Work in Progress: Using the Critical Incident Technique to Illuminate the Relationship between Engineering Identity and Academic Motivation

Caroline Bolton, Bucknell University
Dr. Kaela M. Martin, Embry-Riddle Aeronautical University

Kaela Martin is an Assistant Professor of Aerospace Engineering at Embry-Riddle Aeronautical University, Prescott Campus. She graduated from Purdue University with a PhD in Aeronautical and Astronautical Engineering and is interested in increasing classroom engagement and student learning.

Dr. Elif Miskioglu, Bucknell University

Dr. Elif Miskioglu is currently an Assistant Professor of Chemical Engineering at Bucknell University. She graduated from Ohio State University in 2015 with a PhD in Chemical Engineering, and is interested in student learning in engineering. In particular, her work focuses on various aspects of students' development from novice to expert, including development of engineering intuition, as well as critical thinking, problem-solving, and communication skills.

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Introduction

This work in progress research paper presents preliminary work on a project that aims to identify whether engineering identity and academic motivation are correlated to the extent that one may predict the other. Engineers face challenges which can result in both failure and triumph. Studying the source of an individual's motivation in conjunction with how they perceive themselves as an engineer may provide long-term insight into ways in which one can positively enhance the other. Previous work suggests that establishing a strong sense of identity in the workplace can result in greater career motivation [1]. We hypothesize that a stronger sense of engineering identity correlates with stronger academic motivation, and that ultimately one may be used to measure the other with acceptable validity and reliability. This connection will allow researchers, and educators, to leverage existing quantitative methods for measuring engineering identity to gain further insights while minimizing student/participant survey fatigue [2].

In past work, it has been shown that different settings (i.e., professional, social, etc.) highlight different aspects of identity. Engineering identity can be defined as a role identity many engineering students embody during college [2]. Role identity consists of the social and cultural constructs an individual associates with a specific role [2], such as in this case, the role of an engineer. In some cases, multiple parts of one's identity conflict with an established version of another [3]. For example, women who pursue careers in STEM often find themselves conflicted between negatively stereotyped feminine traits and stereotyped STEM traits which have become over-emphasized in society [4]. These conflictions can leave women at a crossroads of identity. Women who view themselves as gender-STEM incompatible are more likely to have lower self-esteem and less motivation as a result [4].

Motivation, our other construct of interest, can be viewed as the choices an individual makes to either approach or avoid certain experiences and how much effort they exert in order to do so [5]. Previous work has shown that student motivation in particular is influenced by a perception of the future self, which is also linked to perception of the present self [6]-[8]. From an academic perspective, if a student does not feel confident within their area of study, their motivation towards academic goals may be hindered. This work in progress aims to identify whether patterns exist between the perceptions students carry of themselves as engineers and their motivation towards academic goals.

Methods

In this work, we piloted a new survey. Ultimately, we seek to understand whether motivation and identity, as we define them, are sufficiently correlated to use one as a measure of the other. Here we present preliminary results and analysis that will allow us to refine our study design as we progress towards this goal. Data is collected through a self-report survey, broken up into two sections: (1) Critical Incident Short Answer [9] and (2) Engineering Identity Instrument [2]. In each section, the participant is asked to be honest in the recollection of their individual mindset and behavior. The two sections of the survey were distributed electronically. To minimize survey fatigue, participants were presented the critical incident portion first (short answer), followed by the engineering identity instrument (Likert scale), before ending with demographic questions.

The sample population of this study is 52 students enrolled in a required upper-level aerospace engineering class at a private southwestern university. In Fall 2018, there were two sections of this particular class taught by the same instructor who distributed the survey as homework at the end of the semester. As an upper-level class, the student population mainly consisted of juniors and seniors. We believed it was important that the sample size consist of students further along in their college career, as they have had more time to develop an engineering identity. In addition, they are closer to graduating and joining the workforce of practicing engineers.

The survey begins with the critical incident portion. Critical incident technique collects qualitative observations of human behavior in correlation to a critical incident [9-10]. A critical incident refers to a situation with a clear purpose and observable consequences, open to the interpretation of the researcher [9-10]. In our survey, individuals are asked to a recall two times where they faced an academic or professional failure – one in which they recovered successfully and one in which they recovered unsuccessfully. Failure is thus defined in terms of how the student views it, similar to what they view as successful and unsuccessful. This section is composed of two sets of seven open-response questions, one for an unsuccessful recovery and one for a successful recovery respectively. They are as follows:

a. Approximately, how long ago did this incident occur?
b. Briefly describe the incident.
c. How did you react to this failure? Please elaborate.
d. Describe, if applicable, any immediate effect on your behavior or actions you took in response to the failure.
e. Why do you consider your recovery successful/unsuccessful? Please elaborate.
f. Do you believe others would also consider your recovery successful/unsuccessful? Why or why not?
g. Has your event affected your future behavior?

Based on their class section, participants were either given the “unsuccessful” recovery or “successful” recovery first, followed by the other option. This difference was implemented to mitigate the potential effects of the first failure type reflection on the answers for the other (i.e. a negative reflection could influence the next positive reflection). How an individual responds to failure can give a good amount of information pertaining to the general trends of said individual’s motivation. For analysis of this qualitative data we used emergent thematic analysis to code and subsequently identify thematic categories [11].

Upon completion of the short answer critical incident portion, the participant is asked to complete an engineering identity instrument [4]. This instrument considers three categories within engineering identity: (1) interest, (2) performance/competence, and (3) recognition. On a 7-point Likert scale (0 to 6) with only the endpoints of “Strongly Disagree” (0) and “Strongly Agree” (6) defined, each question prompts the student to evaluate how strongly they find these aspects within themselves as an engineer [2]. For analysis, the scores are averaged within each category. We consider average scores four or above to be “confident identity” individuals with respect to that category, while averaged scores three or less are deemed “weak identity.”

This work in progress works to analytically compare the behaviors students exhibit in response to failure with how they view themselves as engineers. Thus, we will use the qualitative inferences of how strongly motivated an individual appears from the critical incident portion of the survey and see how well those trends correlate with the level of confidence shown on the

engineering identity portion. We hypothesize engineering identity and academic motivation have a direct relationship.

Results and Discussions

Our work in progress report has preliminary analysis for one round of data collection with limited subjects. While we cannot yet answer our research question (is engineering identity correlated to motivation sufficiently such that one may measure the other?), we have gained valuable insight that allows us to re-approach our methodology for subsequent semesters.

Within our quantitative analysis of engineering identity, statistically significant ($\alpha = 0.05$) relationships were found between the three identity categories. Recognition and performance/competence show a direct relationship – high recognition scores correlated with high performance/competence scores ($p=0.0147$). Similarly, there is a direct relationship between performance/competence and interest ($p < 0.001$). In examining how the identity categories compare to demographic data, a relationship between recognition and how the individual is paying for their education arose. Students paying through loans, partial scholarship, or who were family funded tended to have a higher recognition of themselves as engineers ($p=0.0322$). On the other hand, the one student attending the university on a full scholarship had the lowest recognition and interest scores of the sample population. While this individual represents a lone data point, their recognition and interest averages were more than a full point below their peer averages, thus an interesting observation. Regardless of how an individual's scores ranked in terms of the three identity categories, there appeared to be five overarching themes related to motivation, shown in Table 1 which emerged when analyzing the qualitative data (responses to failure). These include the presence of grit/determination, acceptance of failure, change in behavior, change in mindset, and a denial of failure. These categories were defined through emergent patterns from the various responses.

Table 1: Terms of Motivation Categorization

Theme	Working Characterization of the Theme	Sample Evidence
Grit/Determination	The participant displays grit/determination if they appear to work through their failures rationally with strength.	"I was able to pass the course and get qualified [despite obstacles]."
Acceptance of Failure	The participant displays an acceptance of failure if they understand the terms of how and why they failed.	"If you can't deal with defeat, you wouldn't be in school"
Change in Behavior	The participant displays a change in behavior if they change one aspect of their typical habits to accommodate for future failure.	"I learned new study techniques to use in the future."
Change in Mindset	The participant displays a change in attitude and perspective but did not directly change behavior.	"made me humbler."
Denial of Failure	The participant displays a lack of failure if they relay that they have never experienced failure or if they left part of the survey blank.	"I have always been able to recover from an academic failure."

Initial analysis shows that these five categories do not appear to influence each other greatly. In later work, we plan on comparing each category with the three identity categories, as well as study existent relationships in the literature between these five categories and motivation.

More prominently, we did find a connection between identity in terms of race/ethnicity and grit/determination. This connection also correlated with which section of the course students were in. In the earlier section of the class, the majority of students identified as White or Caucasian, while the second section included a higher proportion of underrepresented minorities. The Fisher's Exact Test on section versus race/ethnicity produced a p-value of 0.0461 ($\alpha = 0.05$), meaning this difference in demographic background is statistically significant. In parallel, section one of the class was more likely to demonstrate grit/determination when faced with failure ($p = 0.0432$).

Conclusions

While this work is too preliminary to make any broad conclusions, we do report some interesting results that support future initiatives. As mentioned, we see within our sample population that identity with respect to the performance/competence category is directly correlated to both recognition and interest. We also see that how individuals pay for their education may be correlated to the strength of their recognition of themselves as engineers. Qualitative analysis has shown five major categories in motivation measured as response to failure: (1) grit/determination, (2) acceptance of failure, (3) change in behavior, (4) change in mindset, and (5) denial of failure. We cannot make statements on any five of the general trends in response to failure having a connection to engineering identity, as this analysis is not yet complete. However, it appears that identity or community may play a role in motivation as the two sections of the class showed statistically significant differences in presence of determination/grit.

Future Work

Because this is a work in progress and the first trial of a new study, there are many improvements we are implementing in the study design. In particular, the richness of student responses to the qualitative (short-answer) portion varied greatly, limiting our ability to draw strong conclusions from this data.

In our next iteration, we plan on transforming the critical incident portion into an interview. We will use the engineering identity survey to identify a representative sample of participants for the interviews, aiming to have representation from individuals of varying strengths of engineering identity among the three categories. Similar questions will be asked, but they will be presented face to face (in person or through video conference) with the student, giving a clearer image of their general behavior and personality, as well as the opportunity to ask direct follow-ups to draw a richer narrative. This method will decrease the chance of survey fatigue and provide us with more detail on each individual.

This work in progress focused on establishing preliminary relationships within motivation and identity respectively. Ultimately, we seek to assess whether these constructs are sufficiently correlated that one may be used as a valid and reliable means of measuring the other. Thus, our data analysis will include evaluating criterion-related validity (both predictive and concurrent) [10]. If such a relationship exists, it could support the usefulness of one construct in predicting the other.

References

[1] Blustein, David L., et al. “Relationship between the Identity Formation Process and Career Development.” *Journal of Counseling Psychology*, vol. 36, no. 2, Apr. 1989, pp. 196–202. *ProQuest*, doi:http://dx.doi.org/10.1037/0022-0167.36.2.196.

[2] Godwin, Allison. “The Development of a Measure of Engineering Identity.” *2016 ASEE Annual Conference & Exposition Proceedings*, ASEE Conferences, 2016. *Crossref*, doi:10.18260/p.26122.

[3] Kirn, Adam, et al. "Intersectionality of non-normative identities in the cultures of engineering." *ASEE Annual Conference & Exposition*. 2016.

[4] Ahlqvist, Sheana, et al. “Unstable Identity Compatibility: How Gender Rejection Sensitivity Undermines the Success of Women in Science, Technology, Engineering, and Mathematics Fields.” *Psychological Science*, vol. 24, no. 9, Sept. 2013, pp. 1644–52. *Crossref*, doi:10.1177/0956797613476048.

[5] Dickinson, Leslie. "Autonomy and motivation a literature review." *System* 23.2 (1995): 165-174.

[6] Husman, Jenefer, and Willy Lens. "The role of the future in student motivation." *Educational psychologist* 34.2 (1999): 113-125.

[7] Markus, Hazel, and Paula Nurius. "Possible selves." *American psychologist* 41.9 (1986): 954.

[8] Benson, Lisa, Adam Kirn, and Courtney June Faber. "CAREER: Student motivation and learning in engineering." *2014 ASEE Annual Conference & Exposition*. 2014.

[9] Flanagan, John C. "The critical incident technique." *Psychological bulletin* 51.4 (1954): 327.

[10] Cohen, Louis, Lawrence Manion, and Keith Morrison. *Research methods in education*. routledge, 2002

[11] Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook* (3rd ed.). Thousand Oaks, CA: Sage Publications.