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Narrative Inquiry in Engineering Education: A Systematic Literature Review

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Abstract

This systematic literature review is a theory/methods paper that addresses the state of current literature in engineering education applying narrative inquiry. As areas of research within engineering education have become more exploratory, qualitative research has focused on understanding the engineering student experience through inclusion of students' personal perspectives. One qualitative research method that has been found to be beneficial in this goal is the incorporation of narrative inquiry, which utilizes narrative theory to collect stories from engineering students. Literature reviews in narrative research have not yet specifically focused on the use of this methodology in engineering education.

To address this gap, we conducted a systematic literature review by searching across four databases: Google Scholar, SCOPUS, Web of Science, and ERIC, for the terms "storytelling", "story-driven learning", and "narrative", and paired each of these terms with the search terms "engineering education" and "entrepreneurial mindset". The search resulted in 309 unique articles. The papers were screened by title, abstract, and full paper based on the following criteria: written after 2010, original research papers, related to engineering or entrepreneurship, and content focused on undergraduate students. Papers were limited to post-2010 due to Karan Watson's discussion about the potential impact of stories to encourage change at the 2010 ASEE Conference. A total of 33 papers remained after the screening process. We then classified the papers based on various parameters, including populations of interest, methods of data collection and analysis, and underlying themes identified through the application of narrative inquiry.

We found that narrative inquiry studies often focus on underrepresented groups of engineering students or students involved in a specific intervention or experience. We identified three narrative data collection methods with individual interviewing used 70% of the time, likely due to the intimate and personal approach this method allows. Narrative analysis methods were more diverse, though thematic analysis and qualitative coding were the most commonly used throughout the papers, which may be due to their flexibility and applicability to many types of scenarios. We suggest that due to the limited work in the area of narrative inquiry in engineering education, more research should be done to collect and interpret students' stories to better highlight the engineering student experience.

Keywords: narrative inquiry, systematic review, undergraduate

1.0 Introduction

Engineering education research tends to prefer quantitative methods due to training engineering researchers to use a post-positivist perspective and advanced mathematical and technical skills [1-2]. In Borrego, Douglas, & Amelink's [1] methods sourcebook specific to engineering education, they claim that quantitative research should be limited to outcomes that are generalizable to a larger subset of the population. In contrast, qualitative research should explore questions that cannot be answered without *"rich, contextual descriptions of the data"* (p. 56). However, engineers are often more familiar with quantitative methods and summarizing their findings using numbers [2], which substantially limits the use of qualitative methods.

According to Jackson, Drummond, & Camara [3], the goal of qualitative research involves *"understanding human beings' richly textured experiences and reflections about those experiences"* (p. 22). As engineers have become familiar with qualitative methodologies [1-2], researchers have begun to explore different types of approaches to illuminate the human experience. It is clear that different engineers, engineering students, and engineering faculty experience their education and careers differently, which modern studies have only begun to describe [4-6]. One increasingly popular form of qualitative research is narrative inquiry, as it is argued that humans experience life through storied events [7-8].

The use of narrative inquiry across education disciplines can highlight the student experience in a different way than other forms of qualitative methodology such as grounded theory, phenomenology, and case study [9-10]. Since narrative theory states that humans think, feel, and behave by constantly living out and changing their personal narratives [8, 11-12], it is beneficial to examine how narrative inquiry is used to examine engineering students' experiences specifically. This paper seeks to frame a larger study that will examine how engineering students develop an entrepreneurial mindset (EM) after participating in a research experience for undergraduates (REU) program, where we will be collecting data using a narrative inquiry approach. Therefore, analysis of current literature using narrative inquiry acts as the baseline for developing our own methodological approach to understanding the student experience, including their identities and EM. [4, 13-14]. EM research in engineering education has flourished due to the growing need for engineers with entrepreneurial skills to populate industry positions that require innovation, communication with different disciplines, and technical problem solving [15-16]. However, similar to narrative research concerning the broader engineering discipline, narrative research specific to EM in engineering education is scarce [17]. Given our goals for our upcoming study, we selected to include narrative studies in EM as well as part of this systematic literature review. Exploring the limited engineering and entrepreneurship education research in this area [4, 13, 18-19] will accentuate common methods, approaches, and themes engineering educators are using to gain insight into their students' experiences.

1.1 What is a narrative?

According to Polkinghorne [20], data has three distinct forms: short answer, numeric, and narrative. Narratives can be described as any collection of data that follows the natural way humans speak, such as interview transcripts or field notes [21]. However, more recent research

suggests that the term "narrative" has evolved to be nearly interchangeable with the term "story" [7]. There are many arguments for the theory that human experience is generally lived through a coherent set of stories [7-8, 12, 20]. Stories are more sophisticated than a collection of interview transcripts, as they follow a specific structure involving a beginning, action, plot, characters, and resolution [20, 22].

McAdams [11] describes the human psychological self as consisting of three features: the actor, the agent, and the author. The actor contains one's social roles and skills, the agent contains one's personal values and goals, and the author ties those versions of oneself together through their life narrative [11]. The author finds meaning in their experiences by describing them through what McAdams describes as their narrative identity, which *"aims to integrate the reconstructed past, experienced present, and imagined future"* ([11], p. 279).

Research concerning human narratives has existed for centuries, and we often hear of narratives passed down through generations [10]. It is only in the past few decades that narrative research has made its way into academia, and even more recently that it has populated the social sciences [10] However, following the philosophy of narratives as the best way to understand life and the human experience [7, 10], the introduction of narrative inquiry into research brings us a step closer to understanding ourselves and our experiences.

2.0 Narrative Inquiry in Engineering Education

The inclusion of narrative inquiry in education was introduced by Connelly & Clandinin [7], as they stated *"education is the construction and reconstruction of personal and social stories; teachers and learners are storytellers and characters in their own and other's stories"* (p. 2). Education research has struggled to understand social concepts using only numerical information, as oftentimes, the responses of those in the minority are buried by the standards of quantitative research [10]. Therefore, it becomes necessary to target those minority groups through their narratives, where they can describe their experiences in a way that quantitative methods cannot capture [10]. This has become the overarching focus of narrative inquiry in engineering education, where the identities of individual engineering students are often not considered [4, 13].

As described by Polkinghorne [20], narrative research commonly includes two forms of analysis: narrative analysis, in which structured narratives are built from existing data, and analysis of narratives, in which data already exists in narrative form. This outcome of the analysis of narratives technique often consists of a set of themes that the researcher can use to make inferences about the sample they studied. Meanwhile, the outcome of the narrative analysis technique is a story, ordered chronologically, that synthesizes various data into a cohesive element. This form of narrative analysis can be thought of as writing an account of someone's life, such as a biography. The researcher may interview the participant, but they will also gather personal documents and observe their actions to fully understand their experience. In the case of education, narrative analysis can be used to understand a group of students' experiences in a certain class, project, or discipline.

Kellam et. al's [13] study expands on Polkinghorne's [20] narrative analysis and analysis of narratives by testing three data synthesis methods specific to engineering education research. The first method, thematic analysis, is focused on interpreting data to produce themes relating to the topic of interest. In this method, the researcher's themes are embedded throughout the presentation of the narrative, providing the reader with a clear depiction of the researcher's interpretation. The second method is structural analysis, where a researcher observes a narrative by identifying the outline, or structure, of how it's told. Structural analysis involves piecing together the plot of the story without making inferences that may shift the storyteller's words. The third method, constructed narrative analysis, closely relates to Polkinghorne's [20] narrative analysis technique, where specific events are synthesized to form one main narrative. This form of analysis may involve direct quotes from the participant(s), inviting the reader to make their own inferences.

Kellam et. al [13] points out the trade-offs with using each type of analysis method, as each type may be beneficial for answering different questions. However, they make it clear that the voice of the engineering student participants are preserved in all three methods, which is crucial for making conclusions about their identities. This study examines the state of narrative research in engineering and EM education in hopes to answer the following research questions: *(1) What common themes are seen across different populations of engineering students?* And *(2) What narrative collection and analysis methods are engineering educators using to generate themes?*

3.0 Methods

The following sections will address the process we used to gather and analyze narrative research in the engineering education field.

3.1 Literature Search

Literature searches were conducted using four databases in June, 2022: Google Scholar, Scopus, Web of Science, and ERIC. The search term combinations are listed in Table 1, where the terms in Column 1 were paired with the terms in Column 2 using the conjunction "AND" between the terms, resulting in a total of six search term combinations for each database. The terms "narrative", "storytelling", and by extension "story-driven learning" are often used interchangeably [7], and due to the narrative inquiry methodology being rare in engineering education, all three terms were included to capture as wide a range of articles as possible. The column two terms were chosen because this work concerns engineering education-specific content, but also frames a larger study that focuses on entrepreneurial mindset development.

Table 1. Literature Search Term Combinations

Column 1	**Column 2**
Storytelling	Engineering education
Story-driven learning	Entrepreneurial Mindset
Narrative	

For all searches, the results were sorted by relevance and the first 40 results were taken for further consideration due to the lack of engineering related papers seen after the first two pages of results. After removing duplicate papers that were seen in multiple databases, there were 309 unique papers in the first level search.

3.2 Paper Exclusion and Classification

We followed a predetermined paper exclusion process with various inclusion and exclusion criteria. Papers were excluded if they were written before 2010 (which was limited during the search process), not focused on undergraduate students (such as [23]), not original research papers (such as [24]) and unrelated to engineering or entrepreneurship. The reason to exclude papers written before 2010 was due to the influential presentation given by Karan Watson at the 2010 ASEE Annual Conference and Exposition, which described the importance of including stories throughout education to promote positive change [25]. This acted as a seminal presentation to encourage more research using stories and narrative in engineering education. Papers were included if they used narratives to enhance or understand engineering education or entrepreneurship experiences [26] and/or if they focused on engineering or entrepreneurship identity [27].

Papers were first screened by title by two separate researchers, who had a 93% agreement with a high Cohen's Kappa inter-rater reliability of 0.92 [28] on paper inclusions/exclusions. After the title screening process, 210 papers remained. Due to the high percent agreement for the title screening, one researcher screened the remaining 210 papers' abstracts, and a random subset of 20 was chosen for an abstract consensus with a second researcher. These 20 papers resulted in an 85% agreement with a high Cohen's Kappa of 0.82 [28] between the two researchers, indicating that it was sufficient to move on to the full paper screening.

A total of 86 papers were included in the first full paper screening, where one researcher read the papers' introductions and methods to determine if they matched the inclusion criteria. A randomized subset of 10 papers were chosen for full paper screening consensus between two researchers, which resulted in a 90% agreement and a high Cohen's Kappa of 0.88 [28]. After full paper screening was complete, a total of 33 papers moved to the classification step of the process, as shown in Figure 1.

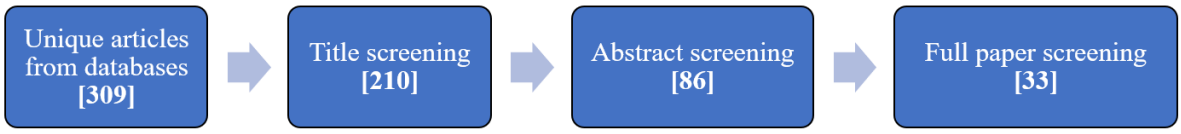

Figure 1. Paper Exclusion Process

The 33 final papers were read thoroughly and classified into a set of parameters that were a mix of predetermined and emergent throughout the process. As papers were read and information was gleaned, it became clear that additional parameters were necessary to capture the full content of the articles. The original parameters were population of interest, data collection

method, and theoretical framework, but after further exploration, sample size, narrative framework/inspiration, data collection questions/protocols/prompts, data analysis method, and validity/reliability were added.

4.0 Results & Discussion

Out of the 33 papers we analyzed, 24 were published in 2017 and beyond, making up nearly 75% of our sample. Though narrative inquiry as a research method has been around for decades [20, 29], sufficient research in this area has only just started being conducted. This increase in narrative research can be linked to the emphasis on the need for qualitative research in psychology in the 1990s [30-31], which sparked the use of different types of qualitative methods in a variety of fields [31]. As qualitative research as a whole became more popular, the use of narrative inquiry trickled into prominence. The growing need to understand engineering students and their identities was prompted by the lack of student retention in engineering programs [32], which encouraged researchers to explore narrative inquiry as a way to understand this problem. Still, it is clear from our sample that this method has only recently been utilized.

We find it necessary to highlight certain researchers that appeared in our subset a number of times, as it draws attention to the very limited body of work in this area. Three papers from our sample were written by Pawley [4, 33-34] as part of a larger project, meaning these three papers included the same participants, to understand gender and race relations in engineering. We decided to include all three papers in our analysis, as each presented results from different interviews and answered different research questions. Similarly, Minichiello [27, 35-36] has been associated with a few high impact works in this field, but all three of her works were included due to her use of different samples and populations of interest.

Finally, Kellam's work was included in our subset of papers six times, encompassing two projects. Kellam worked alongside Walther [13, 37-39], and Cruz [39-41], two other prominent authors in narrative inquiry in engineering education. Five out of these six papers presented results from the same subset of 21 interviews with engineering students conducted in 2015 [13, 38-41]. Due to the different types of analyses and different students' results presented in each paper, we found it necessary to include all in the analysis. More details on these analyses are discussed in a later section.

The following sections will present the results and trends we noticed in our analysis of the 33 papers. To answer our first research question, which is: *What common themes are seen across different populations of engineering students?,* we explored the target populations within the larger engineering group and the themes associated with them (see section 4.1). To answer our second research question, which is: *What narrative collection and analysis methods are engineering educators using to generate themes?,* we analyzed the types of methods used to collect and analyze narratives that produced stories or themes (see sections 4.2 and 4.3). We also examined the research quality of the narrative studies.

4.1 Target Populations

The goal of narrative research in engineering education is to understand the experiences of individuals within the engineering community and their individual identities [4, 35]. The 33 papers we reviewed revealed that researchers were examining three main subsets of engineering students as depicted in Table 1.

Table 1. Range of Populations of Interest

Population	Description	Frequency	Example
General engineering students	Engineering students of all grade levels, courses, and experiences	7	[42]
Specific engineering student subsets	Engineering students in a specific year, course, project, or participating in a specific experience	14	[27]
Underrepresented engineering students	Engineering students who identify as nontraditional, non-white, non-male, or underrepresented within the engineering discipline	12	[43]

Though it is important to examine the identities of engineering students as a whole [44], 79% of the papers targeted subsets of the engineering student population. These papers often explored groups of students whose participation in large scale quantitative studies is masked by the dominant race(s), gender(s), year(s) of study, or disciplines.

Three studies explored the experiences of women in engineering or STEM fields [45-47]. However, these three studies looked to answer different questions. Paloheimo, Pohjonen, & Putila [45] was interested in how women choose their engineering discipline, Secules et. al [47] was interested in one student's experiences to explore the practice of theorizing, and Tomko et. al [46] was interested in women's participation in makerspaces. However, the three studies, though diverse in their results, reported a similar theme, which is that the women in their studies had a heavy influence from their support network including mentors, family, and friends, which helped them make decisions and/or feel comfortable in their chosen environment.

Five studies presented results that highlighted the experiences of underrepresented races in engineering, as shown in Table 2.

Table 2. Representation of Underrepresented Races in Narrative Inquiry Studies

Source	Sample Focus
Camacho & Lord [48]	Asain, Latina, & white women
Pawley & Phillips [33]	Black students

Pawley [34]	African American/Black, Native American, Latinx, multiethnic, & white women
Sharbine et. al [43]	American Indian women
Qaqish, Grant, & Bowles [49]	Black males

One common theme throughout all five of these papers was the influence from the faculty and other students at their institution. When faculty are accepting and well-versed in diversity and inclusion and are empathetic to the challenges faced by underrepresented students, they feel more motivated and empowered to stay in engineering [33-34, 43, 49]. Contrarily, faculty may not be aware of their own biases, which can lead to unintentional microaggressions that have a lasting negative impact on underrepresented students [48]. Other students can also influence underrepresented students' success, as having positive experiences with other students brings about a sense of belonging [33, 49]. For example, Qaqish, Grant, & Bowles [49] reported that their participants often formed communities of practice with other community college transfer students. However, Sharbine et. al [43] highlights one participant's experience with feeling a constant sense of judgment from their peers, which made her feel inadequate. This was also observed in Camacho & Lord [48], who reported on one woman's experience with judgment from peers, saying *"this student struggles to maintain her status in this hostile context, and even feels she has to change herself as a mechanism of adaptation"* (p. 4).

The most populated group within the populations of interest was the specific engineering student subsets group, making up 42% of the papers we included in this review. These papers targeted one or more subsets of engineering students based on their experience, such as year in the curriculum [27], specific course [50], and/or students who have experienced a certain event or intervention [26, 51]. Four studies explored students in their first and second years [14, 27, 52-53], and two focused on students in their final year [17, 54]. Minichiello & Hanks' [27] study concluded that their second year engineering student participants often point out their professional identities, indicating they are considering their future as professionals early in their curriculum. Kopparla et. al [52] revealed through their analysis of first year students' narratives that by the end of their first year, some students are already excited to become engineers, while others are reconsidering their major choice. Though these two studies were examining different research questions, they both pointed out that students who are more motivated and persist through challenges are more likely to identify as engineers. Trenshaw et. al [14], who specifically explored intrinsic motivation in second year engineering students, similarly observed that students with higher levels of intrinsic motivation were likely motivated due to their experiences with past failures.

Though the studies that examined students who were participating in courses or interventions were more specific, there were still connections to be made through these students' experiences. Multiple studies identified the emotions students were feeling as a result of their course, project, or experience [37, 50, 55-56]. Kellam et. al [37] reported that students felt frustration and anxiety at the beginning of their projects, suggesting that more structure is

needed when first introducing students to a new project or topic. Their students felt more positive emotions later in the project after they were more familiar with the work. Similarly, Bakar et. al [55] said that once their students practiced in a specific area and became familiar with the process, they felt happy about the work they were doing. Through the different groups of engineering students that were examined, narrative methodologies identified key trends in motivation, emotion, and identity that inform future work that will examine the experiences of undergraduate engineers.

4.2 Narrative Collection Methods

Connelly & Clandinin [7] outline multiple data sources from which narratives can be collected, including interviews, field notes, journal records, and letter writing. In the papers we analyzed, we noticed three narrative data sources as detailed in Table 3.

Table 3. Methods used to Collect Student Narratives

Collection Method	**Frequency**	**Example**
Interview	23	[57]
Focus Group	2	[51]
Written Reflection	8	[50]

As presented in Table 3, interviews were the most frequent method of narrative data collection, followed by written reflections and finally focus groups. Though Connelly & Clandinin [7] do not highlight focus groups as narrative data sources, focus groups offer the opportunity for rich discussion about shared experiences, allowing participants to feel validation from others as they recount their stories [58-59]. For example, Camacho & Lord [48] included the short stories told by the women engineering students in their study, adding value to the direct quotes by including researcher notes such as *"others laughed"* (p. 3) and *"several focus group respondents agree"* (p. 4). The two studies that used focus groups provided evidence of intense discussions and involvement of all participants, generating one cohesive narrative of their experiences [48, 51].

As for the written reflections, all eight of the studies provided students with a writing prompt with instructions to tell a story. Some studies described their intent for students to interpret the writing prompt in a number of ways, hoping to elicit a variety of responses [50, 55, 60]. The studies included a variety of prompts with the shared goal to evaluate students' stories. Some studies were looking to explore engineering identity [53, 61], some were identifying their creativity in their stories [55], and some were evaluating students' experiences with a certain course or project [27, 37, 50]. For example, Minichiello & Hanks [27] provided their students with an optional assignment for bonus class credit where they asked them to *"Reflect on your experiences in this course and write a 1–2 page (single spaced) narrative story about learning thermodynamics this semester"* (p. 1534). Researchers analyzed their narratives alongside the participants' course grades and examined the personal and professional identities students acknowledged in their stories. Though writing prompts were only used as a narrative collection

method in 24% of the papers, autobiographical writing and storytelling can be beneficial for collecting narratives from a large sample or looking to gather sources to create a narrative [7, 20].

Narratives are presumed to illuminate the individual experience and are a more personal, intimate approach to data collection [10, 20], so it makes sense that most research concerning narratives would involve individual interviews with students. Of the 23 studies that used interviews, twelve included single-question protocols. These studies often stated the exact question students were asked and then followed up with example follow-up questions the researchers used to ask for elaboration [33, 40-41]. According to Polkinghorne [20], narrative inquiries often answer one broad question that prompts a story to be told, then additional clarifying questions are asked throughout the process.

For example, Huerta et. al [17] asked their students: *"What is the first memorable, important early entrepreneurship experience you had during college?"* (p. 27), and specified potential follow-up questions to *"dive deeper and learn more about what students learned from their experience"* (p. 27). The broadness of the overarching question allowed for students to interpret it in a number of ways and provide a unique variety of responses. According to Huerta et. al [17], the students' narratives included multiple critical experiences that drove them toward their ultimate career goals, indicating that the question did not limit students to discussing only one experience. In another example, Martin [57] asked students to *"Tell me about how you became interested in engineering"* (p. 1174) and specified follow-up prompts such as *"You named [Name] as someone who was influential to you during the time you were deciding to major in engineering. Tell me (more) about him/her"* (p. 1174). The first generation college student whose narrative was presented cited many different people as being influential to their decision to become an engineer and stay within the engineering major [57]. Once again, this may be due to the many interpretations of the broad protocol, leading to a wide variety of responses. The high frequency of interviews as a narrative data source and following a single question protocol indicates that common narrative inquiry methods [7, 20] are applicable to engineering education research for a number of different groups and approaches.

4.3 Narrative Analysis Methods

Perhaps the widest range of results identified as part of this review pertain to the analysis techniques applied to the narratives from the 33 research teams. As shown in Table 4, there were 12 different types of narrative analysis presented, with three papers not clearly specifying their method. Some papers used multiple analysis techniques. Many of these methods are overlapping, though we found it important to present the analysis as described by each of the studies. Some of the papers tied their analysis directly to a narrative theory or other qualitative theories [39-40], while others used qualitative analysis techniques described in high impact qualitative methods sourcebooks [50].

Table 4. Methods used to analyze participants' narratives

Analysis Method	Source	Frequency	Description	Example
Thematic analysis	[62]	6	Collecting shared themes between and throughout data sources	[50]
Qualitative Coding	[9, 63]	8	Various processes used to code transcripts such as open coding and axial coding	[47]
Polkinghorne's Analysis of narratives	[20]	3	Generating themes through examining existing narrative sources	[39]
Polkinghorne's Narrative analysis	[20]	4	Generating a cohesive narrative by combining multiple data sources	[35]
Narrative construction	[13]	4	The restructuring of narrative data sources to follow a chronological pattern	[52]
Interpretive phenomenological analysis	[64]	1	Examining a data source through the lens of the participant's psychological understanding of their experiences	[43]
Critical incident analysis	[65]	2	Structuring narratives by focusing on major events told by the participants	[40]
Mindset theoretical analysis	[66]	1	Analysis based on positive intentions of participants to develop a specific mindset	[54]
Constant comparative method	[67]	1	Organization of data into categories that can be structured to form a theory	[49]
Categorical content analysis	[68]	1	Breaking text into small units, or categories, of content without focusing on context	[45]
Qualitative case study	[69]	1	Analysis of one specific topic based on individual systems and themes	[55]
Focus group analysis	[70]	1	Coding individual points and group interactions resulting in the overarching themes of a	[52]

			focus group transcription	

Seven of the analysis methods in Table 4 were used only by one study, indicating these methods' uniqueness to engineering education and/or narrative inquiry. Qaqish, Grant, & Bowles' [49] study used the constant comparative method to analyze narratives of black male engineering transfer students. The categorization of the constant comparative method allowed the researchers to contextualize the narratives to examine how the students were forming communities of practice. The researchers used their categories to analyze all data sources including interview transcripts, observations, and documents provided to transfer students. Adewumi's [54] study used mindset theoretical analysis to examine the development of students' entrepreneurial mindset as related to Dweck's [66] mindset theory. This allowed them to examine themes related specifically to entrepreneurial mindset, and found that students are influenced by EM enablers who encourage their EM development.

Three of the analysis methods were specific to narrative inquiry: Polkinghorne's [20] two options for analysis, and Kellam et. al's [13] narrative construction method. Polkinghorne's [20] "analysis of narratives" technique involves producing themes from data sources that already exist in narrative form. In Kellam et. al's [39] study, 21 engineering students participated in interviews designed specifically to elicit narratives. The researchers described their decision to use analysis methods specific to narratives *"because other methods simply fell short of capturing the complexities of the stories of engineering students and how their self-perceptions changed over time"* (p. 5). The researchers decided to produce themes specific to the emotions students implied during their narrative interviews and determined the patterns across much of their sample.

Polkinghorne's [20] "narrative analysis" technique is different from his "analysis of narratives", in that it involves the creation of a narrative through existing data sources. Following Kellam et. al's [39] analysis of narratives, they performed a narrative analysis to create one cohesive narrative that captured the emotions of all of the engineering students in their study. Kellam et. al [39] claimed that using both techniques allowed for a deeper understanding of the emotions engineering students go through during their undergraduate studies. They reported that students experience frustration and nervousness with specific projects and classes, but overall enjoyment of their program and excitement for the future. Kellam et. al [13] used pre-existing interview transcripts from their study to present a novel method for narrative construction based on Polkinghorne's [20] narrative analysis. In their method, they outlined three potential ways of constructing a narrative to best preserve the experience being shared by the participant. Kopparla et. al [52] decided to use the third person narrative construction method including direct quotes from the participants. Their narrative construction more easily allowed them to identify themes using Polkinghorne's [20] analysis of narratives. They made a few valuable interpretations, such as society often leads students to believe that *"engineers are guaranteed financially viable careers"* (p. 16), which was a dominant reason their participants selected the engineering major. Students were also confident in their math and science abilities, which was another major reason they selected engineering [52].

The most commonly used analysis methods were coding methods and thematic analysis, together making up 42% of the total narrative analysis methods. Qualitative coding and thematic analysis are flexible, interpretive, and accessible methods to all qualitative research [71], making them applicable to a variety of scenarios. According to Kiger & Varpio [71], these methods are often interpreted in a variety of ways, which was also seen within the 14 studies that applied these methodologies. For example, Mogul et. al [50] indicated that they began thematic analysis by starting with four existing themes relating to engineering mindsets, then expanded to open coding to capture more of the students' views. Trenshaw et. al [14] also used multiple methods of coding, but they began with open coding to capture all elements of their participants' experiences, and then used thematic analysis with the open codes to develop four themes that directly mapped to constructs of the self determination theory.

Though many of these studies used unique analysis methods depending on their study's goals, all of them involved producing multiple themes within their participants' narrative(s) to answer their research questions. This result shows that the overarching approach to analyzing narratives in engineering education, whether through interviews, focus groups, or writing prompts, is by collecting themes that are shared between all participants. Through their analyses, these studies discovered valuable themes present within various groups of engineering students. Engineering students shared that they are often influenced by others, which motivates them to select and remain within the engineering program [45-47, 54, 57]. They also tend to find engineering course content to be difficult, but are willing to push forward due to their expectations of a rewarding career [27, 37, 39, 52].

4.4 Research Quality Considerations

In qualitative research, analysis of data often requires specification of validity, which many qualitative researchers refer to as trustworthiness [9, 72], which was discussed by six of the studies. Four studies specified how their study adheres to Walther et. al's [73] research quality constructs, which include steps for data collection and data handling to ensure valid results. Finally three studies mentioned producing quality data in some capacity, but did not specify any qualitative research techniques to ensure quality or validity. Therefore, only 36% of the papers were concerned with specifying research quality before conducting analysis.

Ensuring quality in engineering education research has been a long standing difficulty [74-75], prompting many discussions about the discrepancies that exist within the efforts to produce quality research [76]. According to Koro-Ljungberg & Douglas [77], qualitative research quality is not well reported in engineering education, partially because quantitative research tends to be favored in general. Though Walther et. al's [73] theoretical framework was specific to engineering education, over 60% of the papers in this study did not consider research quality or trustworthiness in their narrative inquiries. As stated, this may be due to the lack of published qualitative research in engineering education [77], but it is also possible that the narrative inquiry approach itself leads researchers away from research quality. The most commonly referenced specifications for following narrative inquiry do not specify approaches for ensuring

research quality [20, 29, 69], which may be due to the interpretive nature of collecting narratives. Narratives are indicative of the human experience, and are often direct, first-hand accounts of people's lives, so it may be that these experiences are already of high quality. However, the acceptance of qualitative research into the engineering education discipline is a slow moving process [76], which requires that we more thoroughly examine the quality of narrative inquiries.

4.5 Limitations

This study presents valuable information about the state of narrative inquiry in engineering and entrepreneurship education, though there are a few limitations. Human error may have caused us to exclude relevant papers or incorrectly classify papers as part of the screening and classification processes.

5.0 Conclusion

This systematic literature review assessed the state of narrative inquiry in engineering and entrepreneurship education by examining 33 narrative studies. Most papers in this area were published in the past six years, indicating that the use of narrative inquiry in studying the experiences of engineering students is fairly recent. Only 36% of the papers we reviewed addressed research quality in their data collection, which may be due to the general lack of emphasis on qualitative research in engineering education. We examined the populations of engineering students commonly investigated, and determined that narrative inquiry often targets underrepresented students and engineering students in one specific course, year or participating in an engineering-related experience rather than engineering students as a whole.

We then identified the types of data sources used to collect narratives, which were most commonly interviews. However, studies that used focus groups allowed for investigation into discussions between multiple individuals based on their shared experiences. In addition, studies that collected narratives through writing prompts allowed researchers to look at a different perspective through students' autobiographical writing. Interviews, however, were clearly the dominant data source to collect narratives. They encouraged broad interpretation of interview questions, and created personalized experiences for students to share their experiences. Finally, we addressed the analysis methods used for these narratives. The overarching trend was that regardless of the method, the studies often developed themes that were used to describe their entire sample, which opens the door for potential applicability to larger populations. Though most studies we reviewed did not include research quality considerations, it is possible that the nature of narratives is high quality given that it documents the human experience.

We ultimately conclude that more research should be done using narrative inquiry to strengthen the themes addressed by these few studies. This would allow for different populations of engineering students to be further explored and trends to be uncovered that point toward understanding the engineering student experience.

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