

Self-perceptions Regarding Researcher Identity Development in Engineering Doctoral Students: Preliminary Results

Abstract ID: 2602

**Diego A. Polanco-Lahoz, Fabiola L. Carrión-Anampa,
Jennifer A. Cross, Kelli Cargile Cook, Mario Beruvides**
Texas Tech University

Abstract

This paper presents preliminary results from a study on the development of engineering doctoral student identity. Although existing research suggests many factors could influence the formation of engineering identity in doctoral students (e.g., on-campus vs. online status, gender, ethno-racial background, previous professional experience), very little research explores identity development in doctoral engineering students specifically and on the process of engineering identity development generally. This paper focuses on the design and initial implementation of a survey to measure self-perceptions regarding researcher identity development, using a preliminary sample of 12 students enrolled in a doctoral course in industrial engineering. Godwin's [13] engineering identity scales are adapted to create a three-factor model of researcher identity: recognition, interest, and performance/competence. The survey also collects data on participant demographics, curricular and extra-curricular activities, specific challenges faced as researchers, and career plans. Although findings are preliminary due to the sample size, they reveal that, on average, participants presented high interest, high competence, and a moderate to high level of recognition; however, a few displayed response patterns that might be indicative of "imposter syndrome," with noticeably lower ratings than their peers in one or more categories. Further, preliminary Cronbach's alpha values provide initial support for the reliability of the proposed scales. In addition to helping to address the research gaps previously identified, this study will ultimately have practical impacts in designing more effective engineering doctoral programs and improving the experience of engineering doctoral students from different backgrounds. Data collection from additional semesters and additional students is ongoing.

Keywords

Survey, Research Identity Development, Engineering Identity, Engineering Identity Development

1. Introduction

The paper looks to address research gaps related to the process of formation of engineering doctoral student identity. In the last two decades there has been increasing research attention on engineering identity formation [1]; however, there is still relatively little knowledge about the process through which engineering students create their identity [2,1,3]. Also, most of the studies that focus on engineering identity development are done with undergraduate education [4,5,1,3]. This study will provide important data on engineering identity formation at the graduate level. There are key differences between engineering undergraduate and graduate students, one being that most of the graduate students in engineering already have an undergraduate degree (usually in engineering) [4], and many already have a period of full-time professional experience before entering the graduate program. Therefore, most engineering graduate students, especially doctoral students, already have a professional identity [6,7].

By understanding better the process of engineering identity development, this research looks to have an impact on the design of engineering doctoral programs and the potential improvement of students' mental health and attrition rates. It is also an ultimate goal of this study to bridge gaps related to gender and race in graduation rates and make engineering doctoral programs a more viable path for students. In general, the study looks to have a positive impact on the overall engineering community (students, educators, researchers, and society).

2. Literature Review

This research focuses on identity as a multi-faceted concept that describes a person's "sense of self" or "sense of belonging" [8,9]. One of the facets of identity as a concept is professional identity, which refers to "personal identification with the duties, responsibilities, and knowledge associated with a professional role" [10, p.631]. As a specific type of professional identity, engineering identity has various definitions [2,1]; one of them is the extent to which an individual and others recognize the individual as being and acting like "an engineer" [11,12]. Another definition refers to the combination of the individual's perceptions of their own skills in the engineering field, their interest in engineering work, and the extent to which others recognize them as an engineer [13].

A previous study by Hancock and Walsh [14] explored STEM doctoral programs and the challenges they face to form an effective professional identity in their doctoral students; this study [14] took into account the many recent changes STEM doctoral students have in their academic landscape, in particular the fact that many of them now end up pursuing non-academic careers but must still successfully forge a researcher identity. However, that study [14] did not focus on engineering specifically. Another study by McAlister et al. [15] introduced a conceptual framework called the Role Identities of Doctoral Engineering Students (RIDES) that helps understand engineering doctoral students' identities. This framework provides a unique perspective to examine the dynamic interactions of different personal (ethnoracial, gender, and other) and professional (student, engineer, researcher, and educator) identities of engineering doctoral students; however, it appears the framework has not been tested empirically at this point. Another important point is that neither of these studies [14,15] have explored or focused on the process of engineering identity formation; also, these studies did not focus on the connection between doctoral engineering students and the creation of their "researcher" identity; therefore, this research also assists in filling that research gap. Although, due to the paper length restriction, the studies cited here are only examples of the existing literature, there is currently a need for more research, particularly longitudinal research, on the process of identity formation in engineering doctoral students.

Another important concept explored in this research is impostor syndrome (or impostor phenomenon), which is defined by Bravata et al. [16] as the situation when high-achieving people fail to interiorize their achievements and are constantly scared of being exposed as impostors. Normally individuals with impostor syndrome tend to fail to accept their success as due to their own competencies and skills [16].

3. Methodology

The results reported in this paper focus on administering a 30-question survey to a preliminary sample of 12 students enrolled in a doctoral program within the industrial engineering department at a large state university. Participants were invited from a summer course given on the university campus. All those invited accepted to participate, for a response rate of 100%. To answer the survey, participants used smartphones and laptops. The survey's creation involved the use of the Qualtrics Survey Maker tool. This study was approved by the institution's IRB as IRB2021-856 Mapping Identity Development in Doctoral Engineering Students.

The items in the survey were mainly close-ended and quantitative, with a few qualitative and open-ended. The close-ended items asked for information regarding participant demographics, researcher identity self-perception (based on Godwin's [13] engineering identity scales), satisfaction with the current degree program, curricular and extracurricular events, perceived competence in several discipline-specific knowledge areas, and factors affecting the selection of their major. Open-ended questions asked the participants to elaborate if they wanted (these were not mandatory) on their answers to certain close-ended items. As indicated in Table 1, the constructs to measure researcher identity come from an adaptation of the three-factor model of engineering identity from Godwin [13]. In her study, Godwin defines recognition as "the feeling that others see them as a good engineering student", interest as "desire/curiosity to think about and do well in engineering", and competence as "belief in the ability to perform required engineering tasks and understand engineering content" [13]. The process of adapting Godwin's [13] survey comprised taking the three dimensions (recognition, interest, and competence), as well as the specific items within each dimension, and adapting them from an engineering perspective to a researcher's perspective. For example, Godwin's first item for recognition was "My parents see me as an engineer", and the adapted survey question is "My family sees me as a researcher". The response scale used for the identity items was a 5-point Likert agreement scale: 1="Strongly disagree", 2="Disagree", 3="Neutral", 4="Agree", and 5="Strongly agree". Another recent study [17] took a similar approach to developing a researcher identity measure, building upon Godwin's [13] items but more significantly altering the wording of most items and also adding 15 new items. Due to the similar approach, the first and third "recognition" items in the current study coincidentally used identical wording as [17] but all other items differed.

Table 1. Comparison of Godwin's engineering identity scales [13] and this paper's researcher identity scales

Factor	Godwin's Items [13]	Adapted Items
Recognition	1. My parents see me as an engineer. 2. My instructors see me as an engineer. 3. My peers see me as an engineer.	1. My family sees me as a researcher [17]. 2. My instructors see me as a researcher. 3. My peers see me as a researcher [17].
Interest	1. I am interested in learning more about engineering. 2. I enjoy learning engineering. 3. I find fulfillment in doing engineering.	1. I am interested in learning more about research. 2. I enjoy learning how to do research. 3. I find fulfillment in doing research.
Performance/ competence	1. I am confident that I can understand engineering in class. 2. I am confident that I can understand engineering outside of class. 3. I can do well on exams in engineering. 4. I understand concepts I have studied in engineering. 5. Others ask me for help in this subject.	1. I am confident that I can understand research concepts presented in my classes. 2. I am confident that I can apply research concepts outside of class. 3. I can do well on research projects in my field of study. 4. I understand research concepts I have studied in my degree program. 5. Others ask me for help using research concepts.

Afterward, data from the survey was used to analyze the reliability of the survey, the average self-perception on the three different identity dimensions (competence, interest, and recognition) for the sampling group, and response patterns from participants in the group. The reliability of the survey was analyzed by calculating Cronbach's alpha values for each dimension. A subsequent interpretation of these results is provided in the Discussion section.

4. Results

As indicated in Table 2, results from the study showed that the group, as a whole, presented high interest, high competence, and a moderate to high level of recognition. Due to the small sample size, no statistical tests of within-group differences were conducted; however, potential patterns were observed. One participant presented noticeably lower interest values than the rest of the group (participant F). Three participants presented noticeably lower competence than the rest of the group (participants C, F and L). Four participants presented noticeably lower recognition than the rest of the group (participants A, C, F, and K). The results shown consider participant J's answers, although this participant omitted answers from the survey regarding recognition and competence items.

Table 2. Participant, their average levels of identity items, and group average on the same items

Participant	Recognition	Interest	Competence
A	3.33	4.33	4.60
B	4.33	5.00	4.80
C	2.33	4.67	3.60
D	4.67	4.67	4.80
E	4.33	5.00	4.00
F	2.33	3.00	3.60
G	4.00	4.67	4.20
H	4.00	4.67	4.00
I	4.00	4.67	4.00
J	.	4.00	.
K	2.33	4.67	4.00
L	4.33	4.00	3.00
Averages	3.63	4.45	4.05

Regarding reliability measures, the study involved calculating Cronbach's alpha for multi-item questions involving self-perception in the survey. These questions focused on: analyzing the influence of various factors on the decision to pursue the major before (Question 7) and after one semester completed (Question 10), self-rating of preparedness in different degree knowledge areas (Question 29), satisfaction in aspects of courses taken while in the program (Question 13), agreement with statements referring to advising experience (Question 15), and agreement with statements related to the three identity dimensions (Question 16). Excepting Question 16, the Cronbach's alpha mean for each multi-item question was not lower than 0.8, and, when analyzed for each item asked for each question, none of them presented any value lower than 0.8 if the item on the respective question was deleted. Literature suggests that over 0.7 is an acceptable level of reliability [18]. Although in the Discussion section specifics on Cronbach's alpha interpretation for this study are presented, Tables 3 and 4 summarize findings on Cronbach's alpha for the survey.

Table 3. Summary of Cronbach's alpha values for Questions 7, 10, 29, 13 and 15

Self-perceived questions	C. alpha average	Comments
Question 7 Importance of factors before decision to major	0.839	Deletion of any item did not change C. alpha below 0.8
Question 10 Importance of factors after one semester in major	0.934	Deletion of any item did not change C. alpha below 0.9
Question 29 Preparedness level in areas	0.861	Deletion of any item did not change C. alpha below 0.8
Question 13 Satisfaction regarding courses taken	0.904	Deletion of any item did not change C. alpha below 0.8
Question 15 Agreement level for statements on advising experience	0.910	Deletion of any item did not change C. alpha below 0.85

Table 4. Summary of Cronbach's alpha values for Question 16's researcher identity dimensions

Question 16 dimension	C. alpha average	Comments
Recognition	0.926	Deletion of any item did not change C. alpha below 0.8
Interest	0.791	Deletion of any item did not change C. alpha below 0.65
Competence	0.776	Deletion of any item did not change C. alpha below 0.65

5. Discussion

From the results obtained from the identity dimension averages, the study showed that the participants of the group presented on average a high level of interest, a high level of competence, and a moderate to high level of recognition. This overall analysis changes when the scope goes from the entire group to individual participants. To highlight these cases, participant L seems to have presented a form of imposter syndrome. Literature describes people with this syndrome as high-achieving individuals who, despite their objective successes, fail to internalize their

accomplishments and have persistent self-doubt and fear of being exposed as a fraud or impostor [16]. This can be recognized for this study as a lower level of self-perception on competence, independent of self-perceptions of recognition and interest. This is the case that participant L presented, where the answers given showed the lowest level of self-perception on competence among the entire group despite similar levels of interest and recognition to other participants. A similar case of imposter syndrome appears to be presented by participant C. The difference between these two cases was the recognition level. Participant C had noticeably lower perceptions of recognition than others in the group, whereas, as previously noted, participant L had similar levels to others in the group.

Another interesting case is the participant with the lowest level of interest among the entire group: participant F. This participant also had the lowest levels of perceived recognition in the group (tied with participants C and K) and among the lowest levels of competence. As the perceived level of interest is also relatively low, this participant's response pattern does not seem to fit the classical imposter syndrome, but instead suggests a struggle to strongly establish their researcher identity to date; this might suggest this individual will be at greater risk for attrition from the program. Future research and examination of other study data (e.g., the linked journey maps being used for other aspects of the study) might shed further light on the reasons for this finding. One potential factor is revealed in the answers to the open-ended question where, when asked "Which of these jobs [jobs the participant believes their research skills prepare them for] most interest you? Why?" the participant answered, "Make money, do not really care about all that [sic] other things". This response may potentially explain the lower values of recognition and interest, i.e., that the participant's motivation in seeking the degree might be primarily financial, and external recognition does not seem to be important to them; however, it does not appear to explain the lower perceived competence level.

Finally, the results of reliability analysis (i.e., Cronbach's alpha calculations) show that the self-perception questions in the survey are reliable for the group analyzed. Literature supports this idea, because, according to Nunnally, at an early stage of research, a value of 0.7 on Cronbach's alpha is acceptable [18]. Preliminary results from the study present the lowest Cronbach's alpha value as 0.8 for all questions except Question 16. For Question 16, the lowest Cronbach's alpha value was for the competence dimension, with 0.776. Following Nunnally's findings, this dimension is reliable for this stage of research, but for future work, this value should ideally increase to at least 0.8. Another important consideration relates to the change of Cronbach's alpha values for interest and competence dimensions if one or more items are deleted. In the current state, the deletion of at least one item for the interest and competence dimension means a drastic fall in the reliability of the survey.

6. Conclusion

Results from this study are auspicious and should be taken as a starting point for future research on engineering identity formation in doctoral students. These results include the reliability of the survey, where the study indicates, by considering Cronbach's alpha values, that the survey is reliable; this helps in assuring that the items adapted from Godwin [13] are a good fit for measuring researcher identity levels in doctoral programs. Results from these adapted identity scales showed that, overall, recognition had somewhat lower self-perceptions from doctoral students than interest or competence; this suggests the need for doctoral programs to improve on the mentorship goals to have students that feel more recognized. Individual participant results from items also presented interesting patterns, where the background of participants will be important to consider in future research. These different backgrounds include participant experiences while in the program. Projects or events that offer cross-functional collaboration or community engagement can help encourage students to be involved with interdepartmental connections; thus, helping them to be motivated and recognized by their professors or peers, and enriching their experiences.

A key limitation of this study is that results are very preliminary and the current sample size is only 12 students. While these preliminary results are being analyzed, the next round of participants is being recruited. The hope is to increase the sample size, which will strengthen analysis and potential conclusions obtained. This survey's psychometric results can be compared and enhanced in the future when new data from the next round of participants are available, as well as compared to those from the longer researcher identity measure in [17]. Data from future rounds of data collection will also be helpful to determine if new patterns can be found, at an individual or group level. Future work will also focus on the longitudinal aspect of identity development in these and other study participants. Data from this study considers participants in different semesters from their doctoral programs, but people in their seventh or eighth semesters are the least frequent of all participants. Future research will help to determine if the self-perception from the first and second-year participants will change or not over time. Finally, other related ongoing research using different qualitative methods (e.g., journey mapping and focus groups) is already being conducted. Future work can compare results obtained from these different methods, aiming to identify more prominent patterns.

Acknowledgement and Disclaimer

This material is based upon work supported by the National Science Foundation under Award No. 2205033. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

- [1] J. Morelock. "A systematic literature review of engineering identity: definitions, factors, and interventions affecting development, and means of measurement". *European Journal of Engineering Education*, vol. 42, no. 6, pp. 1240-1262, 2017. Available: <https://www.tandfonline.com/doi/abs/10.1080/03043797.2017.1287664>
- [2] Patrick, & M. Borrego. "A Review of the Literature Relevant to Engineering Identity". In *American Society for Engineering Education Annual Conference*. June 2016. Available: <https://par.nsf.gov/servlets/purl/10066208>
- [3] A. Elizondo-Noriega, N. Tiruvengadam, K. Cargile-Cook, J. Cross, & M. Beruvides. "Understanding Engineering Identity Formation Mechanisms in Graduate and Undergraduate Education: A State-of-the-Art Matrix Analysis". In *IISE Annual Conference Proceedings*, pp. 1-6. Institute of Industrial and Systems Engineers (IISE) 2020. Available: <https://www.proquest.com/docview/2522431819?pq-origsite=gscholar&fromopenview=true>
- [4] N. Choe, & M. Borrego. "Prediction of engineering identity in engineering graduate students". *IEEE Transactions on Education*, vol. 62, no. 3, pp. 181-187. 2019. Available: https://ieeexplore.ieee.org/abstract/document/8667045?casa_token=ZzGW5lmPdY4AAAAA:gm_Q4_UNkYsq25uGED5An9gYG1Re_0LH4I-4AGKBQ0uV9L3MIMHqu3mtulqvYSJUzyf1V64_Aus
- [5] M. Bahnson, H. Perkins, M. Tsugawa, D. Satterfield, M. Parker, C. Cass, & A. Kirn. "Inequity in graduate engineering identity: Disciplinary differences and opportunity structures". *Journal of Engineering Education*, vol. 110, no. 4, pp. 949-976. 2021. Available: <https://onlinelibrary.wiley.com/doi/abs/10.1002/jee.20427>
- [6] M. Caskey, D. Stevens, & M. Yeo. "Examining doctoral student development of a researcher identity: Using the draw a researcher test". *Impacting Education: Journal on Transforming Professional Practice*, vol. 5, no. 1. 2020. <http://impactinged.pitt.edu/ojs/ImpactingEd/article/view/92>
- [7] L. Hall, & L. Burns. "Identity development and mentoring in doctoral education". *Harvard Educational Review*, vol. 79, no. 1, pp. 49-70. 2009. Available: <https://meridian.allenpress.com/her/article-abstract/79/1/49/31955/Identity-Development-and-Mentoring-in-Doctoral>
- [8] K. Evans. *Negotiating the self*. New York: Routledge Falmer, 2002.
- [9] K. Tonso. "Student engineers and engineer identity: Campus engineer identities as figured world". *Cultural Studies of Science Education*, 1, pp. 273-307. 2006. Available: <https://link.springer.com/article/10.1007/s11422-005-9009-2>
- [10] M. Eliot, & J. Turns. "Constructing professional portfolios: Sense-making and professional identity development for engineering undergraduates". *Journal of Engineering Education*, vol. 100, no. 4, pp. 630-654. 2011. Available: <https://onlinelibrary.wiley.com/doi/abs/10.1002/j.2168-9830.2011.tb00030.x>
- [11] A. Dehing, W. Jochems, & L. Baartman. "The development of engineering students professional identity during workplace learning in industry: A study in Dutch bachelor education". *Engineering Education*, vol. 8, no. 1, pp. 42-64. 2013. Available: <https://www.tandfonline.com/doi/abs/10.11120/ened.2013.00007>
- [12] L. Mann, P. Howard, F. Nouwens, & F. Martin. "Influences on the development of students' professional identity as an engineer". In *Proceedings of the Research in Engineering Education Symposium*, Palm Cove, QLD, pp. 1-6. 2009. Available: http://rees2009.pbworks.com/f/rees2009_submission_64.pdf
- [13] A. Godwin. "The development of a measure of engineering identity". In *ASEE Annual Conference & Exposition*. January 2016. Available: <https://par.nsf.gov/biblio/10042227>
- [14] S. Hancock, & E. Walsh. "Beyond knowledge and skills: Rethinking the development of professional identity during the STEM doctorate." *Studies in Higher Education*, vol. 41, no. 1, pp. 37-50. 2016. Available: <https://www.tandfonline.com/doi/abs/10.1080/03075079.2014.915301>
- [15] A. McAlister., S. Lilly., & J. Chiu. "A Framework for Examining Engineering Doctoral Student Identity". In *2021 ASEE Virtual Annual Conference Content Access*. July 2021. Available: <https://peer.asee.org/36580>
- [16] D. Bravata, S. Watts, A. Keefer, D. Madhusudhan, K. Taylor, D. Clark, ... & H. Hagg. "Prevalence, predictors, and treatment of impostor syndrome: a systematic review." *Journal of General Internal Medicine*, vol. 35, pp. 1252-1275. 2020. Available: <https://link.springer.com/article/10.1007/s11606-019-05364-1>
- [17] H. Perkins, M. Bahnson, C. Cass, M. Tsugawa-Nieves, & A. Kirn, "Development and testing of an instrument to understand engineering doctoral students' identities and motivations." In *2018 ASEE Annual Conference & Exposition*. June 2018. Available: <https://peer.asee.org/30319>
- [18] J. Nunnally. *Psychometric theory*. New York: McGraw-Hill Inc., 1978.