Preliminary Validity Evidence for a Brief Measure of Engineering Identity

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Background and Objective

Considering national initiatives to increase the overall number of engineering graduates, improving the persistence of students to remain in engineering disciplines through to graduation has become a pivotal strategy [1]. This is unsurprising, especially given previous research that indicates a majority of students who start college in engineering in the United States will not graduate with an engineering degree [2]. Although lack of interest or ability has been used to explain why some leave engineering prior to graduating, the degree to which engineering becomes central to a student's self-concept (i.e., engineering identity) has been supported as a superior explanatory factor in retention-related outcomes [3], [4], [5], [6]. While engineering identity has been examined in the past, the majority of extant research is qualitative in nature. Qualitative research offers valuable, in-depth information for understanding student identification with engineering but can be problematic when examining identity in thousands of students entering engineering programs, as it is often time-intensive (e.g., collecting data through observation, focus groups, and/or individual interviews and transcribing and coding the data). A short, quantitative measure of engineering identity could offer a practical way to inform retention interventions as well as quickly identify students at risk of attrition. The focus of this paper is the development of a concise quantitative instrument that measures undergraduate students' engineering identity, thus allowing for further understanding of engineering retention through identity.

Research Design

Participants and Procedure

Survey responses were collected from consenting students in their first year of an undergraduate engineering program at a large southwestern university. Students were invited to respond to online surveys using a link sent to their university email address. Participants were surveyed three times during their first year: prior to entering the engineering program (Survey 1), at the end of their first semester (Survey 2), and at the end of their second semester (Survey 3). Students were given time during summer orientation and during class to complete these surveys. In total, a sample of 2473 participants was used to develop and validate a 5-item engineering identity measure, with Surveys 1, 2, and 3 consisting of 1900, 1083, and 481 respondents, respectively.

Measures

Engineering identity and engineering self-efficacy, the belief that oneself has the ability to be successful in engineering, were assessed in all three surveys. In addition, engineering embeddedness and satisfaction with the engineering major were assessed in Surveys 2 and 3.

Embeddedness and satisfaction were not included in Survey 1, as participants had not yet begun studies in the engineering program at this time point. Engineering embeddedness can be described as the extent to which a student is anchored in their engineering major and is comprised of three dimensions: fit, links, and sacrifice. Fit refers to a passion for engineering, enjoyment of the challenge brought on by the engineering major, and perception of compatibility between the skills and characteristics one has and the skills and characteristics required by the engineering major. Links are the connections one has to activities and to other people in engineering. Finally, sacrifice is what one would give up upon leaving the engineering major. Examples of sacrifice are the prestige associated with the engineering major and non-recoverable costs through a loss of investments, such as tuition. Survey items are displayed in Appendix A. Measures of self-efficacy, embeddedness, and satisfaction in relation to the engineering major were included to facilitate the validation of the engineering identity measure. In addition, participant SAT scores and retention information, indicated by continued enrollment in engineering at the end of the academic year, were provided to the researchers through an anonymized database for measure validation purposes.

Results

Factor Analysis

In developing the measure, 11 identity items, either adapted from the career identity literature or generated for this project, were evaluated. Survey 2 responses were analyzed to determine which items were most suitable to include in a 5-item measure of engineering identity, as participants had not yet entered the engineering program upon completing Survey 1. First, half of the Survey 2 sample was randomly selected to conduct an exploratory factor analysis (EFA). Results indicated that the identity items represented a single construct (i.e., engineering identity) and all items had factor loadings greater than .50. This finding was confirmed with a confirmatory factor analysis (CFA) conducted on the second half of the Survey 2 sample. The identity measure was then reduced to five items based on CFA modification indices, factor loadings, and a preference for items from the existing literature. Fit indices for this 5-item measure were satisfactory, $\chi^2(5) = 7.41$, RMSEA = .03, CFI = .998, SRMR = .01. Next, samples from Surveys 1 and 3 were used to validate the 5-item measure. Fit indices were satisfactory for both the Survey 1 sample, $\chi^2(5) = 34.47$, RMSEA = .06, CFI = .99, SRMR = .01, and the Survey 3 sample, $\chi^2(5) = 12.63$, RMSEA = .06, CFI = .99, SRMR = .01, and Cronbach’s alpha for the identity measure was above recommended levels for all three samples.

Measure Validation

In order to establish convergent validity, the relationship between identity and engineering embeddedness was tested to determine if the two constructs are related as expected. Identity and engineering embeddedness are expected to be positively related, such that students who highly identify with engineering are more likely to perceive a compatibility with and a passion for engineering (i.e., engineering fit), have connections with activities and others in engineering (i.e., engineering links), and have more invested in engineering (i.e., engineering sacrifice). Convergent validity was demonstrated through significant positive correlations between the 5-item identity measure and each of the three dimensions of embeddedness (fit, links, and sacrifice; r ranging from .53 to .73, $p < .001$). Discriminant validity is demonstrated when two seemingly unrelated constructs are found to be unrelated as expected. The relationship between identity and participant SAT scores was examined to test this type of validity, as the extent to which one identifies with engineering is expected to be unrelated to their SAT score. Discriminant validity was demonstrated through non-significant correlations between identity and participant SAT scores for Survey 2 ($r = -.05$, $p = .143$) and Survey 3 ($r = -.10$, $p = .053$). Identity did, however, have a significant negative relationship with SAT scores for Survey 1 participants ($r = -.11$, $p < .001$).

Lastly, predictive validity indicates that participant responses on one measure can predict responses on a different measure at a later time. The relationships between identity and major satisfaction and identity and retention were examined to establish support for this type of validity. Significant relationships between identity and major satisfaction one semester later ($r = .10$, $p = .007$ for Survey 1 identity and Survey 2 major satisfaction, $r = .18$, $p = .011$ for Survey 2 identity and Survey 3 major satisfaction) were observed, demonstrating evidence for the predictive validity of the measure. Survey 1 identity and Survey 3 major satisfaction were not significantly correlated ($r = .05$, $p = .373$). Predictive validity was further demonstrated through retention data. Identity measured upon entry and after one semester in the engineering program was significantly positively related to first-year engineering retention ($r = .08$, $p < .001$ and $r = .22$, $p < .001$, respectively). Correlations between Survey 3 identity and retention could not be calculated because all Survey 3 participants were retained in engineering. Convergent, discriminant, and predictive validity for the 5-item measure will continue to be assessed as longitudinal data are gathered regarding student engineering identity in their second year in the engineering program.

Conclusion

This paper describes progress to date in the validation of this measure, future steps, and the potential utility of the measure. Responses from a total of 2473 participants in their first year in an engineering program were used to derive and validate a 5-item measure of engineering identity. An EFA indicated that the measure had a single-factor structure, a finding supported by three CFAs conducted utilizing data collected at three different time points. In addition, evidence of convergent, discriminant, and predictive validity was demonstrated, further supporting the utility of this measure. Validity will continue to be assessed as data collection continues with participants in their second year in the engineering program. A concise, validated measure of identity will be valuable for quick assessment of student engineering identity and gaining further understanding of retention in engineering disciplines. This measure can also be used to identify students at risk for attrition. Furthermore, this measure has the potential to be utilized in the development of programs and interventions designed to address low levels of engineering identity and improve retention rates. This material is based upon work supported by the National Science Foundation under Grant No. 1504741.

References

[1] S. Olson and D. G. Riordan, "Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics," Executive Office of the President, President's Council of Advisors on Science and Technology, Washington, DC, Report to the President, Feb. 2012.

[2] M. W. Ohland, S. D. Sheppard, G. Lichtenstein, O. Eris, D. Chachra, and R. A. Layton, "Persistence, engagement, and migration in engineering programs," *Journal of Engineering Education*, vol. 97, pp. 259-278, July 2008.

[3] S. J. Ceci and W. M. Williams. *Why aren't more women in science: Top researchers debate the evidence*. Washington, DC: American Psychological Association, 2007.

[4] M. Eliot and J. Turns, "Constructing professional portfolios: Sense-making and professional identity development for engineering undergraduates," *Journal of Engineering Education,* vol. 100, pp. 630–654, Oct. 2011.

[5] H. M. Matusovich, R. A. Streveler, and R. L. Miller, "Why do students choose engineering? A qualitative, longitudinal investigation of students' motivational values," *Journal of Engineering Education,* vol. 99, pp. 289–303, Oct. 2010.

[6] K. L. Tonso, "Student engineers and engineer identity: Campus engineer identities as figured world," *Cultural Studies of Science Education,* vol. 1, pp. 273-307, Sep. 2006.

Appendix A

Survey Items

Engineering Identity

1. **Engineering is an important part of who I am.**
2. I strongly identify with engineering.
3. When I talk about people in engineering, I usually say ‘we’ rather than ‘they’.
4. When someone praises engineering, it feels like a personal compliment.
5. I am interested in what others think of the engineering field.
6. I am excited when advancements are made in engineering.
7. **I feel a personal attachment to engineering.**
8. **Engineering has a great deal of personal meaning for me.**
9. **I see engineering as a significant part of my life.**
10. **I spend a lot of time in casual conversations about engineering.**
11. Engineering is something I care about.

**Note*. The final 5-item Engineering Identity measure is comprised of the items in bold. Response scale ranged from 1 (*strongly disagree*) to 5 (*strongly agree*).

Self-Efficacy

1. I believe I will receive excellent grades in courses required for the engineering major.
2. I’m certain I can understand the most difficult material presented in courses required for the engineering major.
3. I’m confident I can understand the basic concepts taught in courses required for the engineering major.
4. I’m confident I can understand the most complex material presented in courses required for the engineering major.
5. I’m confident I can do an excellent job on the assignments and tests in courses required for the engineering major.
6. I expect to do well in courses required for the engineering major.
7. I’m certain I can master the skills being taught in courses required for the engineering major.
8. Considering the difficulty of courses required for the engineering major and my skills, I think I will do well in these courses.

**Note*. Response scale ranged from 1 (*not at all true of me*) to 7 (*very true of me*).

Engineering Embeddedness

Fit

1. The way I think fits well with engineering.
2. I have the right skills and abilities for engineering.

3. I am well suited for engineering.
4. I thrive on the challenge engineering offers.
5. Engineering is my passion.

Links

1. I like that people in engineering think the same way I do.
2. My professors make me feel more connected to engineering.
3. I feel well understood by other engineering students.
4. I try to bring other people into the engineering community.
5. I enjoy being around other students in engineering.

Sacrifice

1. Because I'm in engineering, I am likely to have a good career.
2. I take a great deal of pride in being an engineering student.
3. I've invested a great deal in my engineering major.
4. I stand out from others because I'm in engineering.

**Note*. Response scale ranged from 1 (*strongly disagree*) to 5 (*strongly agree*).

Major Satisfaction

1. All in all I am satisfied with my engineering major.
2. In general, I don't like my engineering major. (Reverse Scored)
3. In general, I like being in my engineering major.

**Note*. Response scale ranged from 1 (*strongly disagree*) to 5 (*strongly agree*).