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A Reflective Essay: Lessons from Two Engineering Education Qualitative Research Dissertations

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Abstract

Contemporary engineering problems are becoming more complex and multidisciplinary, requiring technical engineering knowledge and incorporating human and social science factors. There is a corresponding increasing level of attention to engineering education research in a variety of engineering areas. Students in engineering education PhD programs with technical engineering backgrounds need a transition from quantitative research training to qualitative research practice. Some practical reflections on engineering education qualitative research dissertations can be helpful for new engineering education researchers who may not have mentors in their department as they transition from engineering students to engineering education researchers.

This study uses two qualitative engineering education dissertations as case studies to summarize valuable practical approaches with new engineering education researchers as the intended audience. It is based on the reflections of two engineering education candidates who offer concrete examples of working with interview data through two qualitative analysis methods. The co-authors used qualitative interview data for their dissertations. Case Study A uses a narrative analysis method, while Case Study B uses a multi-case study. The narrative analysis helps dive into an individual's personal experiences while multi-case analysis is suitable for analyzing students' longitudinal learning. These two analysis methods represent contrasting approaches to understanding student and faculty perceptions in the engineering education area.

This paper does not provide a standard technical lens or rules for analyzing the qualitative interview data. Instead, it aims to excavate detailed reflections that engineering education researchers can refer to as they do qualitative research in engineering education. The authors' reflections draw on their personal experience of doing qualitative data analysis and strategies to overcome challenges with qualitative data analysis for internal consistency and validity. The findings will not be a specific set of steps for analyzing interview data in engineering education but rather detailed reflections on the experience of analyzing qualitative data based on practical and theoretical challenges. The conclusions may offer mentorship for engineering education students who want to do systematic qualitative research with an engineering education background.

1. Introduction

Contemporary engineering challenges demand interdisciplinary solutions that integrate technical expertise with more social science and human considerations. The National Academy of Engineering (NAE) frequently emphasizes the complexity of modern engineering challenges, such as in their report Grand Challenges for Engineering [1]. As engineering challenges become increasingly complex, there's been a notable rise in interest in engineering education research.

More and more engineering education programs have been developed in the US, which have developed dedicated programs to focus on engineering education research. The number of graduate and doctoral degrees awarded in the U.S. has risen since the early 21st century [2], and while engineering and education have long produced PhDs, recent technological advancements have significantly reshaped the PhD process [3]. The formalization of engineering education as a distinct PhD program began in 2004 with Purdue's School of Engineering Education [4], followed by the establishment of similar programs at Virginia Tech, Clemson, Utah State, Arizona State, Ohio State, Rowan University, and Florida International University among others.

This establishment of new engineering education departments across the United States has created opportunities for researchers to delve into the complex dynamics of teaching and learning in engineering. The rapid growth of engineering education programs also reflects the broader trend of engineering becoming increasingly interdisciplinary [5]. Borrego et al. explored the interdisciplinarity of engineering education research and the need for qualitative methods training [6]. Additionally, more flexible and interdisciplinary PhD pathways in engineering education have emerged, further expanding opportunities for doctoral study [7]. As engineering increasingly integrates knowledge from diverse disciplines, the demand for research and innovation in engineering education continues to rise. This growing emphasis on engineering education highlights its role as a critical and expanding field, making it an essential component of the evolving academic landscape.

2. Background and Motivation

Many students entering PhD programs in engineering education come from traditional engineering backgrounds. While they often have strong quantitative skills, their experience with qualitative research methods is usually limited. Making this shift can be particularly challenging for those without access to mentors or formal training in qualitative methodologies within their departments. Moreover, although pursuing a PhD is an intense and unique journey, most individuals go through the process only once. Each PhD graduate carries valuable insights and experiences that may no longer be directly useful to them [8]. To ensure these experiences contribute meaningfully to the academic community and the broader body of knowledge, Secules emphasizes the importance of PhD candidates writing reflections and sharing their experiences in writing engineering education dissertations [9].

Engineering education research is a rapidly growing field that focuses on teaching, learning, pedagogy, curriculum, and assessment [10]. Unlike traditional engineering research, which often prioritizes quantitative data and mathematical modeling, engineering education research frequently relies on qualitative methods to provide a sense of agency, voice, or the knowledge that personal experience can bring. Qualitative research methods hold immense potential in addressing the multifaceted challenges of contemporary engineering education. It is necessary to provide engineering education researchers with more guidance about qualitative research no matter which level of research methodology training they have.

This reflective essay aligns with the ASEE Student Division's mission of letting students' voices be heard and supporting engineering education students [11]. This paper aims to help new engineering education researchers by summarizing valuable reflections on two qualitative engineering education PhD dissertations as an informal case study. These two case studies include narrative analysis and multi-case study thematic analysis, which are two common and complex qualitative research methods in the engineering education area. This paper uses these two qualitative research methods as an example, summarizing reflections on how these two co-authors solved their challenges when they designed and wrote their qualitative research dissertations. By leveraging two case studies, the co-authors offer insights into the multi-case study and narrative analysis methods, providing conclusions and suggestions on using these approaches to help engineering education researchers develop their dissertation research. The first-person portions of this essay are indicated by italics.

3. Author Positionality

The author of Case Study A is an international student who has a higher education and industry standardization engineering background. She has received systematic educational research methodology training including qualitative and quantitative research methods. She had to overcome some challenges with language barriers and different academic writing styles during her qualitative research process. The author of Case Study B is a domestic student who has an electrical engineering background. All of her qualitative research methodology training was during her engineering education PhD programs, as she transitioned to social science research.

These two coauthors represent two different categories of graduate students in the engineering education PhD program. They went through different challenges because of their different educational backgrounds when they were writing their qualitative research dissertations. They used their dissertation writing as two cases to write this editorial-style manuscript, as a guide for emerging scholars while critically examining the broader contexts of qualitative research in engineering education. This paper leverages these two dissertations noted as illustrative examples for qualitative research. There are numerous journal publications out there that describe the methodological, practical, and theoretical considerations of qualitative research; this paper further explores the strengths and challenges of these two qualitative methods and situates its recommendations in other scholars' work in engineering education.

In sharing the motivation to write this paper, the authors wrote:

> *Successfully completing one qualitative research study takes a lot of hard work, perseverance, and determination. Throughout our time as doctoral students, we did several qualitative research projects, however, we still went through lots of challenges during our dissertation writing. These reflections derived from our struggles and learning when we did data analysis and wrote our dissertation.* (The authors of Case Study A&B)

4. Methodology

This paper adopts a reflective approach [12], drawing on the co-authors' dissertation experiences to provide practical insights into qualitative research methods. The two dissertations analyzed in this paper exemplify different qualitative methodologies: narrative analysis and multi-case study. Both dissertations involved extensive use of first-person qualitative data (interviews and reflections), making them ideal case studies for exploring the practicalities of qualitative analysis in engineering education research [13].

While our approach was deliberately reflective rather than theory-driven, the selection of reflection topics emerged through a combination of factors. First, our shared lived experience as researchers navigating the transition from quantitative to qualitative methodologies. Second, the challenges and critical moments that arose during our respective dissertation journeys. Third, the main aim of the study, which sought to illuminate the learning processes and adaptive strategies characteristic of such transitions. Rather than employing predefined categories, we engaged in iterative dialogue and mutual prompting, allowing key themes to emerge organically through the reflective process itself. This approach enabled us to surface nuanced, practice-oriented insights that may be valuable to others undergoing similar methodological shifts.

5. Overview of reflections

Case Study A is one author's dissertation, which uses narrative analysis. The narrative analysis approach focuses on exploring individuals' personal experiences in a logical and structured story-telling way [14]. Examining interview data through a narrative lens enabled the researcher to construct detailed stories that illuminated participants' perspectives deeply. Narrative analysis is valuable to empower individuals to share their stories, hear their voices, and minimize the power relationship that always exists between researchers and participants in a study [15]. The qualitative analysis process usually includes five main steps: organizing, sorting, understanding, interpreting, and explaining data.[16] This section will focus on reflections on the following four elements of narrative analysis: selecting useful information, summarizing data chronologically, deciding the sequence of analysis, and interpreting the significance of some direct quotes within the broader context of engineering education.

Case Study B is the other author's dissertation, which uses multi-case study methods. Case studies examine in-depth contextual experiences [17]. When exploring a phenomenon's variation across contexts, it is appropriate to do a multi-case study. Multiple sources of data need to be integrated such as surveys, documents, observations, and interviews. The participants in Case Study B regularly completed spoken reflections as the most significant data source. This is similar to a close-ended interview, since the participants recorded the reflections based on prompts on their own without follow-up questions. Key steps in the analysis process included coding transcripts, identifying themes, and synthesizing findings to draw meaningful conclusions. This section will focus on the following four aspects of the research process from reflections: fully understanding the context, finding significant experiences, ensuring validity of methods, and working logically and efficiently.

6. Reflections

Different researchers will come to various conclusions from the data analysis. However, every new qualitative researcher may have some common confusions and challenges during their qualitative research. Based on the definition and steps of these two qualitative research areas, this study summarized some reflections for young qualitative researchers in the engineering education area. The reflections on these two dissertations reveal the strengths and challenges associated with each qualitative method, as well as their applicability to different research questions in engineering education.

6.1 Case Study A: Narrative analysis

Following is a first-person reflection from the author of Case Study A.

6.1.1 Selecting useful information

As we know, not all our interview transcripts can be used for analysis. We usually design our research methodology based on our research questions, and then we collect our data based on our research methodology. However, it is challenging to select useful data for research analysis. As a new engineering education researcher, I easily get lost or feel overwhelmed by plenty of data when I start to analyze interview transcripts. We must make decisions about which data is useful for our research and how many direct quotes we need to keep for the narrative analysis.

From my personal practical experience at this stage, continually reading your interview transcripts and getting familiar with your data is a very important step for us to organize the data. We can record any thoughts during the data collection and potential analysis process so we have more evidence to manage data to make reasonable and correct decisions on which data should be analyzed. Using a whiteboard to write some keywords for each participant's transcript is a good way for us to remember each participant's unique data, which is very useful for us later to write a narrative for each participant based on bullet points or keywords. If we don't try to find some ways to simplify our interview transcripts, it is inefficient to select useful information by being overwhelmed by plenty of data.

6.1.2 Summarizing data chronologically

After we summarize some keywords or bullet points for each participant, we need to summarize the information into a coherent story chronologically. There are two main challenges for us on this step. First, how can you paraphrase interview transcripts into clear and concise sentences and also keep the participant's original meanings? We need to invest enough time in understanding the context of the interview transcripts and be prepared to iterate on their analyses to achieve clarity and depth. For paraphrasing, it takes time to practice, especially for non-English native speakers. It is better to put all of the useful data together and then rewrite it into a whole narrative. Because if we try to paraphrase every sentence and then organize them into a coherent narrative, we may miss some important transition or logic from the participant's original meanings.

The second question is how to manage the data chronologically but also keep the narrative coherent. Constructing coherent narratives from fragmented data like key words or bullet points can be challenging, particularly when participants' stories are nonlinear or ambiguous. I found using a whiteboard to draw a map to organize the relationship between the key words and organize the data by drawing a clear logic flow chronologically can help us has clear story flows for narrative writing.

6.1.3 Deciding sequence of analysis

Some studies may need both narrative analysis and analysis of narrative [18]. It is very easy to get confused with these two similar concepts for new researchers. There are lots of references about the differences and definitions of these two concepts, but there are not many references that teach us how to write narratives and thematic narrative analysis efficiently.

From my practical experience of narrative analysis writing, I found the sequence of writing these two analyses highly impacts the efficiency of analysis. For example, I initially planned to write participants' narratives first and then develop the thematic narrative analysis based on my research questions and participants' narratives. However, I found that it was hard to start to write narratives first because writing narratives requires researchers to be very familiar with the transcripts. I figured out that if we started with thematic narrative analysis instead of narrative writing, it would be easier for us to have deeper analysis.

6.1.4 Interpreting the significance of some quotes

Compared to other qualitative research methods, narrative analysis has unique strengths in capturing the depth and complexity of personal experiences or stories. Using direct quotes can enhance the reliability of the narratives. However, accurately articulating and interpreting some of the directly quoted sentences often presents a challenge for us.

I faced confusion and challenges at the beginning of writing, like whether to choose the first-person or second-person perspective and how many direct quotes to retain.

My suggestion is to take the transcript of one interviewee as an example and attempt three different approaches to write the narrative for this interviewee. After you feel clear about how to write a coherent narrative with necessary details by finishing one pilot narrative, you can start to write the rest of other participants' narrative more efficiently. The first approach involves creating a narrative constructed using the first-person perspective and direct quotes. This text can help us quickly summarize and extract useful information. While the transitions between sentences and paragraphs may appear rough and less polished, this method, to some extent, lends authenticity to the story being constructed from the interviewee's words.

The second approach is to rewrite the previous first-person narrative into a third-person narrative without direct quotes. This version forms a cohesive story that resonates with readers and sustains their interest.

Finally, the most challenging part is how to situate an individual's experiences within a broader context, enabling critical reflection on the discoveries and conclusions drawn from these stories. It would be good to develop an individual's narrative by considering the big contexts, which should be undertaken after completing the first two approaches for narratives, as this approach may be relatively easier from a practical writing perspective.

6.2 Case Study B: Multi-case study

Following is a first-person reflection from the author of Case Study B.

6.2.1 Fully understanding the context

Understanding a case's details and context is vital to be able to correctly interpret participants' experiences during that case [15].

My approach to understanding the contexts of each case was to use all of the data sources available to me. When I was able to visit the sites in person and talk to the participants, it was easier to understand. For the cases where that was not possible, I read the reflection data as it was submitted, interviewed other related parties, and read the artifacts such as case documents. It is important to understand as much about the cases as possible before beginning analysis.

6.2.2 Finding significant experiences

After familiarizing myself with the cases' details, I had to analyze the data. The approach that was manageable to me was to create a priori codebook based on literature. I selected a codebook with broad themes, so that many types of learning would be captured. I read through the transcribed data with the codebook and marked the broad codes using a spreadsheet as the first round of analysis.

6.2.3 Ensuring validity of methods

After coding large amounts of data, I needed to do a sanity check and see if the analysis made sense. I spoke with my advisor about the codebook to ensure that it was clear and consistent. Then I reviewed all of the interview data again while doing a second round of coding to label each previously coded section with a specific subtheme. This was an opportunity to revise any codes that no longer made sense, but I found that I generally agreed with my first round of coding. If there was a particularly difficult quote, I checked with a peer or my advisor to see their interpretation.

6.2.4 Efficiently combining themes to write the case report

Details and evidence of assertions in the case report need to be presented for research quality [15]. Readers should have the opportunity to understand a case in-depth so that they can gauge its transferability to other relevant contexts.

After the second round, I began pulling out the coded quotes and grouping them by code. During this process, themes emerged around which I could write my case reports. As I did each case report, this process got faster, and you will likely see the same thing happen. The important points to remember are to track what you are doing for each round of analysis and repeat the process. As I was writing, it was helpful to have the relevant quotes already pulled so that I knew my conclusions were grounded in the data.

7. Discussion

The reflections from the two co-authors on each qualitative research analysis share three common points as follows.

7.1 Need to understand context of data

Both methods require researchers to be familiar with data, which should be a key first step before starting the analysis. For multiple case analyses, this means looking at all data sources, such as observations, artifacts, and interviews. Similarly, in narrative analysis, researchers must deeply understand interview transcripts to capture the context and specifics of participants' stories.

7.2 Analysis as an ongoing process

Both methods stress the importance of an ongoing process to improve analyses. In multiple case analysis, researchers review coded data and get feedback from peers or advisors to confirm their interpretations. Likewise, narrative analysis involves revisiting drafts to effectively paraphrase transcripts and create a clear narrative. By facing these shared issues and using processes that focus on context and iteration, researchers can improve the quality and clarity of both qualitative methods in engineering education.

7.3 Balance of detail and speed

Finding the right balance between keeping important details and being efficient is another common challenge. In multiple case analysis, extracting relevant quotes after they are coded serves as a basis for analysis. Peer review and data reviews also are used to maintain consistency. In narrative analysis, creating pilot narratives or visually mapping key points aids smoother writing while keeping depth in the narrative. This analysis focuses on carefully including direct quotes and revising narratives to authentically reflect participants' experiences.

8. Conclusion

Qualitative research methods are very important for dealing with the challenges in modern engineering education. Reflecting on our dissertations, we share some personal ideas and

experiences with qualitative research to help new researchers solve challenges in the qualitative analysis process. Our key suggestions are as follows. First, whenever you can, work with other experienced qualitative researchers or look at similar studies. Getting real-time help and feedback on the qualitative analysis is vital as you make important decisions for the first time. Many PhD engineering education students feel confused when they write their qualitative research dissertations alone. The writing process requires support and feedback to enhance the validity of the data. Additionally, it is helpful to keep a regular record of your thoughts and decisions during the analysis to ensure transparency and rigor. Lastly, when facing a lot of interview transcripts, start by focusing on one participant's data and create a clear way to analyze this data, which can then be used as a guide for others, rather than feeling overwhelmed by many transcripts. A codebook can also help if your methodology is not entirely emergent. A solid beginning is essential for qualitative research analysis and writing.

Last but not least, we envision this paper as a reflective resource for early graduate students and advisors navigating the transition between quantitative and qualitative research, offering insights into the challenges, learning processes, and adaptive strategies involved. We hope readers will cite this work as an example of reflexive, experience-based inquiry that complements more theory-driven studies, helping to broaden the conversation around methodological transitions in graduate research. While we did not apply a formal theoretical framework, the specific reflection topics emerged organically through our lived experiences, mutual dialogue, and the impressive moments we encountered during our dissertation journeys, allowing us to surface the themes we found most meaningful for other junior engineering education researchers facing similar transitions.

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