

Who's Smarter? Beliefs about Smartness and Self-Identities Across Institutionalized Educational Pathways into Engineering

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Dr. Rachel Louis Kajfez is an Assistant Professor in the Department of Engineering Education at The Ohio State University. She earned her B.S. and M.S. degrees in Civil Engineering from Ohio State and earned her Ph.D. in Engineering Education from Virginia Tech. Her research interests focus on the intersection between motivation and identity of undergraduate and graduate students, first-year engineering programs, mixed methods research, and innovative approaches to teaching. She is the faculty lead for the Research on Identity and Motivation in Engineering (RIME) Collaborative.

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Dr. Dringenberg is an Assistant Professor in the Department of Engineering Education at Ohio State University. She holds a B.S. in Mechanical Engineering (Kansas State '08), a M.S. in Industrial Engineering (Purdue '14) and a Ph.D. in Engineering Education (Purdue '15). Her team, Beliefs in Engineering Research Group (BERG), utilizes qualitative methods to explore beliefs in engineering. Her research has an overarching goal of leveraging engineering education research to shift the culture of engineering to be more realistic and inclusive—especially with regard to beliefs about decision making, smartness, and the causes of race- and gender-based minoritization. In general, she is always excited to learn new things and work with motivated individuals from diverse backgrounds to improve the experiences of people at any level in engineering education.

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Executive Summary

Introduction

The underrepresentation of non-male and non-white individuals continues to be a persistent problem at all levels of engineering [1, 2]. In undergraduate education, multiple pathways into engineering degree programs (e.g., introductory courses offered at regional campuses and community colleges) are often viewed as a way to broaden participation in the field by increasing access and affordability. However, research within the K-12 context has uncovered that educational tracking practices, similar in structure to the pathways seen in higher education, function in ways that perpetuate social inequalities. Often students in less prestigious tracks develop lower self-beliefs and educational attainment goals while being offered less resources and educational support [3]. Despite these parallels, little is known about how institutionalized pathways function in higher education in terms of equity, access, and inclusion.

In addition to the lack of knowledge about institutionalized pathways, little is known about the impact of beliefs about what it means to be smart in engineering. This is important because with an emphasis on math and science, common public messaging emphasizes that in order to be an engineer, one has to be smart [4, 5]. Indeed, prior work has indicated that being recognized as smart is somewhat of a prerequisite in engineering as the students who pursue engineering are those who have been given messages within their K-12 educational experiences that they are smart [6]. Further, students who leave engineering are often considered by others (and themselves) as simply not “cut out for engineering” based on how ability is constructed within engineering classrooms via even the most mundane, day-to-day interactions [7]. As such, the beliefs that students hold about smartness and how they identify as smart can impact who chooses to pursue engineering, through what pathways they engage, and who persists in engineering degree programs.

The overall objective of this study is to understand what, if any, patterns exist in the beliefs about smartness and self-identities of undergraduate engineering students across institutionalized pathways. Specifically, this three-year qualitative study aims to answer the following research questions: *1) What do students believe about smartness and engineering, and 2) how do students express their self-identities as smart and as engineers?* In this executive summary and poster, we will report on initial findings from preliminary analysis of the first of a series of three interviews over the course of our participants' first- and second-years including engineering students from six different institutionalized pathways that feed into one college of engineering.

Methods

For this qualitative, exploratory study, we recruited first-year engineering students from across six institutionalized pathways, which are all designed to funnel into earning an equivalent engineering degree (community college, regional campuses, alternative math starting point,

standard, residential learning cohort, and honors) at a large research-focused university in the Midwest. During the Spring 2020 semester, we selected 37 participants to interview based on their responses to several open-ended questions (e.g., please describe your educational background) and demographic information. The goal of our sampling plan was to capture stories of participants from different pathways with varying social identities and life experiences. Our initial plan was to obtain a demographically representative sample, however, we ended up slightly oversampling those from minoritized groups and non-traditional students to ensure that we were capturing variation in the life experiences of the participants. Of the 37 participants, 28 also participated in the second and third interviews during the Autumn 2020 semester and Spring 2021 semester, respectively.

In accordance with IRB approved procedures, the first (of three) interviews took place during the Spring 2020 semester in the midst of the change to online instruction caused by the COVID-19 pandemic. The interviews were semi-structured one-on-one interviews and lasted approximately 60 minutes. The interview protocol consisted of questions related to each of our main constructs of interest (i.e., beliefs about engineering, beliefs about smartness, smartness identity, engineering identity). The interview protocol was piloted and refined during the Autumn 2019 semester to ensure that the interview questions elicited responses from the participants that would answer our overarching research questions [8]. For the second round of interviews (Autumn 2020), the interview protocol consisted of questions that focused primarily on how the participants' beliefs about smartness impacted their academic decision-making. For the third round of interviews (Spring 2021), the interview protocol consisted of questions based on our preliminary findings (which are presented in this paper) consisting of mostly follow-up questions related to how being identified as *smarter* than others have mattered in their lives and an explicit discussion of the qualities that they believe make engineers *smarter* than others.

To date, we have completed the preliminary analysis of the first round of interviews. We began our analysis with a structural coding technique to categorize the data [9]. Structural coding was also helpful as this study involves multiple complex constructs; thus, our approach allowed us to categorize the data in such a way that we could see where the constructs initially overlapped (e.g., beliefs about smartness overlapped with beliefs about engineering). The next step in the data analysis was a more inductive coding approach, which involved breaking down each structural category into discrete codes and then comparing for similarities and differences across categories [10]. Two members of the research team iteratively developed the codes within each main category of data. We then compared the codes across the main categories of data *and* across the pathways to see which codes were more salient in the given pathways. Future work will consist of data analysis for the second and third rounds of interviews as well as a longitude comparison of how the participants' beliefs and identities changed or developed over time in addition to across pathways.

Initial Findings

*Research Question 1: Students **define engineering and smartness in similar ways** indicating that there is significant overlap between how students conceptualize engineering and smartness.*

Our initial findings based on the first round of interviews indicate that beliefs about engineering and smartness are intricately connected for the participants. Not surprisingly, the consensus among students regardless of the pathway is that engineering is primarily about solving complex problems. Additionally, when students were asked to define what it means to be smart, the students provided similar definitions of smartness. For example, a common response when asked what makes somewhat smart was the ability to apply knowledge to solve problems.

“[a good engineer] is someone who has really good problem-solving skills and someone who can think like, not outside the box completely, but they can find different ways to create something that is needed.” – Daisy (community college)

“I think a smart person is like really tactful in how they approach problems and they're not lazy that they don't want to fall back on someone else or some other outside source. Like they want to, they really try to use their own brain to come up with a solution..” – Chris (alternative math)

We also found that engineering students generally believe that engineers are smart and thus to be an engineer one must be smart. These findings mirror the dominant narratives and messaging that are pervasive within and about engineering [5, 11]. This indicates that students are reproducing these dominant messages about what it means to be an engineer while aligning those narratives with what it means to be smart. As suspected, our findings indicate that engineering and smartness are intricately connected for these students. As such, beliefs about the self as smart and as an engineer are also connected.

*Shifting Research Questions 1: Beliefs about smartness are really about **what makes someone (or themselves) smarter than others***

The second significant finding from our preliminary analysis has led to a pivot from the research team to shift the focus of our first research question from asking *what do students believe about smartness in engineering*, to *how do students decide who is the smarter (or smartest) engineer?* This came from the realization that when students discussed smartness, it was typically framed in a comparative way. For example, we found not only that students believe that engineers are smart but that they are *smarter than others*. Being smart is not just about meeting some standard but rather something determined through social comparisons. For example,

“I think there's just that general sense about STEM majors, particularly engineering...thinking that engineering's the hardest major there is and how we're so much better than arts and science.” – Skyler (Standard)

“I definitely feel like there's a bit of a stigma against engineering students... there's a stereotype of like a prideful engineering student, you know, like a student who just thinks they're better than every other student. Um, which I mean, being in an engineering class I have seen and I have fallen into that trap a few times.” – James (Regional Campus)

Our shift in conceptualizing smartness as a means of social comparison aligns with extant literature on smartness [12]. In her work, Hatt argues that smartness is a cultural practice, meaning that it is something that we *do* to each other (and ourselves) based on the implicit

judgments we make within our local environments (e.g., a classroom, an educational system). This then results in social positioning and power for those identified as smart.

*Research Question 2: Students' beliefs about what makes one smarter are similar across pathways, yet **smartness functions differently across pathways***

Although the students generally had similar broad definitions of smartness and engineering (i.e., problem-solving), the nuanced differences in how the students talk about smartness across pathways have led the research team to an understanding that smartness is *functioning* differently for students in their beliefs and identities among pathways. For example, for some students smartness is functioning as social status, a way to access opportunities, or a motivational influence, to name a few. Our analysis is still ongoing and thus we are still working to uncover how these functions align across pathways, but one finding that is clear is that smartness for students in the more prestigious tracks (e.g., honors) is *functioning as an identity*. For these students, their identity as a “smart” student is often more salient than their engineering identity. For example, J, an honors student, had the following response when asked if being smart was a big part of who he is:

*“[I’m] always kind of going for that next big thing. Always trying to go above and beyond. Um, the whole double-majoring thing. Um, being involved with research...and being in honors and trying to do all of it. Um, I guess **it’s** just kind of a big part of who I am” – J (honors)*

This may reflect the social stratification of educational tracking, with students internalizing available stories (narratives) of overachieving related to being smarter for those in more prestigious pathways [13]. Overall, we have noted that smartness is a function of the context in which it is constructed, and the context of each pathway is of importance in understanding how students construct their identities. As such, this finding is being further explored across pathways, and a conceptual model of smartness identity is in progress to help us further explore this finding.

Future Work

Future work will consist of the full analysis of the second and third rounds of interviews along with a more in-depth exploration of differences (and similarities) across pathways. Future longitudinal analysis will also consider how the participants’ beliefs and identities may have changed over time. Finally, as a preliminary finding of this work is that smartness can function as an identity, we also are developing a conceptual model for how to integrate smartness into engineering identity work based on our data and extant identity literature.

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