Board 292: Findings & Implications of an Exploration into Smartness in Engineering

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Project Summary

Multiple pathways exist for students to matriculate into engineering undergraduate degree programs. These various institutionalized pathways were created to support students in different ways, such as by increasing opportunities for connections in communities [1] or by increasing access to and affordability of undergraduate engineering degrees [2]. Despite such positive intentions, the creation and implementation of institutionalized pathways into engineering have the potential to function in oppressive ways, similar to the problematic educational tracking practices used in pre-college contexts. Researchers have established that these tracking practices function in ways that perpetuate and create inequities. For example, students in tracks considered less prestigious than others have less access to resources and educational support, and the resulting inequitable experiences lead to lower self-beliefs and educational attainment goals [3]. As the underrepresentation of non-male and non-white individuals continues to be a persistent problem at all levels of engineering [4, 5], an understanding of how beliefs and identities manifest in students who participate in different institutionalized pathways into engineering is needed.

Common public messaging around engineering emphasizes that in order to be an engineer, one must be smart – specifically in math and science related topics [6, 7]. Previous research has indicated that a student being recognized by an educational institution/instructor as smart is a prerequisite in engineering; students who pursue engineering are students who have received messages within their pre-college educational experiences that they are smarter than others [8].

Considering the inextricable connection between engineering and being recognized as smart, and the parallels between institutionalized pathways into engineering and precollege tracking practices that have been shown to lead to different self-beliefs in students, we are motivated to conduct research that explores the beliefs and identities of engineering students from various pathways. This executive summary reports the key findings of our work to understand what, if any, patterns exist in the beliefs and identities related to smartness of undergraduate engineering students across institutionalized pathways. Our qualitative study answered the following overarching 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*?

Our qualitative, exploratory research study was conducted by recruiting first-year engineering students from across six institutionalized pathways (community college, regional campuses, alternative math starting point, standard, residential learning cohort, and honors), which are all designed to funnel into earning an equivalent engineering degree at a large, public, research-intensive university located in the midwestern United States. In total, 25 students were interviewed three times during their first and second years in their undergraduate engineering programs. Analysis of these interviews was conducted by a team of undergraduate researchers in collaboration with a graduate research assistant, a postdoctoral fellow, and two faculty members. Using analytic memos to track both participants' beliefs about smartness and engineering across the three interviews, as well as exploring similarities and differences of experiences within and between institutionalized pathways, we answered the research questions and gained insights related to students' beliefs and identity development related to smartness and engineering.

Project Findings & Contributions

We have conveyed the key empirical findings of this project though four main journal manuscripts. Each journal manuscript and their unique contribution to the field of engineering education is discussed below.

In Manuscript 1, we put existing theories of identity in conversation with the theorization of smartness as a cultural practice to show how smartness is deeply connected to identity, particularly in the undergraduate engineering context. We also drew on examples from our own research to show the integration of smartness into existing identity framework commonly used in engineering education and propose explicit ways in which researchers can apply a smartness lens when using those theories in engineering education research. Ultimately, we recommend the intentional consideration and use of smartness as a lens in any research related to engineering identity. By not making smartness an explicit consideration in engineering identity research, we allow smartness to remain implicit and risk preserving the bias embedded in the process of smartness as a cultural practice happening in our classrooms, programs, universities, and society.

In Manuscript 2, we report the finding that engineering students draw primarily on one of three different ways of articulating that they are "smart enough" for engineering. While all but two of the participants identified with being smart enough for engineering, there were three distinct ways in which they articulated why they believed they were smart enough. Students said they are smart enough for engineering because: 1) they have existing skills and experiences, 2) they have innate abilities, and 3) they are hard working. Additionally, we identified patterns between the social identities and pathways of the participants and which of these three ways of articulating themselves as smart enough they drew on most. Specifically, those from the most prestigious pathways (i.e., honors, residential learning cohort) were more likely to believe that they are smart enough for engineering because of their innate abilities. Also, those that believed they are smart enough to be an engineer because of their innate abilities were more likely to hold more privileged social identities (e.g., White, cis-gender men). These findings support our suspicion that while pathways are meant to broaden participation, they also reflect the preservation of inequity.

In Manuscript 3, we explored three women's identities by mapping them to their three distinct decisions for participating in engineering (i.e., join, persist, leave). We considered both their initial decisions to join engineering (all three women) and then their individual decisions to persist in engineering, switch majors within engineering, or leave engineering all through the lens of their engineering and smartness identities. This manuscript provides counter-stories to research evidence that has previously pointed to the importance of a strong engineering identity for students' retention in engineering programs. While an identity as smart was a driving force for all three women in deciding to enter engineering, engineering identity did not predict their persistence. One of the women left engineering while still maintaining her identity as an engineer, while another who identified as an engineer persisted in her program in hopes that she would be seen as smart by others to ultimately be successful in achieving her non-engineering related career goals. By considering not only these women's engineering identities, but also their smartness identities and the social and cultural contexts and forces they were experiencing, we begin to unpack the complex ways in which various identities impact engineering participation decisions.

In Manuscript 4, we present findings based on the first and third interviews with the participants. Based on the first interview responses, we developed a set of 11 emergent and distinct common beliefs about what it means to be a smart engineer. In the third interview, we had the participants rank the value they placed on each of those 11 common beliefs in terms of: 1) what personally

made them feel like a smart engineer, and 2) what they believe was recognized as a smart engineering as enacted in their introduction engineering courses. We found statistically significant differences for six of the 11 common beliefs. Students personally valued working hard, showing initiative and making the world a better place/helping others, but students believed that what was enacted in their first-year engineering classroom demonstrated valuing getting good grades, achieving with little effort, and being born with innate ability. Taken together with the interview data, we found evidence that the cultural practice of smartness in introductory engineering classrooms leads to shared beliefs amongst students that they should 1) prioritize grades over learning, 2) demonstrate achieving with little effort (even though they value working hard), and that they 3) will not be rewarded for helping others or considering the social impact of engineering. These findings indicate that as engineering educators, we need to take responsibility for how we are contributing to the cultural practice of smartness in our engineering classrooms because, to the extent to which our findings are transferrable, our classrooms are enacting beliefs about what it takes to be a smart engineer that are false and problematic.

Implications & Recommendations

The results of our work have three primary implications for different engineering education audiences.

1) Smartness as a cultural practice should be integrated into the study of engineering identity.

   Based on our findings from Manuscript 1 highlighting the theoretical connections between identity theories and the theorization of smartness as a cultural practice as well as the inextricable connection between smartness and engineering, we strongly recommend that smartness should be explicitly integrated into the study of engineering identity. This recommendation is also supported by empirical evidence provided in Manuscript 3 that a strong engineering identity was not always of high importance when making decisions about continued participation in engineering, but identifying as smart was a consistent driving force the three women in deciding to enter engineering.

2) Educators must have a working understanding of smartness as a cultural practice that includes their own responsibility in disrupting the status quo.

   We strongly recommend that engineering educators have a working understanding of how smartness is culturally practiced in engineering classrooms including their own role in disrupting the enactment of beliefs that perpetuate the cultural falsehood that ability or being "smart enough" to be an engineer is an innate characteristic. This recommendation primarily falls from our findings from manuscript 4 indicating that smartness is practiced in introductory engineering classrooms in ways that perpetuate beliefs that what is valued as smart enough for engineering are letter grades over learning, achievement with little effort, but not helping others or considering the social impact of engineering. We encourage educators to reflect on their classroom practice that could be perpetuating such beliefs. We also see evidence suggesting the need for educators to understand smartness as a cultural practice based on our findings from Manuscript 3, which is an example of how women's engineering identities were not the driving factor for persistence, but rather based on how well their identities aligned (or not) with sociocultural forces within their engineering context that were key for their decisions about whether or not to participate in engineering as students.

3) Institutionalized pathways into engineering need to be reconceptualized because they maintain inequities.

   Finally, our work provides evidence that institutionalized pathways into engineering reflect and maintain inequities. The most striking example of this comes from the findings of Manuscript 2 that indicate students who believed they were smart enough due to innate abilities tended to hold more privileged identities and tended to be from pathways considered more prestigious (honors and residential cohort). This aligns with research in the pre-college context indicating that students who participated in different pathways have differing beliefs about themselves and their own abilities [3, 9], which reflect and maintain existing inequities.

Overall, this research study allowed us to gain insights into the complex beliefs that students hold about engineering and smartness as well as the ways in which smartness manifests in engineering students' decisions to enter the field and make decisions regarding their participation in engineering classrooms and their identities. Based on these research findings, we aim to equip different stakeholders (e.g., engineering educators, researchers, and advisors as well as perspective and current engineering students) with recommendations that are grounded in empirical evidence to support students to and through undergraduate engineering programs.

References:

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