ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #38364

Engaging undergraduate researchers: Contextualizing beliefs and identities about smartness in engineering

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Introduction

Undergraduate research is considered a high-impact practice (Zydney et al., 2002). It provides students with the opportunity to improve their critical thinking and personal communication skills and offers the opportunity to build mentoring relationships with faculty, increasing the likelihood of graduate school attendance (Zydney et al., 2002). Additionally, researchers have shown that participating in undergraduate research can build confidence (Reisel et al., 2015) and enhance the undergraduate engineering educational experience overall (Sabatini, 1997). In our qualitative research project on undergraduate engineering students' beliefs and identities, we decided to engage undergraduate engineering student researchers because we felt they could provide a unique perspective to the project as they are living in the context that they are also researching (i.e., the undergraduate engineering student experience). Thus, we aimed to harness the benefits of engaging undergraduate researchers to not only support their development as students and researchers but also to leverage their personal experiences to help us analyze and interpret our data. Additionally, the undergraduate researchers were able to gain personal insight into their own engineering identity development through engaging in reflective qualitative research practices. While the student researchers were not the participants who provided the data, their engagement with the research team helped us incorporate a student view directly into our work as we made sense of our data, which we believe was beneficial and necessary.

In this executive summary and poster, we report on the summer undergraduate research experience by detailing the undergraduate research associates (URAs) engagement with the data. We also provide a summary of our key takeaways highlighting the benefits to both the URAs themselves and to the added quality of the data analysis because of the insight from the URAs. We end with a series of suggestions for researchers working with URAs based on our experience engaging URAs in qualitative research, specifically when engaging URAs who are living in the same context under investigation (i.e., research within the context of undergraduate engineering education). To be clear, in this executive summary we are not reporting on findings from the data analysis of our NSF project but rather on how engaging undergraduate researchers not only helped the URAs develop as students and researchers but also how the URAs helped us develop and contextualize the findings, which we feel added to the validity of our work.

Research Study and Context

During the summer of 2021, we engaged four URAs in the data analysis of our exploratory qualitative research study. The research focused on an exploration of undergraduate engineering students' beliefs and identities related to smartness in engineering. Our interest in studying engineering students' beliefs and identities grew out of the pervasive cultural assumption that to be an engineer one has to be considered "smart" by themselves and by others (National Academy of Engineering, 2008; Sochacka et al., 2014). Yet, who gets counted as "smart" is biased (Hatt, 2012; Leonardo & Broderick, 2011) and can function as a gatekeeper in engineering (Carroll et al., 2019; Secules et al., 2018). We were also interested in exploring students' beliefs and

identities across several different institutionalized pathways into engineering (e.g., first-year honors program, first-year standard program, first-year courses offered at regional campuses and community colleges, etc.). These pathways are often assumed to promote access and diversity in engineering, yet they are structurally similar to ability (or smartness) based K-12 tracking practices, which can perpetuate social inequities and foster lower self-beliefs in those placed in "lower" tracks (Oakes, 2005). Thus, our ongoing research project was designed to investigate the ways in which engineering students understand themselves to be "smart enough" for engineering across the institutionalized pathways into engineering at a single university.

Our study was longitudinal and consisted of three semi-structured interviews with each of the 25 participants. The URAs' main objective was to condense and synthesize the data into detailed analytic memos for each participant, specifically addressing the participants' beliefs about what it means to be "smart enough" in engineering. Given that we frame the study around the concept of smartness as a cultural practice that is locally co-constructed within a given context (Hatt, 2012), the URAs were vital to our sense-making as they are individuals who have experienced "smartness" within the context we were studying.

URA Experience and Data Analysis Methods

To better understand the participants' educational context for our study on undergraduate engineering beliefs and identities related to smartness in engineering, we intentionally selected the URAs from different institutionalized pathways and with diversified positionalities to help us analyze and interpret the data. The summer undergraduate research experience was designed to deeply engage the URAs with the constructs of interest for our study (e.g., beliefs and identity related to smartness) and with the project data. The experience started with an onboarding process that consisted of engagement with literature and extensive self-reflection. The first step in the process was to have the URA's complete self-reflective journal writing in response to prompts that had them reflect on their individual beliefs and identities related to smartness in engineering, such as, *how has being identified as smarter (or less smart) than others mattered in your life, and how has being identified as smarter (or less smart) than others relate to how you view yourself as a person and as an engineer*. We then asked them to read two journal manuscripts based on the major constructs of interest in our study: smartness as a cultural practice (Hatt, 2012), and engineering identity (Patrick & Borrego, 2016). The URAs then met with the lead graduate researcher on the project to discuss the papers and to start developing their understanding of the theoretical framing of the project. We then asked the URAs to go back to the reflection prompts and reflect on them again based on what they had read and the discussion of those articles. We felt that spending the time to do this at the beginning of the URA experience was vital to the URAs' ability to analyze and connect with the data. We felt that it was also an opportunity for personal growth as the URAs were able to reflect on their own beliefs and share with each other.

The majority of the experience consisted of extensive analytic memo writing. Memo writing is a powerful data analysis tool used to synthesize and make meaning out of the data (Miles et al., 2018). Given the amount of data (3 interviews with each participant), the primary task of the URAs was to condense the data (Miles et al., 2018) and synthesize the data from all three

interviews into a single detailed analytic memo for each participant. We designed the memos to provide a factual summary of each participant, summarize major themes from the interviews, and make connections between the participants (Lee et al., 2019). Specifically, the memos were guided by questions such as, *How does the participant defined smartness? How do they decide who's a smart (or smarter) engineer? How do they rationalize their place in engineering? How have the participant's beliefs and identity relative to smartness changed or stayed the same over time?* and *How does the participant relate to other participants?* We assigned the URAs to compile the memos for participants from the pathway context that they experienced. When possible, we also tried to match the social identities (e.g., race, ethnicity, gender) of the URAs to the data from participants they analyzed. We did this because the local context and positionality are central to understanding the cultural practice of smartness (Hatt, 2012), so alignment between the context and identities of participant and researcher enabled us to better contextualize and understand the participants' beliefs and identities around smartness in engineering. At least two members of the research team worked together to generate each memo; memos were written first individually and then compared and synthesized until a consensus was reached on the content of the memo. Additionally, each week we held meetings to discuss the analysis process and any key findings or insights amongst the team. At the end of the summer URA experience, we had the URAs return to the self-reflection exercise to reflect on what they originally wrote, what they learned over the summer, how their own beliefs may have changed, and to summarize their main takeaways from the summer experience.

Key Takeaways from Summer Experience

Beyond the benefits of engaging undergraduates in research as a pathway to graduate education and scientific literacy, we found that engaging URAs during data analysis, specifically in research relevant to their own lived experiences, was additionally beneficial in three distinct ways:

1.) Contextualizing the findings and quality check

The URAs provided a richer contextualization during our data analysis having recently been students in the setting we were researching which provided a vital quality check for our findings. According to Walther et al. (2013), a key component of quality in interpretive research is to validate that the findings represent the social reality under investigation. Given that the URAs had recent personal experience in the institutionalized pathways into engineering at the center of our research project, we felt that when a finding deeply resonated with the URAs, it provided an additional level of validation to the finding. For example, we found that almost all of the participants identified as smart and defined what it means to be "smart" in pre-college experiences through academic achievement (e.g., grades). However, during their collegiate experiences, many of the participants had to expand their beliefs about what counts as "smart" to maintain their identities as smart, particularly when encountering academic struggle (e.g., not receiving a desired grade). The URAs reiterated for us the significance placed on academic achievement and grades in high schools and the difficult transition into the undergraduate experience. Additionally, we felt that we provided additional validation to the findings by hiring URAs with differing positionalities from the initial research team, which had previously been limited to four White, Ph.D. level women. We found that this helped us better understand the lived experience of the participants. For example, one of the URAs helped us more deeply

understand the pre-college experiences of one of the international participants because of their shared nationality.

2.) Contextualizing the implications and recommendations rooted in student experiences
The URAs also helped the research team understand the implications of the findings within the context of the institutionalized pathways into engineering, which helped root our recommendations more firmly in the student experience. For example, the role of grades and academic achievement was interwoven with the students' identities as smart in complex ways. Despite the pervasive presence of grades in discussions around smartness in engineering, many participants did not believe that grades were a complete or accurate reflection of smartness. However, there were still many participants who were not able to detach grades from their identity as smart and their self-worth. The URAs discussed the role of grades in their own experiences in engineering courses and the emphasis placed on grades as a way of understanding who is "smart enough" to be an engineer. When thinking about the recommendations based on this finding, we might have thought that we just need to help students learn to separate grades from their self-worth. However, after our discussions with the URAs, we think a better recommendation is that first-year courses should be evaluated critically to understand how grading policies reinforce "worthiness" in engineering. The URAs helped us come to an understanding that students continually get the message that grades equal value in engineering.

3.) *Validating URAs personal experience and providing connectivity to other engineering students*
The summer undergraduate research experience was important to the URAs because it validated their own individual experiences as engineering students and provided them with a sense of connectivity to other engineering students. For example, almost all the study participants described in their interviews experiencing some form of academic struggle or questioning if they were "smart enough" for engineering at some point during their undergraduate experience. Additionally, several participants pointed out that feelings of struggle or not being "smart enough" is something that almost no one ever talks about. This finding deeply resonated with the URAs and their own experience in undergraduate engineering education. The URAs discussed the comfort they felt in learning that this was such a common experience for engineering students. One URA even described how during the analysis she felt a sense of connection to her fellow engineering students that she had never felt before. Additionally, the project resonated so deeply with her that she decided to continue to engage with the data in a direction of her choosing, resulting in an undergraduate research thesis.

Suggestions

Based on our experience working with URAs on engineering education research, we offer three suggestions to not only provide meaningful experiences for the URAs but to also leverage their positionalities to analyze and interpret data from undergraduate engineering students. Are three suggestions are:

- hire URAs as a cohort,
- offer plenty of opportunities for self-reflection, and
- when possible, have the URAs analyze the data from participants with similar educational backgrounds, cultural backgrounds, and social identities to their own.

First, we suggest hiring URAs as a cohort. We felt that bringing in URAs as a cohort during the data analysis process was deeply beneficial. The support that they provided each other during data analysis was key in fostering an inclusive and productive working environment. This suggestion aligns with the recommendations from other researchers who have advocated for the importance of undergraduate research communities (Kight et al., 2006). Along with a cohort approach, we also suggest providing plenty of opportunities for the URAs to engage with each other in group discussions. These discussions were facilitated by a graduate student, but we noticed that the more the URAs engaged with each other, the more they connected to the data and to the participants. Additionally, we suggest offering plenty of opportunities for self-reflection. The self-reflective exercises helped the URAs connect the constructs that we were investigating (i.e., beliefs and identities related to smartness) to their own lived experience. Indeed, reflecting upon one's positionality is of critical importance in qualitative research as positionality fundamentally impacts research practices (Secules et al., 2021). Ultimately, the self-reflection helped the URAs connect with the participants' lived experiences. Finally, we suggest, when possible, having the URAs analyze the data from participants with similar educational and cultural backgrounds and social identities to their own. Again, this helped connect the URAs to the participants, which in turn, helped us make sense of the participants' lived experiences.

We found that the summer undergraduate research cohort hired to aid in data analysis on our project investigating the beliefs and identities of undergraduate engineering students was deeply beneficial in 1) supporting the development of the students as researchers, 2) leveraging their positionalities to analyze and interpret the data, and 3) connecting them to their lived experiences within their undergraduate engineering programs. We write this executive summary with the intent of sharing what we learned from our most recent cohort of URAs to encourage others to engage URAs more deeply in their engineering education data analysis. We also hope that with this executive summary, we can start a conversation on how best to engage undergraduate researchers in this type of work to foster a deeper understanding and meaning in our research. In closing, we end with a question to consider when hiring undergraduate researchers: *What ways in your work can you help connect your undergraduate researchers to their lived experiences and to the constructs being investigated?*

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. 1920421. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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