Development and Refinement of Interview Protocol to Study Engineering Students' Beliefs and Identities

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Executive Summary

The underrepresentation of non-male and non-White individuals in engineering continues to be a persistent and critical problem [1-3]. A widespread and commonly accepted approach to recruit and retain diverse individuals in engineering is to provide multiple pathways into engineering degree programs, such as offering introductory courses at community colleges or regional campuses. Although these pathways are intended to promote diversity, they are similar in structure to the educational tracking practices common within the K-12 context, which extant research has shown perpetuate social inequalities [4]. Specifically, students in less prestigious tracks have lower educational aspirations and less favorable self-beliefs [5]. As such, the objective of this research is to understand the beliefs and identities with respect to smartness and engineering of undergraduate engineering students from different institutionalized pathways into engineering. Each pathway is a trajectory to earning an engineering degree from a large, public, research-intensive university in the Midwest, which enrolls just over 1600 new first-year undergraduates in engineering each year on the main campus alone. Specifically, this project is designed to address the following research questions**:** 1) What do students from different institutionalized pathways into engineering believe about smartness and engineering? 2) How do these students express their personal identities related to being smart and being an engineer?

In order to answer our research questions over the scope of the full, three-year project, we will collect and analyze a series of three interviews with 30 participants across six different first-year institutionalized pathways into engineering: main campus-honors program, main campus-residential cohorts, main campus-standard program, main campus-alternative math starting point, regional campuses, and community college. The first interview is to establish the participants' beliefs and identities related to smartness and engineering. The two follow up interviews, conducted approximately six months and one year after the initial interview, will provide additional insight by looking back at what aspects of the individuals' beliefs and identities have changed or remained the same during their degree progress. During the time span of the data collection, it is expected that participants will move between institutions, pathways, and perhaps even out of engineering.

To date, we have completed the pilot phase of this multi-year, qualitative study. During the pilot, we conducted semi-structured, one-on-one interviews with nine first-year engineering students across three different institutionalized pathways into engineering. The main objective of the pilot was to develop and refine the interview protocol. As a constructivist study, we are interested in how each participant assigns meaning through their subjective experiences [6]. As such, the one-on-one interviews are the primary means of data collection, and it is essential that the protocol elicits responses from the participants that allow us to answer our research questions. The methods utilized during the pilot, the interview protocol development and refinement, and future work will be discussed in the following sections of this executive summary.

Pilot Methods – Participant Selection and Data Collection

For the pilot, we recruited a total of nine students across three different institutionalized pathways into engineering offered at a large, public Midwestern university. The three pathways included the main campus-honors program, the main campus-standard program, and a regional campus. We selected only three pathways for the pilot because the main goal of the pilot was to refine the protocol, which we felt could be accomplished using a smaller sample of students and pathways then planned for the full study data collection. Further, we chose these three pathways because we felt it would provide a representative enough sample for the interview protocol refinement. We recruited participants through an announcement of the study made during their introductory engineering course. A follow up email was then sent to the students with a link to a recruitment survey. The survey consisted of demographic questions as well as short-from questions regarding the students' educational background, experiences, and goals. We selected three participants from each pathway based on their responses to the short-answer questions because we were interested in participants who would provide insightful and information-rich responses. We also considered the participants' gender, race, country of origin, and first-generation college student status, as prior research has shown that perceptions of experiences, attitudes, and beliefs can significantly differ for students with various social identities [7-10].

Following approved IRB procedures, one graduate student (first author) conducted the pilot interviews in either a private location (e.g., small conference room) or through an online video communication platform (e.g., Zoom). Each interview lasted approximately one hour, was audio recorded, and was transcribed using a secure transcription service. Each participant was given a $25 gift card as compensation for their participation.

Interview Protocol – Development and Refinement

A well-developed and refined interview protocol is an important component to ensuring quality research. A thoughtful and comprehensive interview protocol leads to increased insight during the interview process [6] as well as provides direction and clarity to the research team during data collection [11]. In this study, the semi-structured pilot interview protocol was originally designed around the main constructs of interest for this research: beliefs about engineering, beliefs about smartness, identity as engineer, identity as smart. The questions included in the protocol were directly related to our research framework, which is summarized in Table 1. We also drew on the research team's prior experience studying the constructs of beliefs about smartness and engineering identity. Additionally, the intersection of these constructs is important and complex, so we engaged in a series of structured steps in order to refine our protocol so that we are confident its use will result in the collection of data that can answer our research questions.

Table 1. Framework for Accessing Constructs

	Engineering	**Smartness**
Participant Beliefs	What does it mean to be an engineer?	What does it mean to be smart?
Participant Identity	**(Role Dimension)**	**(Personal Dimension)**
	Are you an engineer?	Are you smart?
	Why or why not?	Why or why not?

The initial interview protocol began with introductory questions regarding the participants' educational background, experiences, and goals. This allowed the interviewer to build rapport with the participants as well as provide context for the interview. We then asked questions directly related to beliefs about engineering (e.g., What does it mean to be an engineer?), engineering identity (e.g., do you consider yourself to be an engineer?), beliefs about smartness (e.g., What does it mean to be smart?), and smartness identity (e.g., do you consider yourself to be smart?). Finally, we asked questions designed to solicit data related to the intersection between these constructs (e.g., Do you think you're smart enough to be an engineer?). The whole protocol was semi-structured, which allowed the interviewer to also ask probing and follow-up questions to help the participants think deeply about these constructs and obtain rich data related to the constructs of interest.

Despite the importance scholars and qualitative methods book authors have placed on interview protocols, we found little information on concrete procedures for developing and refining interview protocols, especially about complex and interconnected constructs. Therefore, the research team created our own protocol refinement tool in the form of a spreadsheet which was targeted at ensuring the interview protocol elicited responses from the participants that would help us answer our research questions. The top row of the spreadsheet consisted of our research questions broken down by our constructs of interest:

- What does the participant believe about engineering?
- How does the participant identify with engineering?
- What does the participant believe about being an engineering student in their pathway?
- What does the participant believe about smartness?
- How does the participant identify with smartness?
- What does the participant believe about the relationship between smartness and engineering?
- How does the participant identify with smartness and engineering?

For each pilot participant's transcript, the members of the research team filled out the columns of the spreadsheet independently. We then came together to discuss our interpretations and to determine the adequacy of the data gathered with our initial interview protocol for answering our research questions. While we occasionally had different interpretations of the participants' responses, which is expected as we have different positionalities, we were able to come to a consensus through the use of our protocol refinement tool for most questions based on participants' responses. Most importantly, we were able to agree, based on the results of this process, about which areas of the interview protocol needed refinement before using it to collect the data for the full study.

By using our interview protocol development and refinement process, we found that the most insufficient portion of our initial protocol was the portion designed to have participants relate their engineering identity to their identity as smart (or not). This difficulty could be a reflection of the complexity of the interconnected relationship between smartness and engineering [12] and the implicit role that smartness plays in engineering culture (i.e., students usually aren't asked to say if they think they are smart enough to be an engineer or not). To help the research team

navigate this complex issue during the interviews, we added several follow-up questions to the interview protocol (e.g., Earlier you said you believe "xxx" about your own smartness and "xxx' about you as an engineer (or engineering students); how are these two things related?). Furthermore, it seemed difficult for some of the participants to reflect upon and articulate how they identify with engineering since as first-year students, they may in the very earliest stages of their engineering identity development. Further, some of the participants had yet to pick an engineering discipline, which is related to engineering identity. Therefore, we also added several follow-up questions to all of the identity portions of the interview protocol to help the participants think more deeply about their identity (e.g., is engineering a big part of who you are?).

We also discovered during the pilot interviews that the interview questions, in some cases, elicited emotional responses from the participants. For example, one participant, when asked if she was smart enough to be an engineer, responded somewhat defensively as if she felt the interviewer was questioning her ability or place in engineering. Another example comes from when one participant was asked if she ever questioned her own smartness. She responded that it was something she questioned daily and became visibly upset. During our protocol refinement process, we also discussed how we could be more prepared to navigate these responses by preparing to offer thoughtful and caring reactions motivated by empathy to the participants when they are willing to be vulnerable and show emotions—above and beyond our concerns about getting sufficient data for our research study. Because we certainly do not want to offend our participants in any way, and because we know that engineering culture and the construct of smartness are indeed raced and gendered [13], we added language to the protocol about the direct nature of some of the questions and to clarify the intent of this research.

Future Work

The refined interview protocol will be used for data collection during full study, which will include interviews with 30 participants across six different institutionalized pathways into engineering to understand how participation in different pathways relates to students' experiences, beliefs, and identities with respect to smartness and engineering. These participants will be interviewed up to three times to follow their development as they transition beyond introductory engineering courses regardless of if they continue with the engineering or not. Our work will provide valuable insights into the complex beliefs and identities about engineering and smartness of students participating in different institutionalized pathways into engineering. Ultimately, we believe our findings will inform the ways in which this common structural approach to broadening participation is enacted in engineering.

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