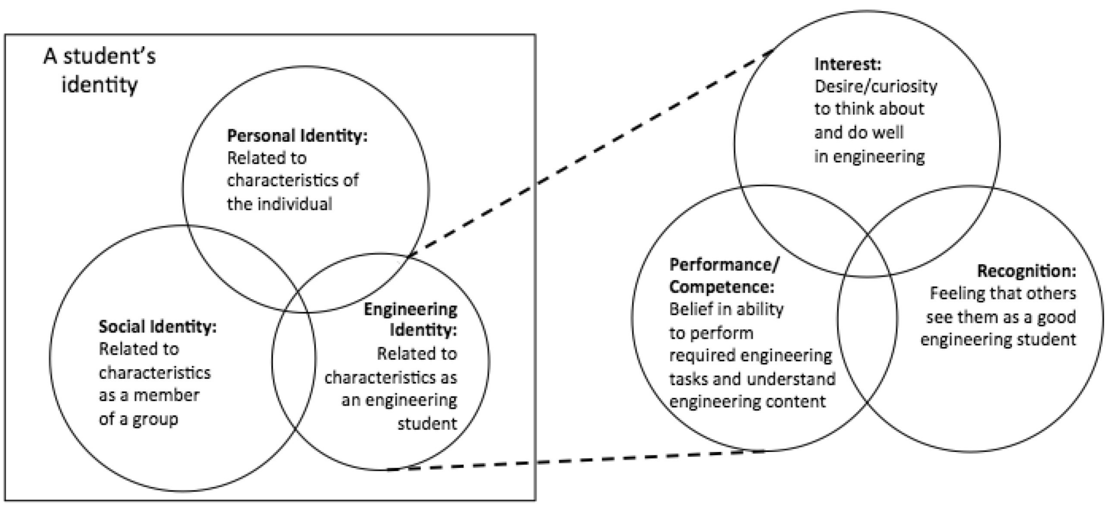


**Fig. 1.** Framework for students' identification with engineering, adapted from Godwin [14].

tion behind students choosing engineering as a career. They reviewed many of the choices students make in engineering due to the external and internal motivations that drive them to persist in the major. While students in this study placed different levels of personal importance on earning an engineering degree, the main differentiating factor with respect to engineering persistence was the degree to which engineering aligned with a student's personal identity.

While there have been few studies of engineering persistence that explicitly consider identity, there are several constructs related to performance/competence, interest, and recognition that have been related to persistence. Several other researchers have presented evidence on the importance of support from family and friends in the role of fostering identity development both in and out of STEM [e.g., 13, 39, 40]. Pierrakos et al. [21] included the influence of others in their investigation of professional identity formation in engineering persistors and engineering switchers. While neither group possessed high levels of knowledge about the profession, through interviews the authors found that persistors were more interested, more engaged in engineering activities before and during college, and had stronger social and professional networks.

## 3. Methods

This study was cross-sectional; it aimed to measure engineering identity and persistence in engineering by comparing identity, and the measured factors that comprise it, between engineering students at different stages in their college career (freshmen and sophomores vs. juniors and seniors). Data on engineering identity formation is particularly lacking for students beyond their first-year. In their cross-sectional study of undergraduate engineers, Godwin and Lee [41] demonstrated that similar identity measures can be used for undergraduate students across all levels.

### *3.1 Instrument administration and participants*

The survey, which took approximately fifteen minutes to complete, was administered in class on paper during the second week of the fall 2015 semester in a total of twelve engineering courses: six civil engineering (CE) courses, two architectural engineering (AE) courses, and four mechanical engineering (ME) courses. The setting was a large public institution in the U.S. with high-ranking engineering programs where the students are admitted directly into specific majors (there is no general or first-year engineering program). Of the twelve courses in which the survey was administered, five were designated by the institution as lower-division (freshman and sophomore level) and seven were upper-division (junior and senior level).

The population for this study was architectural engineering, civil engineering, or mechanical engineering (ME) undergraduate majors. Architectural and civil engineering students are in the same department and share many required courses; for this analysis, they were grouped together (collectively labeled CE). Students with more than one major were retained in the analysis as long as one major was CE or ME. Non-ME and non-CE students were removed from the data set. A total of 563 participants consented to the survey; we only examined responses with complete data on engineering identity survey items and persistence through fall 2016. The response rate was 70%. The final data set ($n = 474$) included 304 males and 170 females, 64% and 36% respectively. Based on first semester of enrollment, 21% were freshmen, 11% were sophomores, 22% were juniors, and 46% were seniors. The racial/ethnic composition of the sample was 53.1% White, 18.4% Hispanic, 16.7% Asian, 0.4% American Indian, 5.3% International, 4.0% reporting two or more race categories, and 2.1% Black. All demographic data was gathered from university records.

### *3.2 Instrument development*

We created the engineering identity scales of the Identity and Persistence in Engineering survey [42] from items used in previous survey studies using two strategies. First, performance/competence, interest, and recognition items about math and physics were adapted to engineering (often through simple substitution of "math," "physics," or "science" with "engineering"). Second, we borrowed items related to our theoretical framework from existing survey studies of engineering student persistence, which were not designed using performance/competence, interest, and recognition. These strategies were meant to develop engineering identity scales based on prior work in both math/science identity and engineering identity/persistence.

As listed in Table 1, we used items from Academic Pathways of People Learning Engineering Survey (APPLES) [16], Sustainability and Gender in Engineering (SaGE) [31], Hazari et al. [25], and Meyers et al. [9] in the construction of the Identity and Persistence in Engineering survey. Both SaGE and APPLES contained items specifically designed to address engineering outcomes. SaGE contained items that address engineering related (math and physics) attitudes directly; items that formed the performance/competence and interest factors were used and/or modified to fit our current survey design. We replaced the words "subject" and "physics" with the word "engineering" in the SaGE and Hazari et al. scales, respectively. While APPLES did

**Table 1.** Borrowed instrument items. Construct labels from original survey are listed, with mapping to current framework in parentheses as needed

| Survey | Construct | Items |
|---|---|---|
| Sustainability and Gender in Engineering (SaGE) (Godwin et. al 2013) | Performance/ Competence | I can understand concepts I have studied in this subject<br>I am confident that I can understand this subject in class<br>I can overcome setbacks in this subject<br>I am confident that I can understand this subject outside of class<br>I can do well on exams in this subject<br>Others as me for help in this subject |
| | Interest | I enjoy learning this subject<br>I am interested in learning more about this subject |
| | Recognition | My subject teacher sees me as an subject person |
| Hazari et al. (2010) | Recognition | Parents/Relatives/Friends see you as a physics person? |
| Academic Pathways of People Learning Engineering Survey (APPLES) (Sheppard et al., 2010) | Motivation: Intrinsic Psychological (Interest) | We are interested in knowing why you are or were studying engineering. Please indicate below the extent to which the following reasons apply to you:<br>I feel good when I am doing engineering<br>I think engineering is fun<br>I think engineering is interesting |

not include identity items or factors from previously validated scales, several of the items addressed other important aspects of identity. These items were well worded and did not need modifications due to content. From APPLES, we purposely included items related to reasons for studying engineering to add more robustness to the interest factor previously identified in SaGE. We included additional items potentially related to interest and recognition. Our dependent variable was taken directly from Meyers et al. [9] with modification to the response scale to allow greater variation. The original dependent variable only had "yes/no" response categories, whereas our variable expanded the categories to a 5-point Likert scale.

We used several student variables as controls. Participants self-identified the highest level of education their mother had completed; this was used as a surrogate to control for socioeconomic status. Additionally, we collected demographic data including gender, classification, major, and first semester of enrollment from university records after survey administration. Although race was also collected as part of the demographic data, it was not included in the analyses due to small frequencies in some of the categories.

Borrowed items relating to our theoretical framework are listed in Table 1. The current analysis focuses on 20 engineering identity items, a subset of the newly constructed Identity and Persistence in Engineering survey consisting of 119 quantitative items within 18 multi-item Likert scale questions and 1 open-ended response question.

### *3.3 Data analysis*

Data analysis was conducted using StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP. Prior to statistical analysis, we conducted simple descriptives to check the normality of the data. As a result of this preliminary analysis, we discovered the dependent variables, engineering identity and persistence, were negatively skewed and non-normally distributed. Thus, our data did not meet the assumptions for linear regression, namely constant variance, normality, and correct functional form. Therefore, we performed a logistic regression to account for these violations. Specifically, logistic regression correctly bounds predicted probabilities by specifying a correct S-shaped versus linear functional form; doing so allows us to develop an equation to make predictions of group membership (e.g., persistor or non-persistor). In total we ran four models: Model I and III only included control variables and Model II and IV tested the effects of the controls and engineering factors as independent variables on engineering identity and persistence respectively.

We created several control variables for our models. All control variables were dummy coded 0 and 1; 0 refers to the reference category. Gender was coded as 0 for male and 1 for female. Major was coded 0 for mechanical engineering and 1 for civil engineering. Students' classification was partitioned by division (freshman and sophomore = 0; junior and senior = 1). Mother's education was partitioned by degree status; Bachelor's, Master's, Doctoral/ Professional degrees were coded as 1; all other responses were 0.

The dependent variable for our first outcome, engineering identity, was a factor composed of two questions: "Do you consider yourself an engineer?" and "Do the following see you as an engineer: Yourself?" These items were measured on a modified Likert scale with 1 corresponding to Definitely Not, 2 for Probably Not, 3 for Not sure, 4 for Probably Yes and 5 for Definitely Yes; and 1 "No, not at all" to 5 "Yes, very much." The engineering identity factor was recoded to 0 for participants selecting 1–3 and 1 for those selecting 4–5. Our second outcome, persistence was a variable created by the observed one-year persistence of the student within engineering. Persistence is defined as 1 for those currently enrolled in an engineering major as of fall 2016 or those receiving a degree in engineering as of fall 2016 and 0 for those not currently enrolled or those who transferred to other majors.

Though a large part of the instrument was composed of previously validated items, the inclusion of new items necessitated the use of an exploratory factor analysis (EFA) to group survey items into significant factors. We conducted an EFA of the 20 engineering items to determine how well the items composing interest, recognition, performance, and competence loaded together. Table 2 lists the items composing each factor. We employed Promax rotation because the theory allows correlations between the factors. These factors were the independent variables for our models. All factors were measured on a Likert scale from 1 for "Strongly Disagree" to 5 for "Strongly Agree." To make interpretation meaningful in the model, all items from a factor were standardized and the factor was standardized again to have a mean of zero and standard deviation of one. For consistency across all models, only participants with observations on all variables for each factor were included in the model to ensure the same group was being compared across each factor.

## 4. Results

### *4.1 Exploratory factor analysis*

Table 2 presents the results of the exploratory factor analysis. All items were compared to the minimum item communalities of 0.40 and threshold loading of 0.32 [43]. Of the 20 items theorized to predict engineering identity, 18 were retained, and these loaded onto 5 factors. Unlike previous findings based on only first-year students [30], "Others ask me for help" and "recognition by teacher" each loaded on a single item factor and thus were not retained in the final analysis. This may mean that students in this sample did not relate others asking them for help in engineering to their performance/competence in engineering. We can also infer students' perceived recognition by a professor and perceived recognition by family and friends are not related. "I am interested in learning about engineering" cross-loaded on interest and a single item factor. The cross loading, 0.38, was near the cutoff of 0.40 but not in excess of what is considered severe cross loading, 0.50. After examination of this item in relation to the others comprising interest and previous work, we retained this item in the final analysis. The loadings and internal consistency for each of these factors are listed in Table 2.

The engineering identity factors align well with the previously validated math and physics identity factors from which they were adapted. Simply substituting "engineering" into previously validated math and physics identity scales was a generally effective means to create a new scale for engineering identity. Engineering interest, previously composed of only 2 items, was enhanced by the addition of items directly from APPLES. Additionally, by separating recognition by others

**Table 2.** EFA of Engineering Identity Factors

| Latent Construct | Item | Factor Loading | Unique Variance | Construct Reliability |
|---|---|---|---|---|
| Performance/ Competence | I can understand concepts I have studied in engineering | 0.656 | 0.438 | 0.864 |
| | I am confident I can understand engineering in class | 0.803 | 0.351 | |
| | I can overcome setbacks in engineering | 0.511 | 0.438 | |
| | I am confident I can understand engineering outside of class | 0.580 | 0.463 | |
| | I can do well on exams in engineering | 0.794 | 0.424 | |
| Interest | I feel good when I'm doing engineering | 0.620 | 0.458 | 0.851 |
| | I think engineering is fun | 0.803 | 0.322 | |
| | I think engineering is interesting | 0.722 | 0.509 | |
| | I am interested in learning more about engineering | 0.440 | 0.542 | |
| | I enjoy learning engineering | 0.549 | 0.293 | |
| Engineering Identity | Do the following see you as an engineer? Yourself | 0.620 | 0.360 | 0.726 |
| | Do you consider yourself an engineer? | 0.672 | 0.573 | |
| Recognition by Others | Do the following see you as an engineer? | | | 0.857 |
| | Parents | 0.823 | 0.292 | |
| | Relatives | 0.852 | 0.273 | |
| | Friends | 0.563 | 0.431 | |

into parents, relatives, and friends, we can see that these three dimensions of recognition do indeed constitute one factor, as was the assumption in previous studies. Collectively, the findings from our EFA were in line with similar measures of engineering identity (see [14]).

### *4.2 Logistic regression*

Table 3 shows the descriptive statistics for the variables on their original scale as well as the results of simple t-tests on these variables based on gender. Given the emphasis on gender in outcomes in engineering, it was necessary to determine if there were any gender differences in our sample. Although we found a gender difference in the means of student's engineering performance/competence beliefs, males and females reported approximately the same attitudes on all other predictors.

Table 4 shows the correlation between the dependent and independent variables. Although all correlations between identity and the independent variables (Table 4, first column) are significant, the correlations are moderate, indicating each independent variable contributes uniquely to the outcome variables. Notably, engineering performance/competence has a large correlation with engineering interest. This reflects the relationship between perceived ability and interest. Conversely, persistence is neither significantly correlated with any of the independent variables nor identity (Table 4, second column).

Results of the logistic regression models are presented in Tables 5 and 6. Models I and III are control models for identity and persistence, respectively. Final models II and IV include the control and independent variables. Odds ratios are standardized and can be interpreted as effect sizes; values of 1.5, 2.5, and 4.3 are considered small, medium, and large respectively [44]. An odds ratio less than 1 means the variable has a negative effect on the outcome.

Logistic regression models (Model I and II) for engineering identity are presented in Table 5. Model I shows there are no significant differences in engineering identity based on gender, major, student classification, or mother's education. In Model II, all controls remained non-significant even with the addition of engineering interest, engineering recognition by others, and engineering performance/competence to the model. Engineering interest ($p = 0.000$), engineering recognition by others ($p = 0.000$), and engineering performance/competence ($p = 0.041$) were found to be significant predictors of engineering identity. As seen in the odds ratios, the strongest predictors of identity are engineering interest and recognition by others. This indicates that for a one standard deviation increase in interest and recognition by others, the odds of considering oneself an engineer increases by a factor of 2.31 and 2.06, respectively, controlling for all other variables in the model. Engineering performance/competence also has similar effects on engineering identity. Controlling for all other variables in the model, for every one standard deviation increase in performance/competence, the odds of considering oneself an engineer increases by a factor of 1.45. Collectively, the independent variables account for an additional 27% ($R^2$ 0.28 minus 0.01) of the variance in engineering identity.

**Table 3.** Descriptive Table of Dependent and Independent Variables by Gender

| | All | | Males | | Females | | Scale | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **Mean** | **S.D.** | **Mean** | **S.D.** | **Mean** | **S.D.** | **Min** | **Max** | **Significance** |
| **Dependent Variables** | | | | | | | | | |
| Engineering Identity | 0.84 | 0.37 | 0.84 | 0.37 | 0.84 | 0.37 | 0 | 1 | n.s. |
| Persistence in Engineering | 0.97 | 0.17 | 0.97 | 0.17 | 0.97 | 0.17 | | | n.s. |
| **Independent Variables** | | | | | | | | | |
| Engineering Interest | 3.77 | 0.59 | 3.77 | 0.55 | 3.56 | 0.56 | 1 | 5 | n.s. |
| Engineering Recognition by Others | 4.39 | 0.83 | 4.39 | 0.85 | 4.38 | 0.80 | | | n.s. |
| Engineering Performance/Competence | 4.26 | 0.57 | 4.31 | 0.55 | 4.19 | 0.60 | | | 0.02* |

*p ≤ 0.05; **p ≤ 0.01;***p ≤ 0.001.

**Table 4.** Pearson's correlation matrix of dependent and independent variables

| | Identity | Persistence | (1) | (2) | (3) |
|---|---|---|---|---|---|
| Identity | – | | | | |
| Persistence | 0.058 | – | | | |
| (1) Engineering Interest | 0.393*** | 0.058 | – | | |
| (2) Engineering Recognition by Others | 0.360*** | –0.038 | 0.215*** | – | |
| (3) Engineering Performance/Competence | 0.318*** | 0.001 | 0.554*** | 0.243*** | -- |

*p ≤ 0.05; **p ≤ 0.01; ***p ≤ 0.001.

**Table 5.** Logistic regression predicting engineering identity

| | Model I | | Model II | |
|---|---|---|---|---|
| | **Odds Ratio** | **S.E.** | **Odds Ratio** | **S.E.** |
| **Intercept** | 7.27*** | 2.64 | 10.5*** | 4.60 |
| **Controls** | | | | |
| Gender (Male = 0; Female = 1) | 1.17 | 0.31 | 1.17 | 0.37 |
| Major (Mechanical = 0; Civil = 1) | 0.66 | 0.17 | 0.70 | 0.22 |
| Student classification (Fr. & Sop. = 0; Jr. & Sr. = 1) | 1.10 | 0.30 | 1.79 | 0.60 |
| Mother's Education | 0.70 | 0.20 | 0.56 | 0.19 |
| **Independent Variables** | | | | |
| Engineering Performance/Competence | | | 1.45* | 0.26 |
| Engineering Interest | | | 2.31*** | 0.40 |
| Engineering Recognition by Others | | | 2.06*** | 0.27 |
| Pseudo $R^2$ | 0.01 | | 0.28 | |

N = 474; *p ≤ 0.05; **p ≤ 0.01; ***p ≤ 0.001.

**Table 6.** Logistic regression predicting persistence in engineering

| | Model III | | Model IV | |
|---|---|---|---|---|
| | **Odds Ratio** | **S.E.** | **Odds Ratio** | **S.E.** |
| **Intercept** | 31.1*** | 26.8 | 34.6*** | 31.0 |
| **Controls** | | | | |
| Gender (Male = 0; Female = 1) | 1.47 | 0.85 | 1.42 | 0.85 |
| Major (Mechanical = 0; Civil = 1) | 0.19* | 0.15 | 0.15* | 0.13 |
| Student classification (Fr. & Sop. = 0; Jr. & Sr. = 1) | 4.13* | 2.55 | 5.55** | 3.68 |
| Mother's Education | 1.77 | 1.00 | 2.34 | 1.39 |
| **Independent Variables** | | | | |
| Engineering Performance/Competence | | | 0.72 | 0.25 |
| Engineering Interest | | | 2.50** | 0.89 |
| Engineering Recognition by Others | | | 0.51 | 0.22 |
| Pseudo $R^2$ | 0.13 | | 0.19 | |

N = 474; *p ≤ 0.05; **p ≤ 0.01; ***p ≤ 0.001.

Models III and IV of persistence are shown in Table 6. Model III shows there are no significant differences in engineering identity based on gender and mother's education. However, both major (p = 0.023) and student's classification (p = 0.010) are significant predictors. Upper division students were more than 4 times more likely to persist in engineering for one year following the survey than lower division students controlling for all other variables in the model. This is to be expected since most students who leave engineering majors do so within the first two years; freshmen and sophomores in a cross-sectional sample of engineering majors cannot be expected to be equivalent to juniors and seniors for this reason. In this sample, civil engineering majors were also far more likely to persist than mechanical engineering majors. This appears to be a local trend that is not present in national engineering retention data.

We also ran an intermediate model (not shown) of persistence with engineering identity and the controls as predictors. Engineering identity was not a significant predictor (p = 0.250) and only accounted for less than 1% of the variance in persistence. Therefore, Model IV became the final model of observed persistence. Model IV includes the control variables with the addition of engineering interest, engineering recognition by others, and engineering performance/competence to the model. Only engineering interest (p = 0.010) was found to be a significant predictor of persistence; engineering recognition by others and performance/competence were not significant predictors. Engineering interest had a positive medium-sized effect on persistence. Controlling for all other variables in the model, for every one standard deviation increase in engineering interest, the odds of persistence increases by a factor of 2.50. Surprisingly, persistence is uncorrelated to the independent variables (Table 4). The independent variables account for 6% ($R^2$ 0.19 minus 0.13) of the variance in persistence. The overall variance explained by the final model is 19%.

## 5. Discussion

This study developed scales for measuring engineering identity using previous survey studies of math and physics identity and engineering pathways. The scales aligned well with the theoretical framework that engineering identity is composed of interest, recognition, and performance/competence within engineering. In logistic regression models, the engineering factors predicted 27% of the variance in engineering identity and 6% of the variance in observed engineering persistence one year after survey administration.

Our work expands on previous research in several ways. The sample includes students from each phase in their undergraduate study, rather than focusing on first-year students. We built on prior theoretical frameworks of identity in engineering, math, and science to focus specifically on engineering identity and persistence in engineering. We measured identity directly with engineering factors, rather than with math and science identity factors. Most importantly, this study may be the first to relate measures of engineering identity to observed persistence in engineering majors. These are important steps in advancing research on engineering student identity. With this study, we extended theory specific to engineering identity and validated scales for use cross-sectionally or longitudinally with engineering undergraduates at all levels.

Our first research question regarding alignment of adapted survey items with the theoretical framework was supported by our findings. The newly constructed items do align well with previously validated math and physics identity factors, as evidenced by the exploratory factor analysis. Moreover, these results are comparable to those of Godwin [14] who used a similar set of items to develop a measure of engineering identity. Further, the item about recognition by a teacher did not factor with recognition by others as it has in studies of math and science identity in first-year students. These results indicate that influence or recognition by academics or perhaps working engineers is perceived by engineering undergraduates as fundamentally different from recognition by family and friends, particularly for this sample of engineering freshmen through seniors. The four factors, engineering interest, recognition by others, engineering identity, and performance/competence establish the beginnings of a scale to measure engineering identity and persistence as evidenced by the results from the logistic regression models.

Our second and third research questions were to what extent do the engineering factors predict engineering identity and persistence in engineering undergraduates. By modeling each outcome using two separate models, we were able to see the net effect of the engineering factors. While it was important to consider the effects of student experiences and backgrounds, a one-model approach limits the interpretability of our findings. Identity has been touted as a new perspective on engineering interest and persistence, but this is one of the first studies to directly examine relationships between engineering identity and engineering persistence. While it might be expected that our two-item measure of identity did not significantly predict persistence, it is somewhat surprising that more of the identity scales with stronger theoretical grounding did not significantly predict persistence. Identity scales accounted for only 6% of the variance in persistence (Table 6), and only engineering interest was significant. As this is one isolated study, the results need to be replicated to understand whether this relationship between identity and persistence holds beyond this sample.

Relationships between specific identity constructs and engineering identity and persistence are generally consistent with findings from previous studies. *Interest* has largely been speculated to have a major influence on the formation of an identity and persistence. In our findings, interest was the only factor to have a positive effect on both identity and persistence in engineering. As a construct, interest is composed of feelings of enjoyment, thinking engineering is interesting, and learning about engineering. This aligns well with studies relating interest to achievement motivation [e.g., 40]. As mentioned previously, maintaining or not maintaining interest in engineering may be one of the reasons students continue to develop their identities as engineers. Interest was the dominant factor in determining students' persistence in engineering. Previous studies have found those with strong personal interests in a given domain are more likely to persist [1, 21, 45]. It is also inferred that interest in engineering is related to students' feelings of the discipline being fun. Further dissection should be done on the meaning of fun to determine what aspects of engineering are fun to students as well as what other aspects of engineering may not be fun and contribute to student's negative feelings of the discipline. In parallel to findings using the Eccles' expectancy-value framework, those with high levels of sense of self within engineering also tend to report high levels of interest (enjoyment) [38].

*Engineering performance/competence*, often referred to as self-efficacy in social science literature, is clearly important to the development of engineering identity. Self-efficacy is defined as a judgment of one's ability to organize and execute given types of performances [46]. The close relationship between competence and identity is not unknown. Bong and

Skaalvik [47] conducted a thorough dissection of self-concept, the perception of oneself, and self-efficacy in efforts to characterize the distinction between the two constructs in the literature. Their findings support the positive correlations we find between identity and engineering performance/competence in this study. Recently, studies on competence, performance, domain identification, and other student outcomes also found a positive relationship between perceived ability and identity [e.g., 17]. Moreover, psychological self-perception can be more influential than actual performance. For example, Hackett and Betz [48] found mathematical self-efficacy to be superior to math performance in predicting the choice of a math-related major. For our study, the significant gender difference in the performance/competence between men and women may be a reason women do not persist in engineering at the same rate as men despite performing at similar levels academically [49, 50]. However, this does not minimize the importance of fostering competence in engineering, as the ability to perform can lead to recognition by those significant others. Performance/competence, interest, and recognition all share positive significant correlations. Therefore, building confidence in students' ability to perform and understand engineering tasks will likely increase their interest in engineering. In turn, this will increase the likelihood a student will identify himself or herself as an engineer and persist in engineering with the help of support through recognition. Shavelson et al. [51] state the importance of influence by reinforcements and significant others to shaping one's sense of self.

The significance of *recognition* in the model of engineering identity also points to a type of support. Recognition by others had about the same effect size (odds ratio) on identity as interest. Further exploring what types of supports are helpful in fostering engineering identity (e.g., peer mentoring programs, recognition in the form of scholarships or awards, guided instruction) is another area of future work to consider. For example, mentors and role models have been cited as beneficial in fostering a desire to pursue engineering and other STEM disciplines [37, 52, 53]. Additionally, other works cite the importance of same-race or same-gender role models and mentors in supporting students [54–56]. Specifically, Fleming et al. [57] found caring professors and peers strengthen identity in black and Hispanic engineering students at minority-serving institutions. While our results cannot make claims in relation to gender or race matching, we can emphasize the importance of recognition by family, friends, and peers to students' engineering identity.

Surprisingly, none of our controls were significant predictors of identity despite findings from related studies. For instance, among undergraduate engineering students at a single institution, Meyers et al. [9] found gender and student classification (freshman vs. sophomores, juniors, and seniors) to be significant predictors of engineering identity in a logistic regression model using a similar outcome measure to ours. On the other hand, classification and major were significant predictors of persistence in the current study. As expected, lower-division students (freshmen and sophomores) were less likely than upper-division students (juniors and seniors) to persist in engineering. Due to attrition from engineering majors, freshmen and sophomores in a sample of engineering majors cannot be expected to be equivalent to juniors and seniors. In the current study, major had an effect on persistence. As emphasized by Tonso [58] campus culture has an impact on engineering identity and student interactions; departmental culture, a subculture of campus culture, may have a similar impact in this situation.

## 6. Limitations

There are several limitations to note. The sample was drawn from two departments at a single institution and cannot be claimed to be generalizable to the broader engineering student population. Retention levels are particularly high in engineering at this institution. First-year retention rates in engineering are above 90%. There were not enough responses from racial/ethnic minorities to state findings related to those populations. Similarly, our results related to gender differences may be due to unique characteristics of the females in this sample or our lack of more nuanced measures of gender identity. There are benefits and limitations to using institutional demographic data as we have in the current study. Additionally, we lack the details to further explain differences due to major. The response rate was high (70%), but self-selection bias may still have played a role. The outcome measure of engineering identity we used was based on just two items and could be expanded to represent other aspects of identity. The theoretical framework was primarily influenced by math and science identity work and does not fully address the professional aspects of engineering that are likely important to identity [59]. Nonetheless, this study builds on a foundation of scales previously validated for much broader populations and presents intriguing results to be replicated or expanded in future work.

## 7. Conclusion and future work

In sum, those who are interested in engineering, recognized as engineers by their friends and family, and have feelings of ability to do and understand engineering have the strongest engineering identities. While these factors are related, there is only a small to medium correlation between them. Furthermore, those with strong feelings of interest are more likely to persist in engineering. By first gaining an understanding of how students see themselves and why they choose to study and persist in engineering, we can then make more refined changes to our recruitment and retention efforts. In future work, modeling engineering identity and persistence with these constructed factors in conjunction with qualitative data from a purposeful sample of participants would likely provide a richer description of what attitudes and experiences contribute to students' decision to major in engineering. Similarly, investigating what interests students about engineering and how that interest is maintained (or not maintained) over time can contribute greatly to the body of knowledge on persistence. This has important implications for persistence of engineering undergraduates through Bachelor's degree completion as well as studies of graduate students and those entering the professional setting. In future work, longitudinal studies will better inform our understanding of the connection, if any, between engineering identity and observed persistence. Engineering identity frameworks can be further refined to include content-specific identity, professional identity, personal identity, and social identity across contexts and backgrounds including race, gender, major, and campus culture. Truly intersectional work on engineering identity and persistence is a distinct direction for future work, as race, sexual orientation, and other social identities have yet to be substantially considered in the study of engineering identity and persistence. Both quantitative and qualitative approaches are needed, and engineering identity studies should cite and build upon each other more than they have in the past.

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