Work in Progress: Navigating Undergraduate Engineering as a Woman of Color

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***Abstract*—We are interested in understanding the complexities associated with student navigation of engineering. As part of a study associated with a larger project, we interviewed five upper division, undergraduate women of color in engineering during the Fall 2022 semester. In this paper, we present preliminary results from one participant, Nadia, and discuss the codebook development process. Insights from this paper can inform practice and research. Notably, it can help develop more responsive support structures in engineering for students from marginalized groups, specifically WOC. Furthermore, insight about codebook development can help inform qualitative research practices in engineering education.**

Keywords—navigation, undergraduate

I. Introduction

The engineering learning environment produces different obstacles for different students. Therefore, understanding student navigation in engineering requires systemic investigations where an individual person is the unit of analysis to understand which factors are salient to navigation through the engineering education environment. The purpose of this work-in-progress (WIP) is to detail the initiation of a study focused on understanding how women of color (WOC) navigate engineering. For this WIP paper, we specifically looked at one student navigating engineering and the extent to which their identities of being a WOC were salient. This work is situated within a larger project investigating the navigation strategies of marginalized students in engineering.

To address our purpose, we anchor this WIP on the following research question: How does one woman of color in engineering describe her navigation? How might her description of her experience be categorized by parsimonious codes?

The paper is laid out in the following order. First we look at the literature on qualitative codebook development and WOC in engineering. Then we describe our methods for this preliminary study. Then we introduce Nadia, a woman of color in engineering (WOCE) and frame her experiences in the context of the codebook we developed.

II. Background

Prior research on women of color navigating engineering has found that WOC are drawn to engineering often through pre-college STEM interests and engineering activities [1], [2]. However, during their undergraduate engineering experience, they can experience social pain including "being the only one; being made invisible; stereotype threat and being spotlighted; and discrimination and harassment" [3, p. 595].

WOC use various navigation strategies to persist through engineering and cope with the social pain including "modifying internal dialogue and behaviors, cultural adaptation, and giving back" [3, p. 598]. They also persist in STEM by engaging in co-curricular experiences, academic peer support, and undergraduate research experiences [4]. Not only that, WOC seek out mentors outside of their identity groups [5]. WOC have also been found to cope with engineering by fragmenting their identities. This fragmentation involves sharing only some parts of their identities in academic spaces and other parts of their identity in social spaces. In addition to fragmenting their identities, WOC in engineering also use strategies including "changing their internal dialogue, adapting to the culture, and participating in outreach to deal with the socially chilly climate they experience in engineering [3].

One study also identified resilient coping strategies of women in engineering that included claiming legitimacy, finding support, creating belongingness, and seeking meaningful impact [6]. Furthermore, WOC find and create counterspaces in STEM, which help them to develop a sense of belonging in STEM [7], [8]. These counterspaces can be physical spaces and/or conceptual spaces and include spaces like peer and mentoring relationships, STEM diversity conferences, and various campus groups [8]. In addition, WOC benefit from various sources of support throughout their engineering journey. Their support typically comes from their family, peers, and institutional support programs [3].

Prior work studying navigation in higher education has conceptualized constructs relevant to navigating, such a coping strategies and support sources; however research in this space has yet to conceptualize how these factors fit together to produce different demands, obstacles, and opportunities for students in engineering and the navigational tendencies students use as a result. Our study and larger project seeks to build on this foundational understanding of the factors relevant to WOC navigating engineering in order to create more responsive support structures in engineering.

III. Methodology

The focus of this paper is to establish a data condensation strategy using one participant interview that can then be widely implemented for all the interviews in the larger project. Data condensation is a data analysis technique that sorts data in order to develop and deepen understanding. Data condensation can

involve writing different types of memos, coding, and theming the data [9].

After data condensation, data display allows the researcher to succinctly present the story of the data through visual representation. Data display can include methods of exploring, describing, ordering, and explaining [9]. For this project, we believe a case summary can be used to explore and explain our data of student navigation.

The data for this paper includes survey data and interview data. First, we used a pre-screening questionnaire to collect demographic information, such as race, gender, major, number of semesters in engineering, part time job status, and generation of college going status. Then, Author 1 conducted five 90 minute semi structured interviews during November 2022. During these interviews, participants responded to questions related to their engineering experiences, how they have responded to particular engineering scenarios, and their reflections on marginalization in engineering.

To investigate the research question, we thematically analyzed the semi-structured interview data as a team, to avoid threats to reliability and rigor. First, Author 1 used two rounds of coding to code one transcript (initial coding and line by line coding) and generate a codebook. Then author 1 wrote a profile memo for that participant, aligned with the codebook [10]. To ensure reliability of the codes, Authors 2 and 3 independently read the transcript and verified the extent to which the memo reflected the participant interview, providing their feedback in areas where they noticed discrepancies. In this paper, we present the result of this process for one interview.

A. Codebook

In this study, we developed a codebook to identify and categorize student navigation processes in engineering. Codebooks are a qualitative strategy used to organize and manage data across a large data set and/or large team of researchers. Codebooks typically contain a code, a description of the content typically labeled with that code, and an example from the data. Applying a standard list of codes across multiple participants facilitates identifying categories and themes across the data set, which aids in the data condensation and data display processes [9], [10].

We developed a codebook based on a conceptual model of student navigation that the authors developed as part of the larger project [11]. The conceptual model theorizes that a person's individual characteristics as well as the structure of the environment are simultaneously relevant to how that person navigates the engineering learning environment. The conceptual model establishes navigation as a phenomenon composed of the following factors: personhood, sensemaking, and responding. We developed our codebook from the process described in the model to include the following codes: personhood, awareness, sensemaking, coordinating sensemaking and response, and responding. The codes and how they were applied are presented in Table 1.

Table 1. Operationalizing the Codes

Code	Operationalizing the Code
Personhood	What are relevant personal characteristics about the student related to their psychological characteristics, familial and social network, demographic identities, prior experiences, goals and desires, or student status classification?
Awareness	What is the student's level of awareness related to recognition of themselves (self-awareness), their situation (situational awareness), and/or society (critical consciousness)?
Sensemaking	How does the student describe their experiences and obstacles related to academic, professional, and/or social contexts?
Coordinating	How does the student describe how they coordinate their obstacles/demands/opportunities with their response?
Responding	How does the student typically respond to obstacles, demands, and opportunities in the engineering learning environment?

Given that the model details simultaneous processes, we double coded when data was relevant to more than one code. This double coding was especially prevalent for personhood and awareness since awareness is captured within personhood in the original conceptual model.

IV. PRELIMINARY RESULTS

Our results present our preliminary findings, which included the codebook we developed and one participant profile. Now, we will present the results of one interview being coded and organized using the codebook previously described.

Nadia (she/her) is a South Asian woman in chemical engineering at [University], and she was a first semester junior during the time of the interview. She was also working a part time job unrelated to her major/career goals.

A. Personhood

Nadia has been interested in engineering from as early as middle school and participated in several engineering related activities/camps in high school. Initially, "[she] was interested in aerospace [engineering] because [she] was in this program through [State] Space Grant Consortium in high school" and other high school engineering activities. She started college in Materials Science and Engineering (MSE) and "when she was in MSE [she] realized [she] liked the manufacturing side of

stuff and [she is] interested in how things are made." She also had an engineering internship that she "actually really enjoyed" where she worked for a process engineer. Her goal upon graduating is to "get a decent paying job in a nice area."

Nadia spends a lot of time studying by herself when she's not in class because "[she likes] to study on [her] own a lot." A lot of her friends are in her major (chemical engineering), with many being girls and "a lot of Asians."

Although she considers herself "a little bit lazy when it comes to clubs" because she doesn't participate in many university activities/organizations, she has participated in a soccer team and volleyball team organized by chemical engineers, and an Indian dance team (Bhangra). When it comes to professional development, she says she's "not great at networking and … [it's] not [her] favorite thing to do," but she attended the career fair every semester, received multiple internship offers, and participated in undergraduate research.

B. Awareness

Nadia has self-awareness in the sense that she knows herself well and uses that to justify her decisions. For example, she describes herself as "kind of a really nerdy person." She does express some hesitancy or second guessing around who she is and her decisions, which may reflect a combination of self-awareness with lower self-confidence. Nadia has a lot of situational awareness, especially related to academic, social, and professional contexts. For example, she is friends with a lot of chemical engineers "because [she sees] them every single day in classes." Nadia has minimal critical consciousness because she knows "there's never going to be a perfect balance of people with different identities" and "there's not a ton of colored people…in the program, but it's not like [people] treat them poorly or any differently."

C. Sensemaking

Nadia "[likes] being an engineering student" at [University], especially because "[she likes] the people who are in [her] major for the most part."; however, she "didn't "really have that many friends at [University]" because her "freshman year everything was online" due to the COVID-19 pandemic. Nadia is surrounded by chemical engineers, academically and socially and attributes the strong chemical engineering presence to taking classes with other chemical engineers, the American Institute of Chemical Engineers (AICHE) student chapter at [University], and a "big chemical engineering group chat" where AICHE organizes events like an "anime night," "Halloween party," and "mentorship meetings." Nadia believes that "engineers don't have that much time for social stuff, so they mainly [socialize with] other engineers when they're studying or doing homework."

Nadia describes herself as "one of those people who has a lot easier time with picking up concepts" than her peers so she puts in less effort than her friends. As a result, she has friends "who spend hours on homework" and "put more effort in" so "they definitely do better than [she does]." She doesn't seem to mind that her friends are putting in more effort and doing better. In addition, she doesn't utilize resources that are emailed about because she's "the type of person who needs someone to talk at [her] instead of reading stuff."

Nadia's biggest challenge in engineering is "the academics." She has faced obstacles related to her courses from her professors being 'disorganized," "boring" and/or difficult. She thinks the classes are difficult because they take time, like "[her] first separations homework took probably 10 hours" and professors are not always good.

D. Coordinating Sensemaking and Responding

Nadia recognizes that junior year of chemical engineering is especially challenging, "so they need to work together to do homework," and as a result she and her peers use the chemical engineering lounge on campus as a place to work together with other chemical engineers. She doesn't go "that often" but when she does "someone's there to help."

She recognizes that there is no "choice" for instructors in chemical engineering because it's a small major, "so you just get who everyone else gets." Everyone gets the same instructor for every class, so she doesn't "worry" about "choosing" courses.

When Nadia was experiencing an especially challenging course load, she dropped a class and recognized that it was "perfectly normal" because she was originally taking 19 credit hours and "dropped down to 16." When Nadia's tests went poorly, she "studied a little bit harder" because "studying is just a matter of putting enough time in … to know what questions to ask" because when you ask, "someone's going to give the answer, whether it's your peers or a TA or the teacher."

E. Responding

Nadia's main sources of support are herself and her friends. She doesn't seek out additional university support because she seems to get what she needs, so she "never [goes] to office hours" or "emails [her] professors" whereas "everyone else does." Her main strategy is to "keep to [herself] and take [her] notes and do [her] homework." Sometimes, she will "text" her friends "about homework problems and stuff" or go "to a TA for office hours and [ask] a couple of questions."

She seems to have received a lot of proactive support. For example, Nadia describes being "forced' into activities related to developing her professional skills, like a class she thoughts was "kind of boring" where they "forced [her] to make a resume." She thought this external accountability was "good because [she] probably wouldn't have done it unless someone forced [her] to." She also felt "forced" to go to career fair initially but has "found career fair to be the only effective way to get internships" because "applying online is awful."

V. DISCUSSION AND CONCLUSION

We developed a codebook and a participant profile to verify the usability of codebook in understanding how certain students navigate engineering and what factors are salient to them as they experience the undergraduate engineering learning environment. We used the codes personhood, awareness, sensemaking, coordinating, and responding to capture the navigating tendencies of Nadia, a WOCE. Organizing Nadia's data in this way was useful to parsing the simultaneous

obstacles, demands, and opportunities present in the engineering learning environment for Nadia and how she made sense of them and responded. Therefore, we believe that this coding structure can be useful to understand how other WOCE navigate engineering as it illuminates the relevant process associated with navigating (i.e., sensemaking and responding).

Furthermore, our findings for Nadia align in a lot of ways with previous literature on WOCE and how they navigate engineering. For example, Nadia's participation in pre-college engineering activities aligns with previous literature that has found that these types of activities are often what bring WOC into engineering in college [1], [2]. Not only that, Nadia stated she picks up engineering concepts easily, demonstrating a high sense of self-efficacy, which aligns with previous work that has found that WOC in engineering persists through engineering partially due to their strong sense of self-efficacy [12].

Nadia did not describe experiences of social pain within the engineering learning environment or mention navigational strategies previously researched (modifying internal dialogue and behaviors, cultural adaptation, and giving back) [3]. Therefore, it is worth noting that WOC can have a wide range of experiences within engineering, which may be relevant to how salient their identities are to their engineering experiences. In Nadia's case, her low level of critical consciousness may reflect her minimal experiences of being marginalized in engineering or her low level of critical consciousness may contribute to her not recognizing marginalizing experiences in engineering. Given this discrepancy in interpretation, more work is needed to understand how students' level of critical consciousness makes their experiences in engineering easier or harder.

In terms of codebook development, the author team is having ongoing discussions about how to further refine and define the codes. For Nadia alone, the author team disagreed on the exact placement of some of the codes, given that quotes were double coded but only appeared in one section in the memo (i.e., in one code). Furthermore, there were disagreements around the exact boundaries of the codes related to sensemaking and responding since they are often hard constructs to define a starting and stopping point to.

From our findings and discussion, we can conclude that the codebook we developed is an appropriate data condensing strategy for this project, as the codes do reveal how students experience and navigate engineering. That being said, more work is needed to solidify the boundaries of the codes to make them as parsimonious as possible. Future work will include refining the codebook and developing participant profiles for each participant in the study and larger project to better understand individual factors salient to student navigation and broader trends across participants.

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