2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #32456

Examining the Components of an Engineering Leadership Identity

Dr. William J. Schell IV P.E., Montana State University - Bozeman

William J. Schell holds a Ph.D. in Industrial and Systems Engineering – Engineering Management from the University of Alabama in Huntsville and M.S. and B.S. degrees in Industrial and Management Engineering from Montana State University (MSU). He is Associate Professor and Program Coordinator of Industrial and Management Systems Engineering, Associate Director of the Montana Engineering Education Research Center, and a KEEN Leader at MSU with research interests in engineering education and the role of leadership and culture in process improvement. His research is supported by the NSF, private foundations, and industry and has received numerous national and international awards. He is an elected Fellow of the American Society for Engineering Management and serves as an Associate Editor for the Engineering Management Journal . Prior to his academic career, Schell spent 14 years in industry where he held leadership positions focused on process improvement and organizational development.

Dr. Bryce E. Hughes, Montana State University - Bozeman

Bryce E. Hughes is an Assistant Professor in Adult and Higher Education at Montana State University, and holds a Ph.D. in Higher Education and Organizational Change from the University of California, Los Angeles, as well as an M.A. in Student Development Administration from Seattle University and a B.S. in General Engineering from Gonzaga University. His research interests include teaching and learning in engineering, STEM education policy, and diversity and equity in STEM.

Mr. Brett Tallman P.E., Montana State University - Bozeman

Brett Tallman is currently a Doctoral student in Engineering at Montana State University (MSU), with focus on engineering leadership. His previous degrees include a Masters degree in Education from MSU (active learning in an advanced quantum mechanics environment) and a B.S. in Mechanical Engineering from Cornell. Prior to his academic career, he worked in the biotech (Lead Engineer), product design, and automotive (Toyota) sectors for 14 years, and is a licensed Professional Engineer. He has also taught high school and attended seminary. You can find more of his engineering education work at educadia.org or on his YouTube channel.

Monika Kwapisz, Montana State University - Bozeman

Monika Blue Kwapisz (they/them) is an undergraduate at Montana State University studying Industrial and Management Systems Engineering with a minor in Mathematics. Monika is the former president of MSU's Out in Science, Technology, Engineering, and Mathematics (oSTEM) chapter, a cross-country ski coach, and an avid outdoors-person.

Miss Tessa Sybesma, Montana State University

Tessa is in her fifth year of study at Montana State University and is entering into the graduate Industrial and Management Systems Engineering Department in the following year. Her interests focus in organizational development, human resource development, and implementation consulting.

Examining the Components of an Engineering Leadership Identity

Abstract
Most approaches to develop leadership in engineering students center on learning leadership skills or cultivating leadership traits. These approaches show mixed results in terms of longer-term translation of these learning outcomes into graduates holding leadership roles in the workplace or viewing themselves as leaders. Grounded in research on engineering identity, this project posited that an identity-based approach to engineering leadership may provide a more efficacious way to develop leadership as part of engineering formation that integrates leadership into engineers' professional identities. To explore this proposition, this project employed a sequential, mixed-methods study resulting in development of a grounded theory of engineering leadership for undergraduate engineering students.

This paper shares an overview of the project's path during the funded period and highlights initial findings of how engineering undergraduates define engineering leadership. Starting from the assumption that the formation of engineers is fundamentally an identity development process, the framework for this project combined Lave and Wenger's communities of practice model to understand development of an engineering identity with Komives, et al.'s Leadership Identity Development Model for understanding how engineering students cultivate a self-concept as a leader. Overall, findings helped reveal how the components of engineering identity and leadership identity converge in the development of an engineering leadership identity among undergraduate students.

Introduction

There are many reasons that developing leadership skills in undergraduate engineering students is important. Chief among these is that many of the greatest challenges facing society today, such as the NAE Grand Challenges [1] and "Transition to Scale" challenge in Grand Challenges Canada [2], require technical solutions that can only be developed through collaboration within interdisciplinary teams. For these collaborations to effectively harness the diverse capabilities of these teams, effective technical leadership must be deployed.

While the education system has worked to increase graduation rates of technical professionals--such as engineers—there are persistent demands from industry to improve professional skill competencies [1], [2]. This NSF-funded project has worked to bridge this gap by developing a data-driven understanding of how undergraduate engineers develop as leaders through the lens of identity constructs [3]. An exploration of the project's methods, summary of previously published work, and draft of an initial grounded theory is the focus of this work.

Methods Overview

Figure 1 shows the theoretical construct of engineering leadership identity guiding this work, which theorized that an engineering leadership identity existed at the intersection of the more widely researched topics of engineering identity and leadership identity.

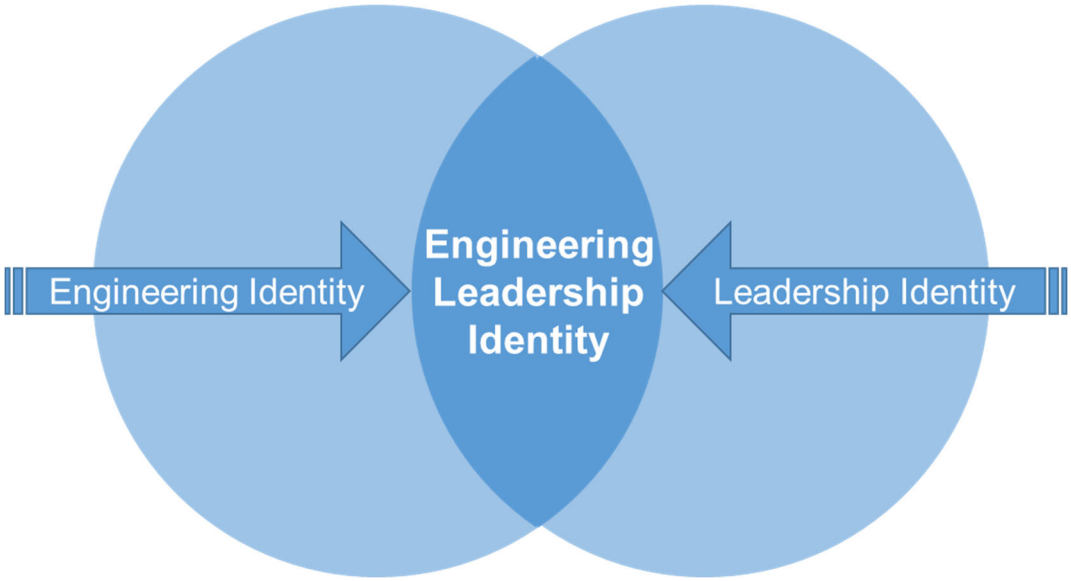

Figure 1. Theoretical Development of an Engineering Leadership Identity

Beginning with this theoretical construct, the project progressed through three phases, beginning with quantitative analysis of two national data sets, followed by collection and analysis of qualitative data from three large universities, and concluding with the development of a grounded theory of engineering leadership identity. Details of the findings from the quantitative studies, including differences between engineering students and their peers in other fields, can be found in [4-9]. The results of those studies were then integrated with protocols found in the literature from numerous qualitative studies of leadership and / or identity to develop the qualitative focus group protocols utilized with students. The qualitative protocols explored three distinct areas of student perceptions: engineering identity, leadership identity, and engineering leadership identity. Table 1 provides an example of the questions utilized in each of the three protocol areas.

Table 1. Sample Protocol Questions by Area

Topic Area	Sample Question(s)
Engineering Identity	Think back to when you first decided to major in engineering. Can you recall what you thought an engineer was or does, at the time?
Leadership Identity	Do you see yourself as a leader? Why/why not? Can you provide an example of a time when you most felt like you were a leader?
Engineering Leadership Identity	Do you see leadership playing a role in being an engineer? What would that role be?

Participants for this study were undergraduate engineering majors at three U.S. universities. These three universities were selected to represent a range of institutional settings with regard to diversity of participants and diversity of their experiences. The three universities were Montana State University, which has been recognized for its commitment to serving American Indian students; University of Colorado - Boulder, one of the top public universities in the United States; and University of Texas - Arlington, a Hispanic-serving institution in an urban setting with a large proportion of commuter students. Over the course of seven months, a total of twenty focus groups were conducted across these schools. The focus groups included 64 total students representing 17 different engineering majors, resulting in over 22 hours of recorded material.

To prepare data for qualitative analysis, recordings were transcribed by a professional service. Research team members then cleaned the transcripts for accuracy and clarity. To begin the development of coding, a single focus group was selected, and all six members of the team were instructed to read the transcript and write their list of initial codes. The group then spent several weeks discussing these potential codes and their applications to the sample transcript. The result was a simplified codebook of twelve codes (three categories with four codes each). The three categories were engineering, leadership, and engineering leadership, each composed of four codes related to development, identity, changes in perception, and traits (the code of particular interest in this paper). Once initial consensus was achieved, the group was split into two triads, with each assigned to a new transcript. Members of these groups then individually coded the transcript in NVivo and met to achieve consensus. These meetings led to further refinement of the simplified codebook.

After reaching consensus on this codebook, each triad returned to their most recent transcript, recoded it individually, and then met to reach consensus. This consensus building took place over several meetings at both the triad and team level resulting in robust documentation of rules for each code's use. These rules were then tested with an additional focus group by each triad. When consensus was achieved with minimal additional discussion and rule generation, the remaining focus groups were assigned to random pairs from the team. Each team member than coded each of their transcripts and met with their partner for that focus group to reach consensus. If the pair could not reach consensus, additional team members were consulted. The result of this effort was consensus coding for each transcript.

Initial Development of a Grounded Theory of Engineering Leadership

Using the text that was consensus coded to the major code of Engineering Leadership Identity (ELI) and its four sub codes: changes in view of ELI, developing ELI, precursors to ELI, and traits of ELI; the team employed a grounded theory approach [10] to develop a list of categories that describe students' definition of an Engineering Leadership Identity.

The most prominent of these categories involves recognition that ELI is grounded in technical expertise, similar to the first orientation from Rottman, Sacks and Reeve in their study of practicing engineers in the Toronto area [11]. In this category, students focused on the need for an engineering leader to provide knowledge and support and provide that support with confidence. Other categories identified in the initial theory development work included employing an analytical approach to dissecting problems, bringing a breadth of understanding to these problem solving efforts, and a willingness to engage in problems beyond their comfort

zone. This last theme was often grounded in growth from experiences with failure. Figure 2 contains a word cloud depiction of some of the most common words students used when discussing elements of Engineering Leadership Identity.

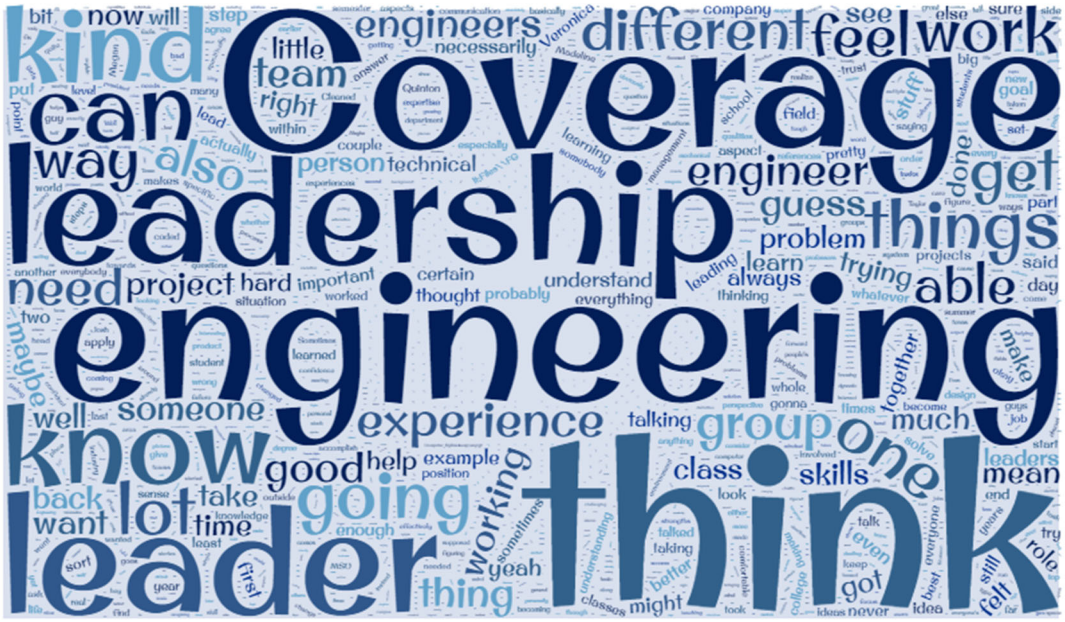

Figure 2. Common Words Students Use when Discussing Engineering Leadership Identity

Conclusion and Future Work

The team is currently working through the analysis to turn these initial themes into a final grounded theory of engineering leadership identity through deeper application of constant comparative approaches examining students' concepts of engineering identity, leadership identity, and engineering leadership identity. At the same time, a series of classroom interventions based on these draft theories are being tested to increase students' view of themselves as engineering leaders earlier in their engineering journey. Final results of both workstreams will be discussed during the conference poster session.

References

[1] National Academy of Engineering. "Grand Challenges - 14 Grand Challenges for Engineering." http://www.engineeringchallenges.org/cms/challenges.aspx (accessed.

[2] Grand Challenges Canada. "Transition To Scale." http://www.grandchallenges.ca/programs/transition-to-scale/ (accessed 12 April, 2018).

[3] W. J. Schell and B. E. Hughes, "An Approach to Understand the Role of Identity in Engineering Leadership.," in *Proceedings of the ASEE Annual Conference and Exhibition*, Columbus, OH, June 23 - 26 2017.

[4] B. E. Hughes, W. J. Schell, and B. Tallman, "Understanding Engineering Identity In Undergraduate Students," presented at the ASEM International Annual Conference, Coeur d'Alene, ID, October, 2018. [Online]. Available: https://search.proquest.com/docview/2193095035.

[5] B. E. Hughes, W. J. Schell, and B. Tallman, "Development of Leadership Self-Efficacy: Comparing Engineers, Other STEM, and Non-STEM Majors," in *FIE 2018 Conference Proceedings*, San Jose, CA, October 2018.

[6] W. J. Schell, E. H. Bryce, P. E. Brett Tallman, A. Emma, M. B. Romy, and B. K. Monika, "Exploring the Relationship Between Students' Engineering Identity and Leadership Self-Efficacy," presented at the ASEE Annual Conference and Exhibition, Tampa, Florida, 2019/06/15, 2019. [Online]. Available: https://peer.asee.org/32817.

[7] W. J. Schell and B. E. Hughes, "Are Engineers' Leadership Attitudes and Experiences Different than Other Students?," in *ASEM International Annual Conference*, Huntsville, AL, October 18 - 21 2017.

[8] W. J. Schell, B. E. Hughes, and B. Tallman, "Understanding the Perceived Impact of Engineers' Leadership Experiences in College," in *American Society for Engineering Education International Annual Conference*, Salt Lake City, UT, 2018 2018.

[9] W. J. Schell, B. E. Hughes, and B. Tallman, "Exploring the Conflict Between an Engineering Identity and Leadership," in *Canadian Engineering Education Association Annual Conference*, Vancouver, BC, Canada, 2018 2018.

[10] B. G. Glaser and A. L. Strauss, *The discovery of grounded theory : strategies for qualitative research*, 7th ed. New Brunswick, NJ: Aldine Transaction (in English), 2012.

[11] C. Rottmann, R. Sacks, and D. Reeve, "Engineering Leadership: Grounding leadership theory in engineers' professional identities," *Leadership,* vol. 11, no. 3, pp. 351 - 373, 2015, doi: 10.1177/1742715014543581.