Engineering Leadership Identity: A Qualitative Approach to Understand the Intersection of Engineering and Leadership Identities

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Abstract

Leaders in industry and government are calling for increasing innovation in STEM fields to maintain the nation's economic competitiveness. Solving today's complex challenges will require cooperation among experts from many fields. Successful leaders must harness the diverse capabilities of teams composed of these experts and be technically skilled. Undergraduate engineering students can fill this need by learning how to be effective leaders during their formation as engineers. Unfortunately, many engineering students graduate with little development of leadership skills; engineering educators do not currently have a sufficient understanding of how engineering students develop into leaders.

This NSF ECE supported project seeks to improve educators' understanding of the interaction between leadership and engineering identities in the formation of undergraduate engineers. This work postulates that a cohesive engineering leadership identity should exist at the intersection of engineering and leadership identities. Now entering its second year the project is wrapping up its quantitative phase and is beginning the qualitative phase of investigation. This paper discusses the process of developing the qualitative research protocols used to explore identity formation in groups of undergraduate engineers at three different campuses. The discussion shows the formation of the protocol using prior work in leadership and engineering identity constructs from both this project and the literature. The protocol development, methods, and findings from early interviews are presented. Initial findings suggest several factors are important to engineering educators interested in developing engineers who are ready to lead. The findings include evidence of some level of conflict between engineering identity and leadership identity as well as further evidence of engineering students' compartmentalization of leadership as outside of engineering.

In addition, this paper includes the learning outcomes of three REU students who joined the project to assist with the development of the qualitative protocol. The REU students made significant contributions to initial data collection as participants and observers. The REU students were the lead authors of this paper.

Introduction

As recently as December of 2018, the U.S. government affirmed a desire for increasing innovation in STEM fields by building "a STEM ecosystem" – an expansive network of relationships between educators, employers, and communities to foster STEM literacy [1]. Despite the focus on collaboration in this strategy, nowhere in the report is there any mention of management or leadership. In contrast to the absence of engineering leadership in this report, engineering leaders will be key to creating a successful STEM ecosystem due to their unique ability to coordinate interdisciplinary efforts to solve complex challenges associated with an increasingly interconnected world. Thus, it is key that engineering undergraduate students receive management or leadership training and build identities that align with leadership. This

paper provides an overview of the qualitative phase of a larger project to understand the development of engineering leadership identity. Results from the earlier quantitative phase can be found in our earlier work [2].

Conceptual Framework for the Development of an Engineering Leadership Identity

The qualitative protocol was built from two existing identity development models, the Leadership Identity (LID) model [3] and the Communities of Practice (CoP) model [4]. The LID model identifies four environmental conditions that influence the development of leadership identity. These conditions include contact with influential individuals, experiences with peers and perceived views of peers, meaningful involvement in curricular and co-curricular activities, and reflection on leadership experiences [3]. Within the Communities of Practice model identity development relies heavily on participation in a community and less so on mandatory, curricular activities [4]. In other words, in this model, formal education has less to do with students learning to be engineers than their activities and interactions, participation, identity, and other elements of simulative theory [5, 6].

A student's engineering identity intersects with personal and social identities. Engineering identity is formed through acquiring interest and competence in engineering, while also receiving social recognition as an engineer [7]. For further explanation of the application of LID and CoP to an engineering leadership study, see [2].

The qualitative research was conducted using a grounded theory approach. Grounded theory, originated by Glasser and Strauss in 1967, has been used in other engineering leadership research attempting to understand identity development [8, 3]. Since its inception grounded theory has been adapted and modified to a variety of contexts. The core principle of grounded theory is the "discovery of theory from data" instead of applying an existing theory to the data [9]. The goal is to reach a point of saturation, in which every participant is described by the model. Discriminant sampling, the questioning of participants who are similar to the individuals used to initially build the grounded theory, allows the researchers to confirm findings [10]. The research team employed snowball sampling, the recruitment of new informants from each sample of individuals interviewed [11].

Data

Sampling Approach

All participants for Focus Group 0, 1, and 2 were undergraduate engineering students attending the research project's host university, Montana State University in Bozeman, MT. Focus Group 0 was performed as a pilot study, so it consisted of all three NSF supported Research Experiences for Undergraduates (REU) students working on the project at that time. Participants for Focus Groups 1 and 2 were taken from a snowball sample starting with REU students working on the project.

Participants

Focus Group 0 consisted of the three REU students who were all industrial and management systems engineering majors and were either juniors or seniors. Focus Groups 1 and 2 consisted

of three students each, ranging in engineering major, academic year, and previous leadership experience.

Sample Influences

All participants in Focus Group 0 and one participant in Focus Group 2 were either currently taking or had previously taken a course on basic engineering management and ethics principles from one of the interviewing researchers. These participants had a preexisting student-professor relationship with the interviewer and a preexisting knowledge of leadership development processes, which were covered in the course.

The researchers were cognizant of this influence on the participants' responses in the Leadership Development and Engineering Leadership Development sections of the focus group protocol. Specific instances of this influence were identified in an effort to minimize the threat to the validity of the study. More importantly, the results obtained from this set of focus groups were only used to fine tune the focus group protocol; they were not used to make conclusions about how engineering leadership identities are formed. As the complete data set is gathered, future focus groups will be designed to better cover the breadth of the study.

Methods

Focus groups were utilized instead of individual interviews for a number of reasons. This included the ability to increase the number of student perspectives gathered and to observe how engineering students might build from or contrast with the ideas of their peers. The focus group protocol outlines a 60 to 75-minute interview session comprised of three main parts: an introduction, a structured list of questions, and a conclusion including a demographic and leadership questionnaire. Additional sections include logistics reminders for researchers, a probing question plan, and engineering and leadership identity checklists. To ensure the focus group runs smoothly, at least two recording devices are utilized to capture focus group discussion, participants are sent multiple reminder emails and texts, and the interviewers' tone is kept friendly and conversational. In Focus Group 0 all three researchers interviewed REU students. In Focus Group 1 and Focus Group 2 two researchers interviewed participants while the REU students and one researcher observed from a viewing room.

Introduction

The introduction is based on standard practice for an IRB exempt study. Participants are welcomed as they arrive. Once all participants arrive, researchers explain the purpose of the study, the structure of the focus group, and ideal response types to use during the focus group (examples and stories). Next, researchers discuss the risks and benefits of the study and establish ground rules for confidentiality and voluntary participation. Participants are given an opportunity to voice questions and concerns. Finally, a consent form containing a summary of the information presented throughout the introduction is given to participants to sign. Copies of the form are made available for participants' records.

Questions

REU students began protocol development by conducting a literature review of interview protocols used in published qualitative studies involving engineering or leadership identity

development previously cited or reviewed by the research group. This was done to improve the quality of the research, as suggested by Baillie [13], and allowed for comparative analysis between studies. The students organized the information into a spreadsheet containing the purpose of the study, the type of identity development investigated by the study, the number of participants, and the specific interview questions if they were listed. Then, questions were organized by question type – engineering identity, leadership identity, or engineering leadership identity. Next, the REU students marked questions in each category that they would like to be asked in a focus group setting. This step was repeated after students read about the types of qualitative frameworks in *Qualitative Inquiry & Research Design* [10], paying special attention to which questions fit well within a grounded theory study.

Using the information provided by the REU students the researchers built the first draft of the focus group protocol. Questions were pulled directly from the literature review, edited slightly, or written by the research team. Next, questions were put into three sections representing the focus areas of the study and ordered for ideal conversation flow. Example questions are shown in Table 1. Transition phrases are listed at the top of each section. For the Engineering Identity, Leadership Identity, and Engineering Leadership Identity sections, 20 minutes, 15 minutes, and 30 minutes respectively are allocated for questions. Additional engineering leadership questions are listed at the end of the Questions section if time allows; these may also guide probing questions.

Table 1: Protocol Question Examples

Section Topic	Example Questions
Engineering Identity	Think back to when you first decided to major in engineering. Can you recall what you thought an engineer was/does? What do you think engineering is now? How has your thinking changed and why?
Leadership Identity	Can you provide an example of a time when you most felt like you were a leader?
Engineering Leadership Identity	How would one become an engineering leader? What essential steps would one need to take and why?

Probing Plan

The probing plan was created by the research team as a guide to explore participants' more complex insights. Part one of the probing plan is integrated into the top of each Questions section of the protocol as a boxed list of four key topics representing themes of interest. For example, in the Engineering Identity Questions section, the four probe topics were engineering ideal, engineering ideal development, engineering identity development (personal and others), and present engineering identity. Part two is a Probing Questions section that includes questions relating to identity development, the characteristics of the LID model [11], the results from the quantitative research [2], and the three values of Godwin's engineering identity framework (recognition, interest, and performance/competence) [6]. As an additional precaution, the team

developed an engineering identity checklist and leadership identity checklist to make sure all areas of interest were covered during the focus group.

Summary

The focus group concludes with a 10-minute closing. Participants are thanked for participating, informed that they may be contacted to verify information or expand on information in a one-on-one interview, and reminded to keep all responses shared during the focus group confidential. Then, participants are asked to fill out a voluntary questionnaire. Section One of the questionnaire asks for demographic information including the participant's current major, if that major has changed, class year, desired pseudonym, gender identity, and racial/ethnic identity. Section Two of the questionnaire includes questions pulled from the Lifetime Leadership Inventory model centering around guidance from mentors, leaders as role models, activities in high school and college to gauge student's previous leadership activity [14].

Changes to Protocol After Focus Groups 0-2

After each focus group, the protocol wording, structure, and flow were honed to create an optimal protocol. Changes to the protocol are listed in Table 2. More significant edits were made between Focus Group 0 and 1 than between the others. Reworking the Questions section to decrease leading questions was the most prominent difference between the pilot and primary focus group. During Focus Group 0 the researchers became aware of how their scripted questions and unscripted probing questions could bias participant responses. For example, one of the researchers responded to a participant's answer during Focus Group 0 the following: "I hear two things [about being a leader]. One is taking the risk and the other is inspiring people." To this the participant responded positively, but the participant's message may have been partially lost in the researcher's interpretation or the participant may have agreed to continue the flow of the focus group. The pilot focus group called attention to leading questions that threatened the validity of the study, so revisions were made to the protocol to resolve this issue.

Individual Interview Protocol

Individual interviews will serve as exploratory sessions to give depth to any item of interest from a focus group. Participants will be selected for individual interviews in two ways. A participant may reach out to researchers if there was a topic they would like to discuss that they were not comfortable sharing during the focus group. Researchers may contact participants after a session for clarification and more depth about a topic of interest as the researchers are transcribing and analyzing recordings. Generally, researchers will reconnect with participants if something a participant said stands out as a concept that may offer significant insight if expanded on. Individual interviews will not follow the full focus group protocol, but focus on a few questions from the protocol that the participant or researchers specifically want to explore further. The individual interview will have a shortened introduction and skip the concluding questionnaire as the participant has already filled it out.

Table 2: Changes to Protocol Between Focus Groups

Section	Changes Between Focus Group 0 and 1	Changes Between Focus Group 1 and 2	Changes Between Focus Group 2 and future Focus Groups
Introduction	1. Ensure there are two or more recording devices 2. Participants told that field notes will be taken during the focus group 3. Added "What is said in this room stays in this room" confidentiality statement 4. Participants told that researchers may reach out for follow up one-on-one interviews	1. Researchers give participants an overview of the focus group layout and a different structure to the ground rules	1. Clarification of how researchers should take field notes
Questions	1. Researchers added time constraints to each section 2. Reworded, changed order, added, and cut focus group questions to hone on what researchers truly wanted to understand and not bias/startle participants	–	–
Probing Questions	1. Added explicit probing topics and checklist to each section	–	1. Probing questions changed to focus on integrative experiences with diverse groups
Closing	–	1. Researchers reiterate the "what is said in this room stays in this room" confidentiality statement	–

Focus Group Points of Interest

The points of interest explored below are highlights noted by the researchers and REU students during the pilot focus groups. These highlights are not fully developed, representative data, but they are interesting concepts worthy of emphasis.

Focus Group 0

Likely due to the participants' unusually high level of familiarity and significant overlap in coursework, Focus Group 0 participants built off each other's answers to questions more frequently than the other two focus groups. This group extensively discussed gender as an important factor impacting the development of their engineering, leadership, and engineering

leadership identities. This was likely because all three participants identify as genders that are minorities in engineering, and they felt as though the other participants could empathize with the unique experiences this presents in the formation of engineering leadership identity. It is also noteworthy that two of the participants were actively involved in special interest groups relating to their genders, Out in Science, Technology, Engineering, and Mathematics (oSTEM) and Women in Engineering Student Advisory Board. The gender focused discussion in Focus Group 0 was interesting, but not replicated in focus groups that followed. The primary research significance of Focus Group 0 was the increased understanding of ideal question timing, quantity, flow, and corresponding improvements in the protocol.

Focus Group 1

Focus Group 1 was the first-time participants from outside the research group spoke to the researchers. Focus Group 1 gave the research team a good picture of how future focus groups would run. In both Focus Group 1 and 2 participants noted relevant courses as important for their development. In Focus Group 1 this course was an interdisciplinary design class. Also, the group expressed a perceived distinction that engineers are professionals who understand theory but are not technicians. Thematically, participants' responses supported conclusions from the quantitative portion of the project and the CoP model that relationships with professors or TAs and internship experiences were important factors in engineering identity development.

Focus Group 2

Of the three pilot trials, Focus Group 2 was most closely aligned to the ideal protocol. As mentioned in the Sample Influences section, one of the participants was taking a class from one of the interviewers. This participant brought up the material of this class; it was of some relevance to the subject of the focus group. This group cited effective leaders as those who lead by example and delegate effectively. Additionally, the participants referred to themselves as "leaders in training," noting that they did not perceive their leadership skills as fully developed yet.

REU Student Learning

Throughout the literature review, the REU students were introduced to the current body of work around engineering identity and leadership identity development research. By reading *Qualitative Inquiry & Research Design* [10] the REU students learned broadly about qualitative research approaches including philosophical assumptions and interpretive frameworks, successful qualitative study design, and the basics of narrative, phenomenological, grounded theory, ethnographic, and case study research. The REU students learned how to build a qualitative protocol that examines multiple identity types and influencing factors by (1) categorizing and editing questions from the current body of work, (2) seeing how the graduate student researcher incorporated development models and the group's previous work into narrowing down questions and creating a probing plan, (3) taking part in a focus group interview, and (4) watching the protocol evolve based on observations of Focus Group 1 and Focus Group 2. By participating in a focus group, the REU students noticed how prior knowledge of the subject and familiarity with others in the focus group impact participant comfort and ability to answer questions insightfully. This is important insight into the participant experience for the study going forward. Additionally, the REU students obtained the CITI

certification for Social and Behavioral Research. Finally, the REU students took the lead in summarizing and analyzing the qualitative research approach and their experience with it by authoring this paper.

Future Work

A second round of interviews will be conducted with undergraduate engineering students enrolled at the host university and two other universities. The host university is a Minority Serving Institution (MSI) for Native American students, and another participating institution is an MSI for Hispanic students. Focus group participants will be primarily identified through criterion sampling based on a variety of criteria including prior engineering leadership experience. In addition, at both MSIs there will be at least one focus group comprised entirely of the served minority to facilitate the sharing of unique experiences.

The data gathered from these focus groups will be used to build a grounded theory model for the development of engineering leadership identity. Once complete this model will be used to create a plan for educational intervention that will promote the growth of engineering leadership identity among undergraduate engineering students. The educational intervention will be tested at several universities. Future work will serve the high-level goal of developing undergraduate engineering students' leadership skills in the classroom to be more effective in an interconnected world.

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