A New Scale for Measuring Engineering Identity in Undergraduates

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Abstract

Identity, or how people choose to define themselves, is gaining traction as an explanation for who pursues and persists in engineering. A number of quantitative studies have developed scales for predicting engineering identity in undergraduate students. However, the outcome measure of identity is sometimes based on a single item. In this paper, we present the results of a new two-item scale. The scale is adapted from an existing measure of identification with an organization that was developed by Bergami and Bagozzi [1] and refined by Bartel [2]. The measure focuses on the "cognitive (i.e., self-categorization) component of identification" (p. 556), and has been found to have high convergent validity with another, rigorous measure of identification with an organization or other entity created by Mael and Ashforth [3]. This measure utilizes one primarily visual and one verbal item to assess the extent to which an individual cognitively categorizes himself or herself as an engineer. The scale was administered to 1528 engineering undergraduate students during the 2016-2017 academic year. Internal consistency of the new engineering identity scale, as measured by Cronbach's alpha, is 0.84. This new scale is an important step toward refining quantitative measures of, and the study of, engineering identity development in undergraduate students and other populations.

1. Introduction

Identity, or how people choose to define themselves [4], is emerging as an attractive explanation for who persists in engineering. Several qualitative and quantitative studies have focused on understanding identity development of engineering students [5].

Some of these quantitative studies use only one survey item to measure identity [6], even though a scale comprising multiple items is generally considered to be stronger [7]. In this paper, we present a new two-item scale for measuring engineering identity in undergraduate engineering students, adapted from organizational psychology.

2. Method

To measure the extent to which an individual identifies with engineering, we adapted an existing measure of identification with an organization that was developed by Bergami and Bagozzi [1] and refined by Bartel [2]. The measure focuses on the "cognitive (i.e., self-categorization) component of identification" [1] (p. 556), and has been found to have high convergent validity with another, rigorous six-item measure of identification with an organization or other entity created by Mael and Ashforth [3]. This measure has been adapted to various contexts by substituting the original, organizational referent in the questions (i.e., an organization) with the group with which identification is being assessed (i.e., engineering). Thus, keeping with prior practice, we substituted "engineering" in place of the original, organizational referent in the scale to derive a measure of identification with engineering. This measure utilizes one primarily visual and one verbal item to assess the extent to which an individual cognitively categorizes himself or herself as an engineer. Participants were directed to circle one response for the each question. Figure 1 presents the items.

The survey was administered electronically in the fall of 2016 and spring of 2017 to mechanical engineering (ME), civil engineering (CE), and biomedical engineering (BME) engineering courses at two institutions. Only engineering students were retained for data analysis. A total of 1528 students completed the survey with full responses to our focal items. The sample was approximately 69% male and 31% female. Based on first semester enrollment, 30.9% were freshman, 23.1% were sophomores, 24.5% were juniors, and 21.5% were seniors across two institutions in the United States. The survey included the new two-item engineering identity scale, as well as scales assessing factors relating to affect towards professional practice, engineering performance/competence, engineering recognition, and engineering interest.

Given that this scale represents a small adaptation of a well-validated scale, one that has been similarly adapted successfully before for application in a variety of contexts, we expected the scale to provide an effective measure of engineering identity. In this study, the reliability and validity of the scale were assessed in a large-scale survey study of undergraduate engineering students. In surveying students for this study, we included a range of variables expected to predict (e.g., number of years of engineering education), and be predicted by (e.g., intention to go to graduate school within engineering) engineering identity.

We used standard analyses for establishing the underlying relationship between the items (e.g., correlation), normality of the new scale (e.g., skewness and kurtosis tests), internal reliability (e.g., Cronbach's alpha), discriminant validity (e.g., Confirmatory Factor Analysis with accompanying fit indices), and criterion validity (i.e., predictive validity) when analyzing the data. Finally, we compared this new scale with a previously studied measure of engineering identity, and assessed the relationship between our new scale and factors relating to affect towards professional practice, and engineering performance/competence.

3. Results

3.1 Normality, Correlation, and Reliability

A multivariate normal distribution is characterized by a skewness of 0 and a kurtosis of 3 [8]. The skewness of the items was -0.58 and -0.40 for the visual and verbal item respectively. Kurtosis values of 3.39 and 3.06, respectively, indicate a non-normal distribution. However, both metrics are within the range for assumptions of confirmatory factor analysis [8].

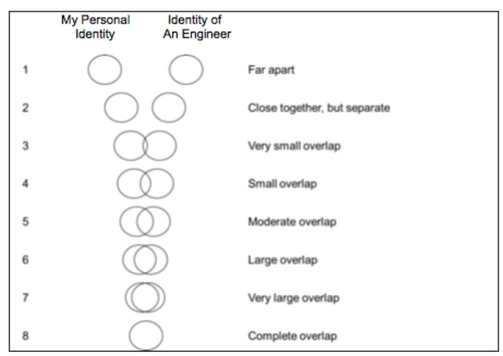
After checking assumptions of normality, we examined the correlation matrix, which showed a strong and significant relationship between the two items in the measure (r=0.72; p <0.000). Additionally, the Cronbach's alpha ($\alpha = 0.84$) indicated a strong internal consistency between the items (Figure 1). In comparison to our previous work from a fall 2015 sample of undergraduate engineering students from the same population, and a two-item factor "Do you consider yourself an engineer?" and "Do the following see you an as engineer? Yourself" measured on a Likert-scale from 1 (strongly disagree) to 5 (strongly agree), this new scale has an improved alpha reliability. The prior scale had an alpha reliability of 0.73. Notably both scales fall within the good to excellent range for internal consistency where values of 0.70 are considered acceptable, 0.80 are good, and 0.90 are excellent. The closer Cronbach's alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale [9].

3.2 Discriminant Validity

Confirmatory factor analysis (CFA) is a research specified technique used to verify the underlying factor structure of observed variables. We examined the goodness of fit of the factor structure derived from the CFA using the following indices and criterion: Comparative Fit Index (CFI; > 0.95) [10], Tuck Lewis Index (TLI; >0.95) [10], and the root mean square error of approximation (RMSEA; values less than 0.01, 0.05, and 0.08 indicate excellent, good and moderate fit respectively) [10]. Discriminant validity was determined by examining a CFA model containing the new scale of engineering identity, engineering performance/competence [11], and factors of affect towards professional practice factors: analysis, framing and solving problems, and design [12]. These variables were chosen due to their significant correlation (ranging from 0.43-0.49; p<0.000) to the new scale. Our results indicate an acceptable model fit (CFI of 0.958; TFI of 0.951; and RMSEA of 0.045).

3.3 Criterion Validity

Criterion validity was established by using the new engineering identity scale in regression. The results showed this new scale significantly predicts intention to go to graduate school for engineering (p=0.001); however the correlation between the two variables was weak (r=0.17). The new scale explains only 3.0% of the variance in intention to go to graduate school for engineering. Comparatively, 2.8% of the variance in this outcome is explained by the single item question "do the following see you as an engineer? Yourself." This question is also significantly but weakly correlated with the outcome variable (r=0.18). Thus, the explanatory power of the new scale is a slight improvement over the single item outcome used previously.


13. Please describe your relationship with engineering by using the following diagrams. Imagine that the circles at the left represent your own personal identity (i.e., what describes you as a unique individual), while the circles at the right represent the identity of an engineer (i.e., what describes an engineer). Which diagram best describes the level of overlap between your own identity and the identity of an engineer?

(CIRCLE ONE RESPONSE)

14. To what extent does your own sense of who you are (i.e., your personal identity) overlap with your sense of what an engineer is (i.e., the identity of an engineer)?

(CIRCLE ONE RESPONSE)

Not at all (1)	(2)	(3)	(4)	(5)	(6)	(7)	To a great extent (8)
1	2	3	4	5	6	7	8

Figure 1. (Top) Question 13. Visual measure of engineering identity. (Bottom) Question 14. Verbal measure of engineering identity.

4. Summary

Based on prior practice of adapting previously validated scales of identification with an organization, our results provide compelling evidence for the use of this scale for measuring engineering identity. The step-by-step development and evaluation of this scale was consistent with best practices in the literature. This new scale improves the reliability of the measure of engineering identity without losing the explanatory power in modeling. This work intends to build and further refine the study of engineering identity in undergraduates as well as those in different places in the engineering pathway such as high school and graduate students. In future work we plan to use this scale to investigate student attitudes across the engineering trajectory, and between groups that have been traditionally underrepresented in engineering.

Acknowledgement

This work was funded by the U.S. National Science Foundation through grant numbers 1636449 and 1636404. The views presented are those of the authors and not necessarily those of the NSF. The authors wish to thank Nathan Choe, Catherine Riegle-Crumb, and Carolyn Seepersad for their partnership on this project as well as the student participants, instructors, department chairs and other department liaisons for assisting with data collection.

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