

Methodological Commitments in Grounded Theory: Experiences of a Novice Researcher

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Abstract – Grounded theory is a well-accepted research methodology within engineering education research and regularly provides new insights contributing to the expansion of this field. The wide range of grounded theory usage and tradition allows researchers to implement grounded theory methods and methodologies in different ways depending on the needs of the research. This variety contributes to the richness of grounded theory and makes it a tool of value to engineering education researchers, but can also prove to be overwhelming and confusing to novice researchers new to the use of such methods and methodologies. This paper describes the experiences of a novice researcher in their process of implementing constructivist grounded theory as a methodology. This methods paper is developed within a larger qualitative study aiming to gain better understanding engineering student's motivation to engage in design activity within the context of a capstone course project. This paper will consider the various methodological implications of engaging with grounded theory, specifically how these often-tacit implications can be a challenge to a novice researcher. Examples of processes such as developing a semi-structured interview protocol, conducting in-depth interviews, and initially coding data will be expanded upon to reflect the researcher's experiences and thought processes when learning about and implementing this new methodology. Research quality, specifically research quality in qualitative research will be discussed and introduce important considerations such as researcher positionality and sensitizing concepts when engaging with constructivist grounded theory. We will use the initial interviews of three mechanical engineering student participants as the basis for our process description. Initial findings emerging from the initial coding of these interviews will be presented and discussed. By transparently sharing our experiences with grounded theory, we hope to make apparent some of the subtleties associated with such methodology and assist other novice researchers in their journey conducting grounded theory research.

Keywords- *grounded theory, qualitative research, motivation.*

I. INTRODUCTION

Grounded theory has been a particularly useful approach to understand nuanced features of engineering education, its use within engineering education research has been broadly accepted and implemented, providing valuable insights and theories on topics such as professional identity in undergraduate engineering [1] engineering competence [2] or familial influence on first generation students [3]. Grounded theory, with its many different approaches [4]–[6] has also been studied from a methodological standpoint in engineering education research [7] providing a wealth of literature for novice and experienced researchers willing to engage with this methodology.

This methods paper focuses on my (the first author's) process using Constructivist Grounded Theory (CGT) to understand motivation to engage in engineering design within the context of a capstone project. Specifically, I will focus on my processes of data collection through in-depth interviews and initial coding and share the challenges I experienced as a novice researcher and insights into the way I resolved these challenges with the help of my co-authors as a way to support other researchers through this process. By providing robust reflection on the first author's experiences of being mentored into grounded theory research, we aim to expand the oft-told narrative of *doing* research as a sequence of procedural tasks to an outgrowth of maintaining methodological commitments of grounded theory [8]

Recognizing the multifaceted nature of cultivating quality in qualitative research [9], [10], we use this paper as a way to contribute to methodological conversations that occur at the front end of grounded theory investigation. Such decisions around interview quality and coding are often hidden from research reports but are critical to inductively generating theoretical claims. We present here the experiential processes of conducting semi-structured interviews for three

participants and completing initial codes in a grounded theory investigation. We further offer preliminary insights from initial coding from 3 in-depth interviews with mechanical engineering students that served as pilot interviews within the larger study. Our focus remains intentionally small so that we may reflectively expound upon our treatment of the methodological commitments that we upheld through our research procedures.

II. CONTEXT OF THE STUDY:

We begin by describing the aims of the larger study that encompasses the aims of this methods paper.

Capstone courses are an integral part of engineering student's experience in many disciplines and aim to simulate as much as possible authentic engineering design and engage students in open-ended projects[11]. Because achieving such authentic engineering design can be a challenge within the confines of academic setting and its requirements, gaining a further understanding of how engineering students engage in design activity and their motivation to do so could be valuable to the improvement of capstone design courses. Our investigation will be framed by the concepts of design activity engagement [12] situated cognition [13] and motivation [14] and attempt to answer the following questions:

How do engineering students connect their identity motivations to design strategies?

How do engineering students make sense of / prioritize / conceptualize design strategies?

How do students' priorities of design strategies relate to ways of constructing professional identities?

In this paper, we report on the initial stages of this larger research focusing on our first research question. This first step towards our final goal was designed to test both the soundness of our methodology and my skills as a qualitative interviewer and researcher. To do so, I conducted one interview with 3 mechanical engineering students engaged in a capstone design course and selected via convenience sampling [15, p. 212]. Each interview lasted between 43 and 66 min and followed a single semi-structured interview guide detailed below. Another motivator to conduct this initial study was to develop my interviewing skills and allow myself to reflect on the content and framework of my interviews within the structured guidelines of a research publication.

III. RESEARCHER POSITIONALITY AND BACKGROUND

I (Elliott) started working on this study briefly after being introduced to qualitative and engineering education research. My knowledge of data collection and analysis was limited to the few studies I had engaged with before and largely consisted of conducting interviews, reading through transcripts, and organizing common themes across transcripts. My prior research background, being in quantitative studies within the field of Materials Science, undoubtedly influenced my interest in grounded theory, specifically for its claim of objectivity and results purely

grounded in data [15]. Dr. Huff and Brown, two researchers experienced with grounded theory studies within engineering education [sources], provided and helped me find useful resources to deepen my limited knowledge of grounded theory methodologies and allow me to take part in the study described above.

IV. METHOD AND PROCESS DESCRIPTION:

Constructivist Grounded Theory (CGT) is described by Charmaz as an iterative process consisting of "systematic, yet flexible guidelines for collecting and analyzing qualitative data" [4, p. 1]. Broadly speaking, CGT consists of collecting data of various forms (including but not limited to interviews, field notes, memos, participant-generated documents, etc.), analyzing the data through subsequent rounds of "coding" (an iterative method consisting of synthesizing and sorting the data to observe emergent patterns), using these codes to develop inductive theories, and repeating the process until "saturation" is reached (saturation corresponds to the point when new data does not generate any new theory) and the researcher has developed a new theory grounded in data. This set of guidelines can be presented in more or less rigid ways depending on the school of thought adopted upon engaging with grounded theory. A practical comparison of these various school of thoughts was done by McCall and Edwards [7] providing valuable insights on the different ways in which grounded theory can be used, ranging from the strict guidelines of classic grounded theory [6] to a flexible "toolkit approach" [7].

This section will describe my process in selecting and implementing constructivist grounded theory (CGT) within this specific exemplar study. My aim is to report as accurately as possible the various considerations and challenges associated with conducting a CGT study. Rather than focusing solely on the procedural aspects of CGT, we intend to provide insights into the mindsets and philosophical considerations associated with such procedures.

A. Choosing CGT

The decision to conduct a study often emerges from an unanswered question or gap in literature that the researcher is interested in addressing. In our case, our interest lies in studying how and why engineering students engage in design activity, specifically in the context of capstone engineering projects. Because this research could provide a context specific theory of design activity engagement, CGT provided a great methodology for us to use in order to inductively advance our knowledge and understanding of the subject at hand, as suggested by McCall and Edwards, "In both pragmatic and constructivist grounded theory, researchers are encouraged to identify causal conditions while emphasizing their contextual and contingent nature" [7, p. 98].

B. Role of the investigator

An important aspect of choosing CGT over other grounded theory approaches is the acknowledged active role that the researchers occupy in data collection and analysis. While Corbin and Strauss perceive the role of the researcher

as an objective tool for data collection [5], Charmaz describes the researcher as an active and influential actor in both data collection and analysis. The constructivist component of CGT requires us to “take the researcher’s position, privileges, perspective and interactions into account as an inherent part of the research reality” [4, p. 13].

This description of the researcher’s ‘duty’ to contemplate their own experience and background as part of the research process resonated with me because of my prior experience and interest in researching identity within engineering, including identity navigation for marginalized students. Such study requires an acknowledgement from the researcher of their own privilege and background, which is linked to the overall quality and reliability of their findings [16].

C. Sensitizing concepts

Despite being limited, my research background and exposure to literature proved to influence my view and interpretations of the study before the data collection even started. The process of “bracketing” is commonly used for various qualitative research approaches [15] and consist in the researcher isolating themselves from any external element that might influence their collection or interpretation of data. This process of isolating oneself from existing literature is an attempt to convey “objectivity” to the research findings.

This removal from the body of literature I was supposed to add to through my own research seemed unrealistic to me for different reasons. Firstly, as mentioned earlier, the interest to conduct a study typically emerges from the knowledge of a gap in literature, which by definition requires a knowledge of current literature in the desired subject area. Secondly, the process of obtaining funding and Internal Review Board (IRB) authorization to conduct a study also requires a detailed description of current literature on the subject to justify the need for one’s study. Lastly, my own internalized research background and the knowledge associated with it contributes to the way I formulate research questions and the different frameworks I am likely to utilize in answering these questions. This conflict between qualitative research theory and my personal reasoning process contributed greatly to the choice of CGT as a methodology to follow. Charmaz explains that *sensitizing concepts*, that is, concepts which the author has previous awareness of before engaging in the research process, “give researchers initial but tentative ideas to pursue and questions to raise about their topics. They can provide a place to start inquiry, not to end it” [4, p. 30].

D. Interview protocol

Our interest in understanding how and why mechanical engineering students engage in engineering design practice dictated the need to collect data emerging from in depth interactions with students. This led us to select in depth interviews as our primary method of data collection.

Prior to conducting interviews with participants, an interview protocol, or interview guide is often created for both getting approval from an IRB to interact with participants, and for the researcher to map out areas of interest they would like to approach during the interview. In

my case, a semi-structured interview protocol [17] seemed to be the best option since it encouraged for the participants to steer the conversation towards their subjects of interest while giving me some guidance as of which general questions and probes to use during the interview, thus potentially diminishing my chances to make the interview awkward and intrusive to the participant [4, p. 63].

The development of the interview protocol was performed as a collaborative effort between myself and the study’s principal investigators, and served as a way for us to broadly map out the areas of student experiences we wanted to inquire about. Developing this protocol was also a valuable exercise for me, a novice researcher, to learn about how to ask good questions. The balance between being so vague that the participants would not understand the question, and so specific that I would force data upon the participants was a challenge and took some iterations to accomplish.

The influence of sensitizing literature was a challenging aspect to navigate for me, as my background in primarily quantitative engineering studies influenced me to frame my questions based on pre-existing theories. The assistance from my two co-authors helped me create a protocol that used pre-existing theories as a starting point but would also provide in-depth descriptions of our participant’s world view, thus creating rich data for us to analyze.

E. In depth Interviews

As put by Charmaz [4, p. 65]: “Interviewing takes skill, but you can learn how to do it”. This enrichment of my skill set was, besides collecting initial data, the principal motivation in conducting these initial interviews.

As a novice interviewer, my main focus when conducting the first interview was collecting valuable data, which led me to closely stick to the interview protocol. My overall nervousness to conduct an interview and my focus on what to ask next certainly compromised the quality of this first interview with Sarah, and a later analysis of my questions with the help of the second author showed many instances in which further probing questions could have been asked. We facilitated the mentoring process by using a tool that was developed from the work of the second author (Authors, 2023). This reflection on my interviewing skills however helped me feel more comfortable in my conversations with David and Maria, who’s interviews contained more probing questions and felt overall ‘smoother’ with each topic generally linked to one another following the participant’s train of thoughts.

Focusing on and eliciting rich descriptions of the participant’s experiences was another safeguard against the influence of sensitizing concepts when asking questions, it helped me relax and be more conversational as the participant took charge of steering the conversation and my role was to focus on what was being said and probe further descriptions if needed. Conducting these initial interviews proved to be a great way for me to reflect upon and improve my interviewing skills.

F. Initial coding

After obtaining the transcripts from each participant interview, the next common step in qualitative studies is getting familiar with the data we just collected through multiple readings and listening of each interview [15], [17]. This process of familiarization was important in my development as an interviewer because it represented the first of many opportunities for me to reflect on the content and structure of the interview. My process consisted in listening and reading through the interviews multiple times, each time reflecting on a different aspect of the content. My first reading and listening aimed to ensure that the interview content was properly transcribed. During the second reading and listening, I focused on the content of the interviews : What were the broad topics we talked about? Was anything shared by the participant that changed the focus of the conversation ? Did anything “stand out” or seemed of particular interest to me ? This focus on content helped me feel more immersed in the participant’s experiences. A third listening and reading session was focused on my interviewing skills: Did I ask questions in the way I intended to? How was the tone of the interview? Could I have asked additional or more pertinent questions? These questions were often answered with remorse and regret as I identified many ways the interviews could be improved upon. Such familiarization processes were for the most part internal and consisted in me thinking about different aspects of the interviews. Moving forward in my research and as the number of interviewed participants increases, I intend to log these thought processes externally using a logbook or similar methods. This will ensure that I can later refer to the evolution of my interactions with the content at hand over time.

Once a better familiarity with the data has been established, it is generally recommended to start *coding*, or analyzing the data. Coding methods are varied among different methodologies and will adapt to the needs of the research question at hand [18] Charmaz describes coding as the process of “naming segments of data with a label that simultaneously categorizes, summarizes, and accounts for each piece of data” [4, p. 111] CGT coding encompasses multiple steps starting with *Initial coding*. This initial coding aims to look in detail at the data and understand “what it is about”. This sense-making of the data is an important part of the subsequent analysis as it establishes the knowledge base that newfound theories will build upon.

The process of initial coding proved to challenge me in various ways. The first challenge was in understanding *how* to code. From my previous experience with coding for narrative analysis [18] or general qualitative theme identification, it was most common for me to identify broad themes and categories that appeared across the transcripts and use these descriptive categories as codes. These categories generally represented themes about which I could write about. Initial coding in CGT however aims to get deeper in the data and to “analyze actions and processes rather than themes and structures” [4, p. 15]. This came to light after my

first iteration of initial coding. After coding all 3 interviews focusing on the principal themes present within the content, I met with the second author to discuss initial coding. I had the feeling that my current coding did not help me in having a good sense of what the transcripts told us about the participants, specifically the results from my coding did not attend to the processes of identity and engagement which we were interested in. The second author pointed out that I had focused my coding on descriptions and coded with nouns, as opposed to focusing on our participant’s processes. We then agreed that I should start coding over again, focusing on these internal processes expressed by participants, and develop codes utilizing Gerunds (nouns derived from a verb, ending in -ing) which better communicated internal processes. This process is also recommended by Glaser [6] for the same reasons. This shift in my coding mindset and process was a great improvement to the richness of our findings, as it provided a lot more useful insights into the participant’s internal processes and finally helped me see what the transcripts contained.

To illustrate the difference such a shift in coding approach makes, the Table I below describes iterations of codes for the same segments of participant interviews. Both examples illustrate the added richness that “action coding” (or coding using Gerunds) provides to this specific context.

TABLE I. EXAMPLE OF TRADITIONAL VS. ACTION CODING

<i>Coded Interview Segment</i>	<i>Traditional Coding</i>	<i>Action Coding</i>
“At first I really liked Legos. It's just really fun to be able to build something and then watch it do the thing that you wanted it to do. It's just such a satisfying, rewarding feeling to see something work how you wanted it to work and to be able to bring something to life like that . Um, so yeah, that was really, I think a big push for me to continue doing it .”(Maria)	Engineering motivation	Feeling rewarded when bringing a design to life
“There's no such thing as a correct answer, just different possibilities. You've gotta make choices. They're always there with anything you choose to do because that's what designing is all about, making choices. If there was one right answer then there wasn't no reason to do the project.” (Sarah)	Description of design process	“Defining the essence of design”

The second area of challenge I experienced was understanding *why* I considered assigning certain codes to certain segments. As described before, sensitizing concepts play an important role when designing an interview protocol, but their role in analysis was even more flagrant to me during initial coding. I found myself mentally referring back to the interview protocol and previous literature while reading the transcripts, which influenced the way I perceived various segments and their meaning. Once again the process of coding through processes and actions expressed by the participants, and focusing on line-to-line coding [4] greatly helped me focus on the content of the interview rather than

my pre-established ideas about the content of the interview. As explained by Charmaz “If you ignore, gloss over, or leap beyond participant’s meanings and actions, your grounded theory will likely reflect an outsider’s rather than an insider’s view.” [4, p. 121].

Overall, the process of coding was (and still is) the most daunting part of conducting a study for me. The notion that my skills as a researcher can have such an impact on the quality of the data and findings is still an important cause of concerns in my development as a researcher. In qualitative research, the search for confirmation that we “are right”, that is, that our study findings are as objective as possible and do not depend on the researcher, often lays under the umbrella of the concept of “interrater reliability” [9], [15, p. 264], [19] which evaluates the extent to which multiple analysts can be consistent in their coding and interpretation of data. In the case of this study where I was the only analyst, ensuring that my interpretation of the data was “right” relies solely on me. Despite being the only coder, I was able to work with the co authors and engage in an iterative coding process supported by their mentoring. Getting repeated feedback on my coding skills and being encouraged to iterate with different coding methods and points of view made me more confident in the validity of my findings, and contributed to protecting the data from my own analytical biases. Staying open to mentoring allowed me to code in new ways, and brought me closer to understanding the participant’s internal processes and experiences.

V. EXAMPLE OF INITIAL INSIGHTS

Initial coding of each interview provided insights into processes through which our participants connected their identity as engineers to the design they engaged with within their capstone courses.

Participants explained their process of selecting the specific capstone project they would engage with over the course of the next six months. Sarah (all participants names are pseudonyms) explained “*I wanted to start from scratch, [...] I wanted the freedom to make a lot more of the design choices. Because I want to do product design when I go out of college, having a large-ish project that I had completed with a team and started from scratch would be good for my career path.*”, while for Maria “*when it came time to sign up for capstone, I was very interested in doing something [topic of interest] related [...] this was the only [topic of interest] related project so I picked it.*”. These descriptions suggested that student’s ideas of their future career interests in engineering could have an impact on the specific project they decided to engage with in a capstone setting. This can be linked to existing theories of student identity and future-time perspective [20], [21]. In Sarah’s case, being able to talk about her project in future job interviews and explain her design process in detail was an important factor in choosing to select a project “*starting from scratch*”. For Maria however, it was the desire for her project to be in continuity with her past internship experiences and personal interest that

pushed her to choose it based on the mechanical engineering field it was representing.

It also appeared that students referred to their already established skill sets as an important factor in how they engaged in the capstone design project. David explains : “*I got put in charge of manufacturing simply for the fact that I have the most knowledge in different forms of manufacturing. I have access to multiple machines in the shop on campus and own several myself. That is a big part of my job.*”. In this case, David assumed a role within the team based on pre-existing skills and access to resources that other team members did not have. In other instances, students would tailor the scope of the project to match their interests and skills : “*The part of the project I’m having the most engagement with wasn’t really part of what we were assigned to do, but it ended up being something that is a good way to quantify the material we are going to use.*” (Maria). In this example, Maria decided to include another task within the project because of her past internship experience. This proved to be a success and greatly satisfied their industry partner.

I initially interpreted David’s statement as him staying ‘in his comfort zone’ by engaging in the projects in ways that relied on already established skills, however upon re reading the interview transcripts and seeing it as a whole, it became apparent to me that David’s choice of engaging with the manufacturing part of the project was rooted in his upbringing and interest in engineering. He explains “*my dad is a millwright and does a bunch of things himself, so I got to learn a bunch of skills growing up. I think I’ve always liked to make things ever since I was a little kid.*”, and describes his career interest as being involved directly with the manufacturing process and involved with machine maintenance. It then made more sense to me to interpret David’s capstone interest as fitting between his past and future representations as an engineer.

An unexpected insight for me was the variation between participants on how strongly they were attached to their identity as an engineer. Sarah explains that to her “*engineering is more broadening of what you can and can’t do. [...] Even if I don’t decide to be an engineer when I go out of college, it’s always a pullback position.*”, while for Maria “*it would be hard to imagine life without being an engineer <laugh>, I don’t know, it’s kind of built into my identity*”. This variation in attachment for their roles as engineers among participants went against my pre-established idea that engineers were strongly attached to their professional identity [22]. This was a novel insight to me and led me to consider additional questions I could have asked during these interviews, but also questions I would add to my future interview protocol when working on the larger study. These unexpected findings and their influence on my subsequent interviews could be interpreted as an indicator that our choice of methodology could in fact produce some original insights and potential new theories despite our pre-existing knowledge of sensitizing concepts and their influence on many steps of our research process.

VI. DISCUSSION

In this methods paper, we aim to provide a reflection on the process encountered by a novice researcher in using grounded theory, and more broadly present the internal processes taken into consideration to increase research quality.

Research quality in interpretive research has been explored by Walther [9] in their development of a quality framework, which presents guidelines relating to both data collection and analysis. Because the knowledge emerging from CGT studies is derived from the interpretation from the researcher of the participant's social reality, Walther explains that "Interpretive approaches thus depend on the researcher's philosophical position rather than on their methodological orientation." [9].

When considering the quality of interpretive research findings, one can refer to frameworks such as Walther's [9] or [23]. These frameworks tend to focus on two important considerations when evaluating interpretive findings: First, does the researcher accurately represent the worldview and social realities shared by the participants [9]? Second, are the findings theoretically generalizable? That is, could the current findings be found in another social setting, or are they specific to this specific setting [23]? Within Walther's quality framework which we will use to discuss our own research quality, these two considerations are respectively referred to as *validity* and *reliability*, and are not only to be taken into account after the data is collected and analyzed, but must be considered from the moment the researcher starts to design the study [9]. This quality framework offers strategies for the researcher to follow along with the study development and the process of "making" and "handling" the data.

Following such a framework proved very helpful in the development of this study, and pushed me to evaluate the potential strength and weaknesses of our research methods. For example, when considering the theoretical validation aspect of our data collection, that is if the interview with participants would be able to represent fully the studies social reality of the capstone design course, we were aware that interviewing 3 participants would not provide strong theoretical validity to our findings, which we accepted since the purpose of this study was to test our overall research protocol and not develop strong results. Other aspects of our data collection process such as asking participants to elicit descriptions of specific incidents (procedural validation) or exploring contrasting accounts in participant's experiences (communicative validation) agreed with Walther's framework and contributed to improving the quality of our results.

Beyond its informative purposes, the description of my process using CGT in this exemplary study also provides insights into the various considerations taken into account when designing and conducting the study. Used jointly with Walther's quality framework, such process descriptions can greatly improve the quality of one's research and its credibility within the body of research it contributes to. Furthermore, transparency and openness about often tacit knowledge such as one's methodological process and

theoretical considerations could, in addition to the specific study's findings, contribute in and of itself to the body of literature and motivate the normalization of such insights into a researcher's internalized processes.

Grounded theory represents a frequently used methodological tool to understand discipline and context-specific phenomena such as design engagement within a capstone project. Evaluating the quality of such methodology should, according to McCall and Edwards, include more than "systematic conceptions of qualitative research that promote rote adherence to formulaic procedures and checkbox approaches to quality" [7, p. 103] by also considering the role of the researcher and their internal processes in that evaluation process. Commitment to inductively let the data speak and reflecting on one's impact on that process will provide fresh insights into the experiences of individuals, and contribute to the field of engineering education research.

ACKNOWLEDGMENTS:

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