Secondary Data Analysis as a Research and a Training Tool: First-Year Engineering Experiences

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Abstract*—In this Work-in-Progress research paper we report on the process of and findings from a secondary data analysis (SDA) investigation that builds on a primary study about the role of First-Year Engineering (FYE) experiences on students' engineering identities and community. The purpose of this SDA work was two-fold: we aimed to train undergraduate engineering students in qualitative methods and understand the process of SDA investigation as a training tool; and build on and expand the primary study's findings. The SDA team was composed of one of the original researchers and three new scholars – a faculty member and two students from an undergraduate-serving institution. The original study sites were two large research-focused institutions that differ in their FYE curricular content and structure. The data sources included pseudonymized transcripts of interviews with students during their second year, as well as institutional demographic data including participants' major and self-identified gender. Thematic and grounded theory approaches were used as the primary analytical tools. Our analyses identified four emergent themes summarized as: (1) feelings of inadequacy and creation of strong bonds with peers; (2) students' perceptions of societal definitions of engineering and their effects on students' career choice and engineering ability; (3) students' perceptions of their own engineering identity and how it aligns with that of society; and (4) formation of support networks and their impact on student's FYE experiences. Furthermore, despite differing FYE structures, we found that students from both institutions describe similarly their engineering identities, including lacking confidence in their engineering identity and concern about external perceptions of what makes an engineer. Finally, we found that SDA serves as a training tool to support the development of undergraduate engineering students using qualitative methods.

***Keywords*—First Year Engineering (FYE), secondary data analysis (SDA)**

I. Introduction and Literature Review

This Work-in-Progress research paper builds and expands on the initial study findings [1] about First Year Engineering (FYE) experiences. This initial study began with surveys to explore changes in five identity-related constructs: major choice, career choice, engineering identity, belonging in engineering, and engineering expectancy/ability, for FYE students at two different institutions with differing FYE structure. Following the surveys, a series of semi-structured interviews were conducted over three years. Using qualitative analytical methods, we investigate students recounting their FYE experiences. We also report the process and findings from this secondary data analysis (SDA) investigation to provide insights into the impacts of FYE experiences on engineering identities and communities. Furthermore, we report on the impact of SDA as a qualitative methods training tool for undergraduate engineering students.

Secondary data analysis (SDA) refers to the use of existing data to answer a question that is different from the original work [2][3][4][5]. Typically, secondary analysis researchers are not involved in the data collection process [3]. One reported strength of SDA is that it eliminates the potential burden of participation from research participants as data can be reused. As well, qualitative data collection processes are expensive in terms of time – participants and scholars – and financial aspects of data collection are reduced or even eliminated in SDA approaches [5][6]. This is particularly important since many qualitative scholars report that much of their data remains un-analyzed due to the continual need to raise additional funding for new research projects [7]. Recent literature indictes that since the secondary analysts approach the data for the first time, with new analytical questions, lenses, and contexts in mind, SDA analyses prove valuable in expanding on original findings [5][6][7]. Comparison of the original findings with those of SDA promises to enable additional checks for the validity of the early findings and allows for their further refinement [4][5][6][7]. Despite these benefits, SDA research is not without limitations. Some SDA critics worry that temporal evolution of social, cultural, and/or political norms between the initial data collection and SDA research may lead to a misinterpretation of the original qualitative data due to its subjective nature [5][7]. Others suggest that SDA may pose an interesting, if not challenging, problem because secondary researchers may find themselves less connected to the data. More specifically, some scholars argue that while being removed from the original data enables secondary researchers to be more objective, SDA process may result in the secondary researchers having less immersion in the original data, and subsequently performing a superficial analysis [5].

Previous research has shown agreement on the importance of FYE courses for introducing the engineering discipline [8]. This places both students' FYE courses and their entire FYE experiences in a unique and pivotal position to impact and begin forming their engineering identities [9]. Development of a robust engineering identity has been linked to persistence in engineering [9][10][11][12] suggesting an increase in "helpful skills and work ethic for their future career" [9]. Research on engineering identities also points to competence, performance, engagement, and future career plans as key indicators of a student's engineering identity and its development [10]. Some research has shown the importance of motivation on student's academic success and has also linked motivation to be an important factor in students' engineering identities [10][13][14]. Competence, high performance, and significant engagement were also identified as indicators of a transformed sense of self, which may increase the likelihood of one's persistence in the engineering field [10]. Similarly, having future career plans and participation in research and internships that pertain to the engineering field serve as indicators for development of one's engineering identity and desire to pursue engineering as a career [10].

In this paper, we seek to answer the following research question: Using SDA, what themes emerge from the original data set related to the first-year engineering students' experience and engineering identity? We also describe SDA as a as a training tool to support the development of undergraduate engineering students using qualitative methods.

II. Methods

Two U.S.-based research-focused institutions that differ in their FYE curricular content and structure were used as study sites for the original study. The data sources included pseudonymized transcripts of interviews with twenty-nine participants – twelve from Institution 1 and seventeen from Institution 2 – during students' second year, as well as institutional demographic data including participants' major and self-identified gender. Students were purposefully selected to identify a diverse pool of participants [15]. The interviews used a semi-structured open-ended protocol. Six primary questions were pursued with the aim of getting insights into students' engineering identities and the communities they were able to form [15]. Interviews lasted anywhere from thirty-five minutes to seventy-five minutes.

The SDA team was composed of one of the original principle investigators and three new scholars – a faculty and two students from an undergraduate-serving institution. SDA was conducted using thematic analysis and grounded theory leveraging a constant comparative approach [16][17][18][19]. In the first phase of the secondary data analysis, the two undergraduate scholars individually read all twenty-nine interview transcripts and wrote individual narrative memos for each. These were then discussed amongst all four scholars with the primary aim of emergent theme identification while also ensuring inter-scholar reliability and validity of emergent findings. To summarize the experiences and findings from individual memos, four summative memos were written – one by each undergraduate scholar for each of the two institutions, – followed by identification of similarities and differences between the two institutions resulting in two additional comparative memos. In this way, the four emergent themes were identified. Further analyses engaged coding for emergent themes using constant comparative method [16][17][18][19]. Memoing the coding process supported analytical coherence and provided documentation for inter-coder reliability (found to be above 85%) and validity checks.

III. Results and Disucssions

Thirteen emergent codes were developed from the four emergent themes in response to our research question. The themes were: (1) students feeling "not as smart as everyone else," associated challenges with group work, and creation of strong bonds with peers; (2) students' perception of how society defines engineering profession and an engineer, and the relationship of this perception to the identity-related constructs of career choice and engineering ability; (3) students' perceptions of their own engineering identity and how much that identity aligns with society's definition; and (4) students' identification of how and whom to include in their support networks and how this relates to the impact of FYE experiences on their engineering identities. For Theme 1, the following open codes were created: "Not as smart as everyone else," Group Work, Strong Academic Bonds, Weak Academic Bonds, Strong Non-Academic Bonds, and Weak Non-Academic Bonds. For Theme 2: What Does an Engineer Do, What is An Engineer, Engineering Confidence, Engineering Difficulty, and Career Choice. For Theme 3: What Does an Engineer Do and What is An Engineer. For Theme 4 the final two codes were: Professional Networks and Getting Help. These codes allowed for investigation of the themes in more depth to examine the role of FYE experiences on students' engineering identities and communities.

In our analyses related to all four themes, students define the construct of engineering identities most clearly in their response to the question "Are you an Engineer?" Students' narratives related to this query revolved around two main ideas. The first is that some students needed concrete accolades and more experience to acknowledge themselves as engineers, such as obtaining a degree or completion of a set of courses. Secondly, individuals who already felt like they were engineers positioned their identities as such because of their deep interest in mathematics and science as well as their analytically-minded thought processes or the way they approached problem-solving. For example, Harry from Institution 1, shared:

> *it's like whenever I see a problem, or … [been] assigned a given problem and how you look at things. Like breaking [a problem] down, how to do it realistically versus hypothetical[ly]… And constantly looking at how … to improve … I look at things very experimentally … always looking to improve on something … I'm never satisfied with … just meeting the standard.*

Harry's musings represent the second idea as he considers himself an engineer due to the way he approaches problems and constantly looks to improve things. Annie from Institution 2, on the other hand, reported:

> *I have to have a job in engineering and technical experience and/or my diploma to become an engineer. I think … until I graduate but I would be more comfortable saying I'm an engineer if I had to have an internship and had some actual experience.*

Annie's answer represents the first idea as she does not consider herself an engineer and ascribes this feeling to her limited technical experience and lack of a degree. This could suggest some students feel a need to prove themselves in some way to receive official external validation in the form of internships or degrees to identify as an engineer.

When analyzed through the lens of performance and competence, engineering identity construct emerges through the following codes: "Not as smart as everyone else," Engineering Difficulty, and Engineering Confidence. The *in vivo* code (i.e., a code developed using the participants language) "Not as smart as everyone else" frames the way students may describe how and why one might not feel as engineer. For example, Christy from Institution 1 describes:

> *[Chemistry] was very different because they expected you to know … things. I was completely out of my element and there were people around me like, 'Oh, pick me, pick me' and they knew all the answers. Intro was like, 'Uh, am I actually supposed to be an engineer because I don't know any of this?' That was hard. There is a lot of doubt because high school [was] easy … here everyone is just so smart. That was the struggle and that was the whole doubting myself.*

Christy describes having moments where she's wondering why she's in engineering while at the same time noticing her peers having an easier time understanding material from a course she was struggling with. As she finds this experience to be "hard," Christy engages in a self-talk about struggling and "the whole doubting." Notably, persistence of such challenges, including distancing from one's sense of being an engineer, may result in smaller probability of one's perserverance in engineering.

In comparison, the code Engineering Confidence representats students' expressed ease or enjoyment in doing engineering-related tasks and stepping into their engineering identity. For example, Daniel from Institution 1 shares:

> *I went into computer science primarily and it just happened to be in the engineering college just because computers and programming are what I excel at and what I enjoy. So it's the major I pursued.*

This sense of confidence in one's ability to perform well, even in a challenging curriculum, is further described by Nikki from Institution 1 who, as a first-year student, identifies as a civil engineer and describes her vision of walking across the commencement stage:

> *As a student, I would say I'm very focused. I came [to Institution 1] as a civil engineer. … Upperclassmen have told me freshman year how hard it was. [But] I'm very focused about finishing my degree, not changing [it]. School is very important to me, and … civil [engineering] is very important to me. Whenever I do graduate, [I will] be walking across the stage with a job. That's something that I really want.*

Although Daniel and Nikki's motivational attitudes related to their formal educational experience in challenging courses are different – Daniel seems to be intrinsically motivated to engage with computing while Nikki speaks to a more externally driven, albeit internalized, desire to complete her degree – both step into their engineering identity in a powerful way. These two students acknowledge "excelling" in their coursework even while it may be "hard."

At the intersection of Themes 1 and 4, both of which allude to development of engineering identity within a community and communal practices, we identified the following codes: Group Work, Strong Academic Bonds, Weak Academic Bonds, Strong Non-Academic Bonds, Weak Non-Academic Bonds, Professional Networks, and Getting Help. Our analysis indicates an overlap between students' narratives of communities or communal practices with the sense of students' developing engineering identity. In their interviews students engage in speaking of communities as those that exist in both academic and non-academic contexts and support formation of both weak and strong bonds. Strong bonds are defined by students as relationships that they explicitly seek out and maintain as opposed to circumstantial relationships. As our data indicate that both academic and non-academic contexts are of importance in students' narratives about community, in our analyses we differentiate between the two by grouping coursework, engineering clubs, and internships into an academic context. Largely, the instances of bonds taking place within non-academic contexts were described by students as involvement with non-engineering extracurriculars, such as interactions with peers in the dorms, at campus events, and sports. As an example of a community bonding taking place in an academic context, Annie from Institution 2 describes:

> *I can remember countless nights that we would all … gather in one of our dorms' study room[s] and we'd all just work through the night… One night specifically, we'd be working on our report and we'd realize at three in the morning that it was not going to be done until eight and we had class at 8am. We'd all look at each other 'alright, we're in this together.' It was a lot of comradery… that specific night, two of my friends … finished an hour before everybody else… and … they decided to stay up and just sit with us when everyone else finished …. it was … a very small thing but it was just the idea that … if none of us is sleeping then none of us is sleeping.*

Annie details a memorable experience co-working with her peers through the night when a communal decision was made to support each other and each other's work, "if none of us is sleeping then none of us is sleeping." This level of comradery and support evidently left a lasting impression on Annie. Her sense of belonging in engineering was most likely heightened knowing that she had this kind of friend group to support her. Students share similar moments and associated feelings about positive academic experiences supporting their engineering identities and engineering identity development.

Another example of an emerging "community" is told by Brent from Institution 2 who recalls:

> *Just basics, information on … I mean, it was very simple code, now I think of it. But he just helped me with basic knowledge. If [my peer] was in the study room, I'd go on this side of him, and just sit next to him and just ask him for help when I would need it. It's not like we sat down together. He helped me when he could.*

Brent mentions an instance where he was able to get help on a programming problem from a peer who lived in the same annex. There wasn't anything special about this moment, but Brent improved his "basic knowledge" with some assistance from a peer he didn't know very well. This interaction helps Brent become more comfortable with programming. In a way, Brent creates a "community" of his own by seeking help from a peer – an act that helps him build his mastery competence, which, as literature indicates, also contributes to an improved sense of engineering identity.

Relevant to Theme 2, the Career Choice code pertains to the future career plans aspect of engineering identities. Students' narratives corresponding to this code take two different forms: most students explain why they went into engineering, while a smaller number of students share what they want to do in the future. In most cases, students describe an intrinsic drive for pursuing engineering as a career, although some do speak to the identified regulation of pursuing the career as something that will create future stability (as is the case with Nikki from Institution 1 described above). For example, Sam from Institution 1 shares:

> *Because if I wanted to do research and development, several of the advisors that I work with closely at work, told me I'd have to get a Doctorate and I was like, 'Okay, I'm cool with that. I'm up for the challenge. I enjoy the challenge. I'll take it…'*

Gabriel from Institution 2 expands on his intrinsic motivation that drives his decision to pursue engineering as:

> *when I was seven or eight years old, I ... [was] just ... mingling around with my bike. I took some part of it and ... I break it down and then it doesn't work. And then my father will send it to the repair shop again, from there I see how ... the man repair[s] it and I've been watching Formula One since I was young so [those are] the only main things.*

Sam is confident in wanting to pursue research and enjoys the challenge when advisors share with him aspects of one's journey toward a Doctorate degree if he is to pursue research. This outlook suggests a level of intrinsic motivation that may help him persist in engineering considering he is taking on additional degree requirements to fulfill a career goal. Gabriel shares a memory of his younger self trying to understand his bike and watching the repairman fix it, as the moment that sparked his interest in engineering. This deeper connection to engineering starting at an early age also implies a level of intrinsic motivation, which again, as demonstrated in literature, supports one's engineering identity development.

IV. Conclusions

The different aspects of engineering identity: competence, performance, engagement with community, and career plans have an underlying connection to FYE experiences. There is a lot of research that reinforces the importance of FYE experiences on the students' engineering identity development. So continued research into further understanding these connections will help educators take advantage of their unique position to improve student's FYE experiences to ultimately better shape students' engineering identities.

There is still a lot of work to be done as we attempt to build on current knowledge around the impacts of FYE experiences on students' engineering identities and communities. For one, this paper presents findings based on the first of three phase interviews from two institutions. As a work-in-progress study, we expect new findings to surface after additional analyses on the subsequent phases.

As we continue to explore the connection between engineering identity, community, and FYE experiences, we invite the FIE audience to start a discussion about how prevalent the observed themes may be in students' subsequent college careers within distinct and diverse higher education contexts. How relevant are this manuscript's findings in students' first year to the rest of their college and engineering experiences? What are the best ways to rehabilitate a student's engineering identity and sense of community after a difficult FYE experience and how necessary is this proposed rehabilitation?

Although the primary focus of this paper was on the SDA findings, we hope our work serves as a testimony to the learning that arose from conducting this study. Driven primarily by two junior engineering undergraduates who have had no prior qualitative research experience, this project's process and ensuing outcomes demonstrate SDA potency as a teaching tool not only for social science and education scholars at a graduate level (and beyond) but also to undergraduate population whose focus may be primarily (or only) in STEM space.

More specifically, the work with SDA served as a great introduction in qualitative research methods. It eliminated the burden of having to collect data enabling the undergraduate students to focus primarily on the analytical aspects of qualitative research and allowed for deep conversations about one's positionality and the need to unpack it prior to scholarly endeavors. As well, this work allowed for exploration of the topic of robustness and "rigor" of qualitative paradigm, a question with which engineering education scholarship is actively engaging.

This project also highlighted a number of challenges for SDA and specifically SDA as a training tool. Firstly, since the analysis was performed using interview transcripts rather than the original recordings, some student's responses were challenging to understand. Furthermore, absence of any other secondary data (e.g., ethnographic notes from the itnerviews) supporting an analyst's undrstandign of the context makes SDA work particularly challenging and necessitating continuous check-ins with original scholars who performed data collection. These, however, were also opportunities for undergradutes scholars to delve deeper into understanding how data collection processes are intricately tied into ensuing analytical processes, and what steps research designers need to make a prior to allow for follow-up SDA analyses to take place.

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