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Analysis of social media forums to elicit narratives of graduate engineering student attrition

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Abstract

Background: Graduate engineering student attrition is prevalent, but most literature that studies graduate attrition is accomplished in disciplines outside of STEM or engineering, yielding an incomplete understanding of either attrition or persistence.

Purpose/Hypothesis: The purpose of this article is to investigate the relationships between motivators of attrition for engineering graduate students.

Design/Method: Data were collected using an online Web-scraping "bot" that mines data from the online forum Reddit. The anonymous textual forum threads collected were qualitatively analyzed through open-coding methods.

Results: The emergent themes reveal the interconnectedness between the roles of the advisor, student perception of cost, their support network, goals, their perceptions of how others perceive them, and quality of life and work. Our model is flexible in that it illuminates underlying combinations of factors that can influence student attrition.

Conclusion: This study provides a framework by which various stakeholders can approach the support and education of graduate students, including mentoring students both toward or away from graduate school per the student's goals.

KEYWORDS

advising, attrition, engineering pathways, graduate education, mental health

1 | INTRODUCTION AND LITERATURE REVIEW

In the United States, the most recent reports estimate attrition from engineering graduate programs to be between 24 and 35% for domestic men and women, respectively (Council of Graduate Schools, 2008), with the attrition rates for students from traditionally underrepresented groups being as high as 57% for African American doctoral engineering students (Sowell, Allum, & Okahana, 2015). Although attrition is costly for students, advisors, departments, universities, and funding agencies, doctoral attrition remains understudied, especially in engineering. Recently, the National Academies released a call to action on graduate science, technology, engineering, and mathematics (STEM) education, which turned national attention to the paucity of effort paid to graduate STEM education in research and practice (National Academies, 2018), recommending research in graduate policy, mental health, and student professional development, among other themes.

Across disciplines, graduate student attrition research typically focuses on the ways in which sociological, psychological, or structural factors in graduate students' lives contribute to attrition. Oft-cited reasons for attrition include

financial and nonfinancial costs, socialization experiences, and student–advisor relationships (Ampaw & Jaeger, 2012; Ehrenberg, Jakubson, Groen, So, & Price, 2007; Lovitts, 1996; Pauley, Cunningham, & Toth, 1999; Xu, 2015). Several studies highlight tension between the expectations of faculty related to productivity and commitment to the discipline (Barnes, 2010; Lovitts, 2001; Maher, Wofford, Roksa, & Feldon, 2017). Specific tension points include but are not limited to the need for mentorship, integration into the department, career preparation, and collegiality (Lovitts, 1996; Lovitts & Nelson, 2000; Maher et al., 2017; Ruud, Saclarides, George-Jackson, & Lubienski, 2018).

The tensions caused by a misalignment of expectations can make student–advisor relationships more difficult, another strong motivating factor for students to leave their programs (Ampaw & Jaeger, 2012; Barnes & Randall, 2012; Golde, 2005; Kniola, Chang, & Olsen, 2012; Lovitts, 1996, 2001; Lovitts & Nelson, 2000; Maher et al., 2017; Ruud et al., 2018). Literature suggests a concerning frequency with which students feel that their advisors were unsupportive, demeaning, and disrespectful (Golde, 2005; Lovitts, 1996; Maher et al., 2017; Ruud et al., 2018). Further, Weidman and Stein (2003) found that without emotional and academic guidance from an advisor, students are less inclined to engage in integration activities and persist through their programs, a finding echoed by many other scholars (Ampaw & Jaeger, 2012; Golde, 2005; Kniola, Chang, & Olsen, 2012; Spaulding & Rockinson-Szapkiw, 2012; Sweitzer, 2009). Hunter and Devine (2016) reinforce that "emotional exhaustion" can drive students to leave academia, due in part to advisor issues, feelings of not belonging, and high-pressure work environments.

While "fit" and "integration" into a lab and department are part of the graduate socialization process (Austin, 2002; Austin et al., 2009; Gilmore, Wofford, & Maher, 2016), these themes across this body of literature hint at less-studied psychological aspects of attrition, especially how students' experiences initiate doubts on completion or otherwise impact the decision to depart. Few studies apart from Lovitts (Lovitts, 1996, 2001; Lovitts & Nelson, 2000) and Nerad (Nerad, 2004; Nerad & Cerny, 2000) have sought to understand the decision-making to depart from programs. Indeed, sampling for a population of graduate students that may be considering departure or who have already departed from a PhD is difficult. As a proxy for recruiting hard-to-access populations of noncompleting graduate students, some researchers ask current students about their confidence in their ability to persist (Hunter & Devine, 2016; Litalien & Guay, 2015). These types of studies, while laying groundwork and motivation for further research, are therefore inherently incomplete because they do not study students who decided to leave. Nationwide research is similarly limited (Cass et al., 2018; Council of Graduate Schools, 2008; National Academies, 2018; Sowell et al., 2015), and most longitudinal studies available only capture data from one institution (Lott, Gardner, & Powers, 2010).

While many causes of attrition likely transfer across disciplinary settings (e.g., student–advisor relationships), the context of engineering motivates a disciplinary perspective. For example, two common themes in attrition literature for social science and humanities students are related to lack of funding (Ampaw & Jaeger, 2012; Ehrenberg et al., 2007; Lovitts, 1996; Pauley et al., 1999; Xu, 2015) and lengthy time to degree completion (Gardner, 2008, 2010). In contrast, upward of 80% of engineering graduate students are fully funded, and engineering is a fast- and high-completing discipline (Crede & Borrego, 2013, 2014; Gardner, 2009). Yet, attrition rates in engineering remain high, indicating that attrition is not fully understood.

While "STEM" is a convenient label, it is an ill-designed grouping by which to study graduate attrition. The structure and expectations for graduate programs in the physical and biological sciences, engineering, and mathematics vary significantly from one another (Crede & Borrego, 2014; Dabney, Chakraverty, Hutton, Warner, & Tai, 2016; Herzig, 2004). For example, engineering students do not face the same funding challenges as mathematics students (Barnes & Randall, 2012; Herzig, 2004) nor do they usually experience the rotational nature of many science graduate programs (Dabney et al., 2016). Engineering students often work in collaborative groups and lab settings, working on more than one project at a time (Crede & Borrego, 2012, 2014). As a result, the challenges faced by students in these programs vary significantly.

Of the few researchers who focus on engineering graduate student attrition, Crede and Borrego noted the experiences of graduate students in different research group sizes (2012) and retention of graduate students with respect to nationality (2014). Their work indicated that the structure of the research group may affect the type and style of mentorship students receive and perhaps affect retention. This finding augments Nerad's prior work that alludes that student attrition can also negatively affect other students on a team and may influence others' decisions to persist or depart through shared turmoil or resulting workload increases (Nerad & Cerny, 2000). Other groups link engineering graduate student attrition with the lack of critical professional competencies, particularly academic writing. Hasbun, Matusovich, and Adams (2016) attempt to intervene in the attrition processes for underrepresented PhD students through their annual Dissertation Institute by providing students the tools to make progress in their writing and dissertation during an in-person intensive weeklong "bootcamp" model. Berdanier and Zerbe (2018a, 2018b) linked academic writing attitudes with graduate engineering students' openness to various career trajectories, with findings indicating

that students who do not feel positively about the writing process are not open to academic or research and development industry careers. These findings indicate that students who are not prepared to write well for academic contexts may not feel like they should complete a PhD.

In addition to the lack of disciplinary literature related to attrition of graduate engineering students, there are several gaps in the higher education literature. First, studies focus on sociological or structural requirements for persistence (e.g., mentorship available, funding), without examining how an individual's experiences mediate the attrition decision. Nerad (2004) theorized a two-dimensional model for attrition that captured both individual and structural causes of attrition, but at that coarse level, no indication of the decision-making process can be seen. Though qualitative research explores the factors for attrition (Breckner, 2012; Lovitts, 1996, 2001; Lovitts & Nelson, 2000), the typical presentation of data through thematic analysis rarely highlights the ways in which factors interact. Further, most studies do not capture the decision-making process to persist or depart, perhaps because populations who are considering departing are difficult to recruit. As a result, recommended interventions fail to explicitly address complex, nuanced, and individualized student concerns, and do not capture the temporal nature of the decision to depart or continue in a PhD program.

In this work, we assume that attrition is a process in which the student has agency in that they decide whether to persist or depart rather than a discrete event that "happens" to a student. For our purposes, we define attrition as departure from an academic program before intended degree completion: This might include leaving with no degree, or it could be departure from the PhD via the master's degree. Definitions of attrition vary among studies, with some capturing only those students who leave with no degree. We challenge this interpretation of attrition in engineering because students who depart from their doctoral programs with a master's degree can be "counted" as degree conferrals rather than as attrition. Further complicating these definitions in engineering is the common practice for students to accomplish a master's degree first before continuing on to a PhD, such that on paper, students might be master's students but may be fully intending to pursue a PhD. Therefore, in this study we do not distinguish between attrition from the doctorate or the master's degree, though most of our data were from students aiming for a PhD.

We also use internet forums as a method to capture student thoughts from those who self-identify as those considering leaving their engineering graduate programs, without adding in researcher bias that occurs during an interview. From a psychosocial perspective, this research posits that the causes of attrition layer uniquely in students, and we expect that each student in their own lived experience has a different threshold by which certain factors weigh more heavily toward the decision to depart. The overarching research questions that this study answers are:

1. What factors do engineering graduate students attribute to the consideration of departure from graduate engineering programs?
2. How do students considering attrition describe the relationships among these factors?

2 | THEORETICAL FRAMEWORK

To explore the factors influencing graduate engineering students' considerations of departure, we employed a modern incarnation of Expectancy-Value Theory (EVT; Eccles, 2009). EVT is a psychological theory of motivation that articulates how students' expectations for success (i.e., expectancy) and valuing of tasks influence their actions in a given context (Eccles, 1983, 2009; Fishbein & Ajzen, 1975). Expectancy is an individual's perception that the task can be successfully completed and heavily influences their actions in a given context. The constructs of EVT have been shown to influence the decision to enroll in graduate school (Mosyjowski, Daly, Peters, Skerlos, & Baker, 2017; Peters & Daly, 2013), academic performance as measured by grade point average (Jones, Paretti, Hein, & Knott, 2010), and major choice (Matusovich, Streveler, & Miller, 2010). In addition to students' expectations of success, EVT consists of four value components that describe students' internalized decision-making processes: intrinsic value, utility value, attainment value, and cost.

Within EVT, intrinsic value is defined as the enjoyment an individual gains from performing an activity or the subjective interest the individual has for the subject. How well a given task relates to current and future goals, such as career goals, is called utility value (Eccles & Wigfield, 2002). In the context of graduate education, for example, a task that helps an engineering graduate student finish a chapter of their dissertation would have positive value as it facilitates progress toward an important future goal. Attainment value is the importance that an individual places on

excelling at a task. Finally, costs are negative aspects of task engagement. Costs are typically figurative, such as fear of effort needed to succeed, or lost opportunities from making one choice rather than another (Eccles & Wigfield, 2002).

The modern incarnation of EVT moves beyond only understanding the internalized student decision-making processes (i.e., expectancy and the four value components; Flake, 2012; Weiner, 1985; Wigfield & Eccles, 2000) to focus on the ways student identities, as constructed by socially driven interactions over time (Godwin, Potvin, Hazari, & Lock, 2016; Oyserman, 2015), influence motivated action in a given context (DeShon & Gillespie, 2005; Eccles, 2009; Oyserman, 2015). Eccles (2009) highlights that

> the contents, salience, and valence of various personal and collective identities develop over a lifetime based on (a) the social and psychological experiences individuals have as they are growing up and moving through adulthood; (b) their own agency in both interpreting and creating social roles and experiences that serve to reinforcement, redefine, or undermine particular personal and social identities; and (c) the co-construction of the content, meaning, and salience of various personal and social identities by the individuals themselves in conjunction with the people with whom they interact each day and over time. (p. 79)

Through the development of their identities, students undertake activities, behaviors, and tasks that they believe align with their identities. Tasks that align with students' salient identities take on high value and motivate students to act. Depending on the results of student actions, these experiences can either positively or negatively develop their identities (Godwin & Potvin, 2016). By leveraging this modern perspective of EVT, we can extend previous findings with engineering graduate students (Mosyjowski et al., 2017; Peters & Daly, 2013; Tsugawa-Nieves, Perkins, Cass, & Kirn, 2018) to understand how this theoretical perspective influences attrition decisions.

3 | METHODS

3.1 | Data collection through internet forums

To answer the research questions for this study, we employed qualitative data collection and constructivist open- and axial-coding methods to explore the relationships among reasons for decisions to drop out of engineering graduate programs. To collect data, we used a novel form of data collection that harnesses public and anonymous data from the social media forum Reddit.com. Reddit is a social media platform by which users can post content or questions online and can anonymously engage with others, used by people of all ages across the United States, with 58 and 33% of users between ages 18–30 and 30–50, respectively (Statista.com). The Reddit platform houses "subreddits" that focus on specific topics or issues, and as such, there are hundreds of subreddits related to graduate school, to engineering careers, and, in our interest, to leaving graduate engineering programs.

The anonymous nature of Reddit offers several advantages for data collection: Rather than trying to recruit students across the United States who admit to considering leaving their programs, and then eliciting authentic interviews from them, users of Reddit volunteer what they consider to be relevant information about their circumstances, with the intention of asking advice from other online users. While as researchers, we cannot always interpret demographic information (e.g., gender, race) from users, we can assert that the users will identify information they perceive to be relevant to their situations. The anonymity also leads people to be forthright about their decision-making process, which is likely not conveyed to advisors or department administrators through exit interviews. Other disciplines have harnessed these attributes, using online forums and social media for research related to political engagement, semantic analysis, and distance education. The development of this method for this context is presented in our prior work (Whitehair & Berdanier, 2018), and relevant details are included here for clarity.

Data collection was accomplished through an automated Web-scraping bot. A bot (short for robot) is a program written to perform a certain task, in this case specifically through Reddit. This bot searched within a designated set of subreddits, where discussion for particular groups or on particular topics occurs. All subreddits have associated subreddits (determined by the moderators for the subreddits), and as such, we used them to conduct a form of snowball sampling to identify more subreddits to mine for data.[1] The bot uses both inclusion and exclusion search criteria to "scrape" Reddit to find relevant discussion forums within a given subreddit, mining the data and saving to digital files. For the bot to scrape a particular forum, it needs to meet two sets of inclusion criteria, shown in Table 1. The search terms were designed to cast a wide net, with the goal of not excluding searches that used different syntax and phrasing.

TABLE 1 Search criteria for Reddit forum mining

Inclusive search criteria		Exclusionary search criteria
Set 1	**Set 2**	
Grad, graduate, PhD, doctoral, doctorate, MS, MSc	Leave, leaving, dropping out, drop out, quit, quitting, mastering out, left, done, withdraw, withdrew	Disney, high school, highschool, dungeon

The exclusion terms were empirically defined after running the bot and continually getting erroneous hits related to online gaming and a particular internship for high schoolers at Disney. For each subreddit, up to 500 posts that met the search criteria were automatically collected including username, date and time of submission, post title, and post submission text. The scraped threads were then gathered from the bot, which outputs the data as text that can be analyzed through qualitative techniques.

The corpus was then sorted by hand to remove any post not related to graduate student attrition. From there, we sorted the posts into three academic discipline categories: engineering, STM (science, technology, and mathematics) and non-STEM. Of these threads, there were 28 unique usernames whose discussions explicitly related to engineering graduate school attrition per the writer's self-identification. Because this study was qualitative and exploratory in nature, these numbers were found to be appropriate (Creswell, 2012). After preliminary analysis of this dataset, we reached saturation in that no new themes emerged from the forum threads (Creswell & Plano-Clark, 2011; Marshall & Rossman, 2006), so we chose not to perform another search with the Web-scraping bot under broader search terms. A number of posts mentioned that the author was in a STEM field, but these were not included in the engineering categorization because they could not explicitly be identified as engineering.

Because the method of collection was passive (collected from public online forums rather than seeking out individuals), no efforts were made to sample by gender, ethnicity, engineering field, or degree objective (MS vs. PhD). This one-time collection of data resulted in thread dates ranging from 2010 to 2017. There were also a limited number of posts by the same users. If these posts were simply the same post copied to another subreddit, one was excluded. Otherwise, they were grouped with the previous posts by that user in chronological order. Any subreddit without posts in the past 6 months related to graduate attrition was excluded from the set of subreddits.

The Reddit posts ranged significantly in length, from approximately 10 sentences to 42 sentences, including edits and update posts from the same users. Of the participants who did self-identify details about themselves in their posts, four of the 28 users identified as women and no users identified themselves as men. Sixteen users self-identified as PhD students, and nine identified as master's students. Many users identified how long they had been in their graduate program, with 10 identifying as being in their first year; three in their second year; five in their third year; three in their fourth year, and three as having been in their graduate programs 6 years or longer. These numbers do not sum to our 28 users because they were based on the information the users wrote on the forum posts. Two users mused at the possibility of returning to graduate school at a later point in their lives after working in industry, and two users wrote about the possibility of switching universities (as they had fellowships that could be transferred).

3.2 | Narrative analysis methodology and methods

We chose narrative analysis (Polkinghorne, 1995) as our method of choice. Narrative analysis methodology is consistent with our mission to understand the ways in which engineering graduate students make sense of their graduate school experiences. Through this method, we seek to elicit connections and insight into how themes interact with one another through the discourses (Case & Light, 2014; Watson, 2012) of attrition. Although brief "snapshots" of a narrative, the forum posts establish sequence and clearly articulate factors that are weighing on these students during the decision process either to persist or depart from graduate school.

First, we analyzed the narratives through paradigmatic analysis methods (Polkinghorne, 1995) to establish primary themes and connections among themes. After collecting and sorting the data submitted, the corpus of forum posts was analyzed through a constant comparative analysis of the initial submission by each user. We followed procedures of open and axial coding from a constructivist paradigm (Charmaz, 2005; Charmaz & Belgrave, 2012; Glaser & Strauss, 1967; Marshall & Rossman, 2006). This approach allows us to search for emergent themes without preemptively

restricting the data to fit within preconceived notions of what the themes would be, in addition to acknowledging and accepting that meaning-making occurs at the individual level (Charmaz & Belgrave, 2012; Creswell & Miller, 2000).

Preliminary themes were established through initial open coding, and then these themes were further clarified and regrouped through several rounds of iterative axial coding. We employed jottings to capture researcher interpretations throughout the process since, as with all data interpretation, the researchers bring their own positionalities to the data. Since the data were anonymous in nature, there was not an opportunity to member-check; however, decisions about coding were discussed with the research team, leaning heavily on theory and literature to interpret findings rather than our personal experience. These themes and subthemes were then related to existing knowledge and findings in graduate persistence and attrition literature.

We also present and solidify these themes through the use of individual narratives, in a manner consistent Polkinghorne (1995). As we present the data in Section 4, we introduce four narratives that demonstrate the nuances in themes and relationships among the themes, and provide voice to our main themes. We selected these four narratives because, in total, they represent all the major themes in this study and show how the same themes can manifest in different ways. These posts are also compelling in that they are poignant, reflective, and written in ways that illuminate our themes. We also aimed to present a diversity of perspectives from a variety of different discussion board forums to show the variety of narratives.

3.3 | Limitations

As with all methods, there are limitations to the unique approach used in this work. One limitation is that the anonymous nature of these forums is a double-edged sword in that it may allow users to be more open and honest without fear of repercussions, but it also means that users are not guaranteed to be truthful and must be taken at their word for validity of all statements. Second, anonymity can create a negativity bias where users simply use these forums to vent their frustrations without the expression of positive experiences. Similarly, forums show only one side of the story. We cannot collect the points of view of advisors or other actors who influence the students whose testimonies are presented, but we also argue that if we assume that each student is telling their reality, then it does not necessarily matter for the purposes of attrition research what the other realities are. The student perceptions will be the ones ultimately causing students to depart or stay in graduate school. Third, there may also be self-selection bias present in this group of participants. Individuals who post on these forums are seeking discussion and feedback though many participants noted they were more comfortable talking to anonymous strangers on the internet than anyone in their own department. This means that we may still be missing important themes of attrition from those who leave silently.

Fourth, we as researchers have no idea as to how the writers identify in gender, age, race, or other demographic, a severe limitation with regard to the fact that women and underrepresented groups have higher attrition rates from engineering doctoral programs than white men. However, in these forums, we get a deep, rich perspective on the process of attrition that will help make strides in graduate attrition research in general. The final limitation is related to the discourse patterns embedded within online customs. As with any written exchange, certain emotions and sentiments may be difficult to convey without tone and social cues like facial expressions. Some semantic ambiguity has been mitigated by certain online customs; for example, within Reddit, users use characters to create emojis such as =) to indicate a friendly smile. These modes of internet discourse could be interesting to study in future work but were not considered in this research.

4 | RESULTS

From the analyses of individual student posts, six common themes emerged, several of which contained distinct subthemes (Table 2). All narratives represented multiple themes and subthemes.

The relationships between the themes and subthemes are shown in our Graduate Attrition Decisions (GrAD) model (Figure 1). Of note in the GrAD model is the chaining structure of the ways in which factors often link. The thicknesses of the lines connecting the nodes show how primary themes are linked both with other primary themes as well as the subthemes, and the subthemes with each other. In this depiction, a holistic and visual understanding of the complexity of attrition is evident. The linkages represent connections emerging from any of the participants represented by the corpus of 28 forum posts. Through the GrAD model, it is understandable that a person's past experiences, temperament,

TABLE 2 Themes

1. Advisor Role and Relationship—Mention of advisor role and relationship, positive or negative
2. Support Network—The network of friends, family, coworkers, counselors, faculty, etc. (excluding advisor)
3. Quality of Life and Work—The general quality of life and work an individual is experiencing during graduate school compared to previous or other work-life opportunities
3a. *Quality of Life*: General quality of life, including work-life balance
3b. *Work Type*: The type of work an individual is performing outside of coursework and including teaching assistantship work, grant writing, etc.
3c. *Work Environment*: The work environment of an individual including department culture and location
3d. *Coursework*: Any discussion related to coursework, including the structure of courses, quality of teaching, the course requirements, etc.
4. Cost—The general cost associate with the user's decision to stay, transfer, or leave their program
4a. *Time*: The cost in terms of time including lost work experience time
4b. *Money*: The cost in terms of money, including lost work wages/opportunities
5. Perception by Others—How others will perceive the user's decision to stay, transfer, or leave their program
6. Goals—The goals that students hold when entering and throughout their time in graduate school whether that is attending graduate school for the prestige of the degree or to obtain a specific job
6a. *Certainty of Goals*: How certain or uncertain the user is in their goals and motivations for pursuing graduate school
6b. *Change of Goals*: A change of goals, whether determined by internal or external factors, during an individual's time in graduate school

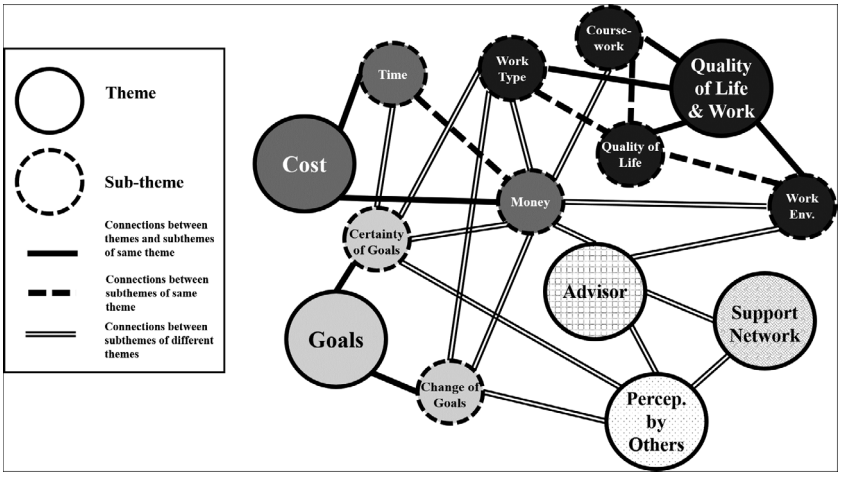

FIGURE 1 GrAD model primary themes and sub-themes emergent from online narratives of graduate engineering attrition

or situation might activate a particular chain of factors that could influence their decision to persist or depart their graduate program. The chain representation hints at the idea of a threshold model for graduate attrition. Engineering graduate students take a great deal of time to make such a significant decision, and the factors are integrated with one another rather than separate factors within the decision to stay or depart. To this end, none of the forum threads referred to only one facet of attrition.

Four of the six themes have been noted in engineering and higher education graduate attrition literature before, particularly the role of the advisor, support networks, (financial) cost, and quality of life/work. However, the themes of Perception of Others and Goals have not been articulated in graduate literature, and the Cost theme is rarely discussed in graduate education outside the literal financial costs of tuition. Therefore, in the following sections, we briefly contextualize each of the six primary themes within the data in the context of engineering graduate programs, with more detail on the more novel themes than the confirmatory themes. The connections among the themes are the emphasis of this work, so most of Section 4 will dissect four powerful Reddit posts in light of the relationships among the six themes. As a note, the posts are not modified or censored in any form, including if the writer swore or used otherwise

unprofessional language (although some spacing/formatting has been modified for presentation). The uncensored nature of the data provides researchers access to unfiltered narratives on the decision of whether to depart from graduate school. The decision to maintain the texts in whole, despite brief instances of expletive language, stems from the goal of maintaining the integrity and authenticity of these texts.

4.1 | Themes of attrition

4.1.1 | Advisor Role and Relationship

Advisor relationships and mentorship are well established as being among the most important facets in a student's decision to depart or continue to degree completion (Barnes, 2010; Curtin, Stewart, & Ostrove, 2013; Di Pierro, 2007; Mansson & Myers, 2012). The Advisor Role and Relationship theme categorizes experiences where students mention their advisor, the working relationship with the advisor, or any other attributes where a participant explicitly notes the research advisor. The literature notes that formal advising relationships are not equivalent to mentorship (Johnson, 2016), which entails specific deeply personal and reciprocal mentoring roles across career and psychosocial functions (Kram, 1985; Ragins & Kram, 2007). Many graduate students expect a mentoring relationship with their research advisor, a discrepancy that can cause tension in light of a variety of structural and personal obstacles (Johnson, 2016). Some forum writers indicated negative relationships with research advisors as being one major facet in their decisions to persist: one participant classified her or his advisor as being "a jerk" or disorganized and uncommunicative, while others cited disagreements in regard to research goals and interests. As examples, one participant simply "realized I am not interested in what [my advisor] wants me to do" and another realized that she or he was not getting as much face time with the research advisor as expected. In contrast, many graduate students considering leaving noted that they felt supported by their advisors and indicated positive experiences with advising that complicated their decisions to leave.

4.1.2 | Support Network

Excerpts coded in the Support Network theme noted relationships with others: friends, family, colleagues, or faculty who play a mentoring role (excluding research advisors, which were coded in the Advisor theme). While some forum participants noted having consulted family and friends about their situations, most mentions of support manifested as the lack or loss of a critical relationship or isolation from important family and friends during graduate studies. Significant changes in support network status (e.g., relationship breakups) seemed to act as a catalyst for reevaluation of the student's situation, highlighting other issues like the decision to attend a certain school only to be near a significant other or the decision to persist because they had a partner to support them. Findings also indicated the dependence of current graduate students on online social networks to replace or augment a support network in their lives, indicating they did not feel they had anyone to talk to at their institution. One participant summed it up: "So here I am, asking strangers for advice." Some users indicated that the Reddit community was their support network. Others signed their posts with fondness, such as the "heart" emoji, "<3," or "love you all." These data indicate that current graduate students may reach out to an anonymous online community either in addition to or instead of finding community in their geographical communities or campuses.

4.1.3 | Quality of Life and Work

Quality of Life and Work served as a broad theme by which to capture interconnected issues related to the subthemes Quality of Life, Work Type, Work Environment, and Coursework. Even as some participants noted enjoying their research, their experiences with an unhealthy lab environment or department climate made the prospect of completing a PhD daunting. One student noted that "the environment in the lab is full of constant tension and depression" and another said "I think I'm finally truly over it. The continuous hammering without results and stress of feeling like I don't know anything has really crushed my ego. I'm suffering from imposter syndrome and I think I want out." Multiple participants indicated that they sought counseling for mental health or struggled with depression and/or suicidal thoughts during their tenure as a graduate student. While most students understood the amount of work required to

persist, and rather than worrying about the amount of work, they wondered "if it will be fulfilling" while another expressed that "there's just too much stress, and I had a much better quality of life before." Other students articulated struggling with not enjoying their work: "My experience in grad school [...] has been boring, frustrating, and uninteresting. [...] I miss having concrete objectives to work towards. And even after finding a specific topic that can be researched, I feel like any contribution I will make will be so minute that I won't be satisfied with it." Nuances in these reflections indicate that students are also weighting the current and hypothetical future well-being in relationship to their decision to stay or leave their graduate engineering programs.

4.1.4 | Cost

We defined the theme of Cost as being the literal or figurative expense associated with a graduate student's decision to stay in a graduate program, leave, or transfer programs, including costs related to the subtheme of Time and Money. In a literal sense, and different from student comments from social sciences and humanities, engineering graduate students are not worried about supporting themselves during graduate school. For example, one participant noted, "My tuition would be covered by research grants and scholarships. So far, for my first year I've even gotten money back on top of my monthly stipend." Other students note winning prestigious national fellowships that would fund them for the majority of a doctorate. Most engineering graduate students discussing finances acknowledged that their stipends were far below what they could be making working in industry (e.g., "I want to make the 80K paycheck I deserve"), while others desired "[to have] stability from a job, [to] pay off loans, and reclaim a life/work balance." Cost extends into the figurative domain in terms of the time and effort spent in graduate research, often at the expense of mental health or relationships. Graduate students expressed frustration with the idea of "wasting" more time in school: "To push a lot further and get a PhD is something I worry about: I fear spending the next 2 or 3 years of my life alone and being 27 when I graduate...." This sentiment was echoed by those who felt as though they are not yet "real" adults, or a part of the "real" world; they felt as though they were "behind" their friends and family who chose different career paths. Students alluded to the gain of the PhD at the expense of personal happiness or satisfaction. The figurative costs of graduate school seemed to weigh heavily on students who also were struggling with issues related to the type of work they were doing and changing goals for their career in light of their graduate work.

4.1.5 | Perception by Others

The Perception by Others theme included excerpts that expressed concern for how the decision to leave from graduate school would be perceived by others, including friends, family, advisors, and future employers. At times, the language in the forum posts indicated guilt related to the decision to leave. One student expressed a fear of informing their advisor of their decision because they felt their advisor "essentially did not benefit from having me as a student at all." The fears related to advisor relationships were coupled with other narratives related to whether leaving their program would hurt their future employment chances: In the words of one post, "[w]ould others understand where I'm coming from?" In tension with these emotions, many forum participants expressed a fear of regretting a potential decision to leave, even in light of not "want[ing] to spend years being miserable so that I can follow a career path that I might not even like" but often countered their own argument with sentiments like "I don't want to regret leaving since I have the funding opportunity." Furthermore, some of these students expressed uncertainty with how their families or friends viewed their perception to stay in graduate school, feeling like they were the only ones "still in school" and "behind" their peers outside academia.

4.1.6 | Goals

The final theme in this data is an explicit and implicit discussion on goals, and the lack or change of goals and repercussions on persistence. Two subthemes emerged, Certainty of Goals and Change of Goals. The Certainty of Goals subtheme was also allocated to describe students' lack of goals, as some students realized they did not have strong rationales for pursuing graduate school (e.g., being laid off a job and being subsequently offered a graduate position by a former mentor). One participant used the word "lured" to describe how her advisor convinced her to enter graduate

school: "My senior year one of the professors took a special interest in me for some reason and lured me into committing to a research project with him for a thesis by giving me funding [...] He was really pushy [...] saying that American students should all get PhDs and especially women." All but two of the students who discussed uncertain goals also expressed a fear of regret related to uncertainty in their persistence decision. Common worries emerged related to "regretting not sticking it out" or the fact that they were wasting a "great opportunity" when they already had a research position and fellowship or scholarship funding. Alternatively, other students' goals simply changed, either related to technical interests, career plans, or personal life priorities. The majority of the students who discussed a change of goals indicated that they were financially supported for their research but were not satisfied with the type of research they were conducting, resulting in a change of goals. As one student noted, "The program has given me funding and research but more [than] anything it has taught me a lot about myself, i.e., that I want to be a manager of engineers and not an engineer." It is important to note that these individuals are not citing something wrong or negative about the program or environment, but that it is truly a difference of goals and career path aspirations. One student noted that "[the research projects] sounded like projects that I wanted to work on, but now that I've started working on them, I'm realizing that I absolutely hate this work."

4.2 | Integration of themes

Even in the short excerpts from the data that are used to characterize each of the major themes, elements of integration between the themes are evident. In fact, none of the forum threads referred only to one facet of attrition; always two or more were in combination with one another. In this section, we present four forum posts exactly as they appear from participants. Each forum post will be discussed as a whole to illuminate how the codes interact with one another in light of individual circumstances. These four posts were selected because they each cover at least three of the six primary themes and represent the deeply personal decision-making processes within attrition. These data are raw, personal, and show that attrition is a process through which a student journeys, rather than a singular event that occurs when a student informs her or his university of a decision to depart. The author names are created by the Reddit users themselves, and the author names and titles often give an immediate impression (such as that of *sadstudent15*).

We arranged these narratives in an explicit order, discussing the narratives in relationship with one another throughout the section rather than all at once. This decision was advantageous for two reasons. First, because we refer to the narratives and students by their Reddit usernames, it can be difficult to hold all the narratives and experiences in mind at once before an overall discussion. Second, we felt that readers can build a more nuanced understanding of how the themes manifest and couple in complex ways and can vary in connotation and complexity between various narratives. We start by introducing *imagradschoolquitter*, whose thoughtful and reflective narrative held five themes, to introduce many of the complex themes. Then, we present the narrative of *sadstudent15* because it presents most of the same themes, but with a much different tone. Both these students' advisors seemed to support them in graduate school; therefore, we chose to present *academic_nut's* narrative third, representing a gut-wrenchingly complex advisor relationship in spite of an otherwise "successful" career. Last, we present the narrative of *Harperssocks* at it holds the same themes as *imagradschoolquitter*'s but is genuinely alarming in terms of this student's physical and mental health. This arrangement best presents our data while capturing the frustration, trepidation, and grim realities of graduate students as a launching point for the discussion.

As a note, some users rely on internet shorthand, for example, other forum threads on Reddit are referred to with the notation "/r/," and the acronym "tl;dr" stands for "too long; didn't read," giving a brief summary of the forum post for readers those who do not read the full post. During analysis and in presenting the results of this study, we were careful to not assign gender to any participant unless explicitly self-identified in the post. Therefore, we use the gender-neutral "their/they/them" unless a gender was otherwise indicated by the user.

Narrative 1: Imagradschoolquitter

Primary Themes Connected: Advisor Role and Relationship, Quality of Life and Work, Cost, Perception by Others, Goals

> AUTHOR: imagradschoolquitter.
> TITLE: Quitting—lament of a grad school burnout.
>
> SELFTEXT: Throwaway. I've been active off and on on /r/gradschool, /r/engineeringstudents, and /r/engineering throughout my Reddit tenure under several usernames. I've given and received some good advice on Reddit. I am not sure exactly why I'm posting here. It'd be wrong to say I do not need words

of encouragement... but maybe I can offer some feedback to grad students who are struggling, too. Feel free to ask me questions, if that strikes your fancy.

My story:
I was an engineering PhD student at a big public research university in the U.S. Came here for my MS degree about 6 years ago, fell in love with research, decided to stay for PhD. My adviser is well known in his field and was enthusiastic to have me on board for the PhD, but had no funding to offer when I started out––so I chugged away at a temporary assistantship within my department until a project came through that would offer me a few years of funding. My dissertation project was industry-funded, entailed a lot of very laborious lab testing and was in a somewhat isolated environment (off campus lab). Endured a lot of difficulties getting my laboratory equipment to work, ultimately became more and more stressed out (from lab testing) and disillusioned about academia (stresses of finding funding, politics, isolated work environment). Became depressed, started seeing counselors, and after several very difficult months I realized that quitting would probably be a better choice for me than keeping at it.

I never felt that academia was my sole career aspiration. I stayed on for the doctorate because it seemed intriguing, provided an intellectually stimulating/satisfying job for a few years, etc. In fact, I did not even think I had an interest in academia when I started out. Later on I gave it some serious consideration, started thinking about applying for faculty positions and so forth. But ultimately I started wondering whether it was a good idea after all, in no small part because of the stress I carried with me throughout the laboratory work.

My adviser has been supportive, but I was terrified of making this decision and breaking the news to him. I guess I figured I was letting him down & he'd be disappointed in me. I'll never know if he actually was bummed out—he's been supportive and complimentary the couple of times we have spoken since I made the decision. But I'll always wonder if he really thinks I'm just weak, or that I let him down and committed a crime of morality by abandoning my dissertation project. It was a practical project with lots of potential benefit to society. It's hard to let go of that. I just could not take it anymore. I needed to end the constant stress and worrying, and find something to do that would offer a "real" paycheck. I want to work 9 to 5 and have my weekends off and start a relationship sometime and just live my life.

I made this decision about a month ago and have been coming to terms with it since then. I'm almost out of money, but my adviser is funding me for a few more weeks to finalize the parts of my research that I've completed thus far, and to give me some time to figure things out in my life. I do not want to move back home yet (I'm quite far from my hometown), and I'll probably strike out to a new city for my next job. Adviser has told me he was very happy with the work I did and he's happy to write letters of recommendation for my next job.

I have a lot of close friends in this college town, so of course it's going to be very difficult to leave too. Currently my plan is to live on my credit card for another month or two, apply for jobs and tie things up with my business around here. All things considered, I'm a really lucky person. But the last few months have been really difficult emotionally. I know I was qualified, and capable of finishing my degree. It sucks giving this up. I have a deep fondness for people in science, engineering and academic research, and I know now I'll never be part of "the club." I'll never be able to say I "did my PhD," or talk with other concerned citizens about the problems facing the world with any kind of formal qualification. I know my intelligence and civic worthiness do not rest on a piece of paper, but it sucks not to finish what I started. I'm just going to remain that person who spent the better part of a decade in graduate school while everyone else was making money and procreating. I feel like I'm behind.

Anyways, that's it. Just wanted to share. Best of luck to all you struggling students in /r/gradschool—you are doing great work. I have to leave you now but I love ya just the same.

Imagradschoolquitter offers a summary of 6 years in graduate school as a means of mentorship or advice for others who are struggling in graduate school, in part because of the mentorship and support network that helped to sustain them through past forum threads and conversations. The theme of Quality of Life and Work is immediately noted, that

the research work was high-stress and compounded by the effect of isolation. However, the urgency of the project—potentially related to the quality that made the research high-stress—was something important "with lots of potential benefit to society." As evidence of complex feelings of guilt or shame, this author muses that perhaps leaving the dissertation project was a "crime of morality." In addition, this writer spends nearly half the post debriefing on their Advisor Role and Relationship, which seems to have been supportive. However, *imagradschoolquitter* consistently worries that they let their advisor down and that, even though the advisor has been complimentary and has written strong letters of reference, might "really just think I'm weak," an attribute that was categorized as Perception by Others.

The external perception of weakness is noteworthy with respect to the explicit confidence statement in the ability to complete a PhD, noting that they felt "qualified, and capable of completing the degree" from a technical standpoint. Though their "intelligence and civic worthiness don't rest on a piece of paper," nor are they committed only to an academic career (Goals), here the tone of the post changed from confidence to regret in "not being part of the club" or not being able to say they "did [their] PhD." These phrases exemplify the tension in how the internal and external perceptions of self may collide during the decision to stay in or leave academia. To this end, *imagradschoolquitter*'s career-based regret is that perception that they will "never be able to ... talk with other concerned citizens about the problems facing the world with any kind of formal qualification," indicating they do not assign worth to the time spent in graduate school. After rhetorically parting with their past academic identity, *imagradschoolquitter* immediately jumps to personal identity decisions such as starting a family or establishing a career. They claim a new identity as "that person who spent the better part of a decade in graduate school while everyone else was making money and procreating" and note feeling "behind" in life, manifestations of the Cost theme. Hints of isolation emerge again, feeling disconnected with experiences in life that are designated to be more "normal." These quotes demonstrate tension between the internal and external perceptions of self, but also seem contradictory to the earlier strong statements of self-confidence. Rather than treating dueling statements as invalid, they can be true simultaneously, showing that the complexities of attrition, identity, self-esteem, advisor, and perceptions of others are intricately connected with work environment in the decision to depart.

Narrative 2: sadstudent15

Primary Themes Connected: Advisor Role and Relationship, Support Network, Cost, Perception by Others

> AUTHOR: sadstudent15.
> TITLE: Just finished year 4 of PhD work, want to quit!
>
> SELFTEXT: Tonight I called my boyfriend crying once again, because I want to quit grad school. I wrote my master's thesis and defended that after 2.5 years of grad school, and ever since then I've had about one night every two or three weeks where I swear up and down that I'm going to quit. But I never do. I'm still here. I've made a little progress on my dissertation work, but for every little step forward there have been way too many tears.
>
> Over the last year and a half I've been convinced not to quit by my advisor, my mother, my father, my peers, and my grandma. Here are a few of the reasons they have given me, and my response.
> "You'll regret it if you don't finish." "I'm already proud of myself for the master's degree."
> "You're so lucky that you're being paid for a higher degree at a great university." "But I'm miserable almost every single day."
> "You will be in a very elite group." "Not a lot of people have master's degrees in engineering."
> "You'll be able to earn lots of money." "I could earn a lot with the degree I have, plus money doesn't mean shit if you hate going to work every day."
> "You're so close, you can't quit now." "The hardest and worst part is yet to come."
> But really the only reason I have not quit is because I do not want to disappoint anyone.
>
> So here I am asking strangers for advice. Is hating grad school normal? Did you want to quit so many times but then got your PhD and were so happy you did not? Why do I care so much about what other people think?
>
> Edit: I'm meeting with my advisor tomorrow, and I'm going to bring the idea up of not finishing. I'm sure he'll try to convince me to stay. And honestly out of everyone I ask for advice he's the only one that could convince me to stay.

Sadstudent15, this author's self-defined name, articulates dialogues that this student has had with multiple people in their network, indicating that a support network has been a central theme in their life. This student has confided in multiple people about their decision to depart the PhD (Support Network) including their advisor (Advisor Role and Relationship), who seemed to have worked toward convincing this student to stay in graduate school, despite continual breakdowns over the past 9 months of doctoral work. The emphasis here is how much value *sadstudent15* places on the words of family and friends, and the self-awareness of how much other people's opinions factor into the decision. Although support networks typically have a positive connotation associated with them, with known connections between support networks and persistence (Gardner, 2010; O'Meara, Knudsen, & Jones, 2013), this post hints at a potentially toxic effect from a support network that continues to push toward persistence in spite of continuous misery. Paralyzed in the decision, this student reaches out to "strangers" on Reddit, wanting to know if others were happy in their decision to persist despite "hating grad school."

Like *imagradschoolquitter*'s narrative, *sadstudent15* gives competing narratives regarding their commitment to leaving, due to the inherent need to please others. *Sadstudent15* knows how they feel about each of the rationales for staying in graduate school and has legitimate responses to the reasons their network gives them for staying. Perhaps the most provoking statement of all is the commitment that "money doesn't mean shit if you hate going to work each day" (Cost), a statement that could easily be applied to their current situation in "hating" their doctoral experience.

The theme of Advisor Role and Relationship is intricately connected to both the themes of Support Network and Perception of Others. *Sadstudent15*'s advisor has already convinced them not to leave. The post echoes of self-fulfilling prophecy, that in bringing up the possibility of leaving with this advisor, that he will convince *sadstudent15* yet again to stay, and that *sadstudent15* values his opinion more than anyone else's (though they all recommended staying as well). Strikingly absent from this post is an indication of *sadstudent15*'s initial interest in graduate school or research. While *imagradschoolquitter* discussed the thrill of intellectual stimulation and an inherent interest in the societal good of their project, this post gives no indication of goals, motivation, or what types of career trajectory this student would like to pursue, either after a PhD or after leaving academia. While the post is reflective in terms of wondering if others were happy they had persisted and in identifying that they perceive others' opinions more valuable than their own, the readers are left with little sense of who this writer is apart from the desire to please others.

Narrative 3: academic_nut

Primary Themes Connected: Advisor Role and Relationship, Support Network, Perception by Others, Goals

> AUTHOR: academic_nut
> TITLE: Thinking of quitting grad school in the 6th year
>
> SELFTEXT: I'm using a throwaway account. My advisor relationship has grown steadily more antagonistic to the point where I think he is actively holding me back from graduating. I'm a 6th year engineering PhD at an Ivy with one paper published and another paper ready to submit. I was set to defend in March with 100 pgs of my thesis written already. All of a sudden, my advisor wants to enforce a 3-papers-published-before-graduation rule—a rule that he has not done with any of his previous graduate students. Not a single one in over a decade. I find the requirement ridiculous because papers can easily be stuck in revision for a year in my field and would bump my total time to 7 years+.
>
> I've gradually lost respect for my advisor. He's pretty much not an expert in anything, but uses his position as a gatekeeper to the equipment to get his name on a lot of papers. He is on terrible terms with half the department, and they don't talk though there is ample room for productive cooperation. I really like my research/thesis and have gotten to the point where I am independent. In some weird way, I feel my advisor finds this threatening, which is leading him to become incredibly critical of my work. My coworkers/authors (staff researcher and assistant professors) have complimented my work so I think my advisor's concerns are unfounded.
>
> On this backdrop of a dysfunctional department divided into political hegemonies, I don't know where to go for advice. I feel the science deans or department head will side with the professor. To me it almost seems like a tacit understanding that graduate students are like serfs. I've had overall positive experiences in grad school but now the psychological torment of another year or quitting in the 6th year is starting to

really drag me down. I feel if I quit, I would land on my feet eventually due to the skills I've acquired and references from my coworkers. Sorry about the long post, but what does Reddit think are my options?

TL;DR. Advisor has become increasingly critical of my work though coauthors approve, and I'm thinking of quitting rather than doing another year or more.

Academic_nut's narrative centers around adverse experiences with the theme of Advisor Role and Relationship, the most dominant code used to analyze the post. As a backdrop, though, the Support Network, Goals, and Perception of Others themes also emerge in this post, but not in the ways they have emerged in prior posts. For example, the Support Network in *academic_nut's* circumstance is other researchers in the department, many of whom are colleagues, who seem to perceive this student as qualified and capable. Indeed, the student has already accomplished many scholarly milestones, including publications—an indicator of external scholarly validation. There seems to be a great deal of tension between what the student considered to be the benchmark or goals to accomplish before earning a PhD in relationship to the advisor's inconsistent metrics for this particular student.

Unlike the narratives of *imagradschoolquitter* and *sadstudent15*, *academic_nut*'s narrative contains consistent language in terms of their own self-confidence in the ability to complete a PhD under normal circumstances and the ability to "land on [their] feet" if they were to leave graduate school. The complexities in this narrative arise from the tension of the discrepancies in Perceptions by Others. For example, embedded within the advisor's new "three paper"' rule is the implicit perception that *academic_nut* is not ready to graduate, yet the other professors and colleagues seem to be supportive of the student's research and capabilities. The Perception by Others theme intersects with Quality of Life and Work, as *academic_nut* highlights emerging critiques of academia, the department, and the advisor within departmental "hegemony" and "politics" and the perception that graduate students are viewed as "serfs."

Narrative 4: Harperssocks

Primary Themes: Advisor Role and Relationship, Quality of Life and Work, Perception by Others, Goals

AUTHOR: Harperssocks.
TITLE: Urgent Help! Told to leave PhD after PASSING my prelim.

SELFTEXT: I am a PhD student, starting my third year, and an NSF-GRFP fellow (2 more years remaining).

Yesterday I successfully defended and passed my departments Written Examination. Several professors wanted to fail me and there were reservations but I passed. Afterwards I was told they want me to discontinue my PhD and leave the program with a Masters degree. This is unprecedented and took me by complete surprise. My adviser has told me I am smart, creative, I have a strong work ethic, and everything I've suggested we do in my project he has approved. He is a new professor trying to get tenure and I am his first PhD student. I was originally co-advised but left another professor because he was emotionally abusive. There were no conditional passes, suggestions to take courses to fill in educational gaps, or chances to revise my proposal (which is within the examinations guidelines).

I am extremely uncertain how to proceed. My adviser sent me an email confirming in writing—I passed my exam and they want me to leave. I e-mailed the Head of the Department (who likes me to my knowledge) and am awaiting a response. I do not know what to do and any help or advice is appreciated. At this point—even if I COULD return to my PhD I am extremely skeptical since I no longer feel like my department supports me. I may try to leverage my 2 fellowship years to a new program but academia has left a really bad impression on me at the moment.
<3 thank you.

AUTHOR: Harperssocks.
TITLE: [Update] Told to leave PhD program after passing my prelim.

SELFTEXT: I really want to thank everyone for their support and recommendations. I have a small update and a lot of hard thinking ahead.

> My adviser and I met yesterday and he did offer me a very sincere apology. Some faculty would like me to leave but my adviser has the final say and wants me to continue (he is new and went along with consensus). He made some conditions for me to stay which mainly continue what I'm doing, and he would like to meet weekly and write a review paper together (I would have loved to do this before it was a "condition"). He has been really wonderful and has largely let me direct my work. He even supports me doing my own queer science outreach events. The bad news—My department still is against me. I've hated being in the building after I left my emotionally abusive advisor and am now even more terrified. My emotionally abusive ex-advisor is still connected to my funding and a part of my project. He is even on "sabbatical" and hired himself as his own "post doc" working alongside me on the project. He barely shows up to work and I've never seen him in lab so I'm not too worried about him.
>
> **Where I am currently at:**
> * I am grossed out by academia and not sure if I want to be a part of it
> * I have 2 years of NSF funds that I should not waste by leaving (but am willing to)
> * I do not need a PhD to teach community/tech college (current goal—but the PhD helps)
> * I wish I were doing more math/engineering (microbiology focused enviro. Engineering lab). Consulting would let me do that
> * I love the idea of stability from a job, pay off loans, and reclaim a life/work balance
> * If I stay with this program, I can leave with my Masters at any time. If I leave now, I cannot return.
>
> I am leaning towards staying since my adviser has been pretty wonderful despite terrible experiences with the rest of the faculty. I would love any questions or comments you have asked yourself to tease out emotions on big decisions.
>
> Thank you all again <3

Harperssocks' story is one that confronts the sociological norms and expectations of academia. Language used in the post indicates that *Harperssocks* may not entirely fit within many of the norms of academia or engineering. For example, the mention of conducting queer science outreach events is an explicit refusal to accept the heteronormative and predominantly male engineering culture. The theme Perception by Others manifests not in the sense of how others think about the decision to leave or stay in academia; however, because this student does not know how others perceive them, they seem to be afraid for their physical and/or emotional safety (Quality of Life and Work). More than just an unhealthy culture, *Harperssocks* indicates that others' perceptions make them "now even more terrified" to be in their building. Although *Harperssocks* seems to have academic potential, having been awarded the National Science Foundation Graduate Research Fellowship, and although this student is supported by their advisor (Advisor Role and Relationship), who "has been pretty wonderful," *Harperssocks* is considering leaving graduate school.

The decision, though, is further complicated by *Harperssocks*' professional ambitions (Goals), which include teaching at the community college level, a goal that can more easily be achieved with a PhD. This student has reflected on the possible avenues for the future, which could also include consulting and reclaiming work-life balance (future Quality of Life and Work) but could also translate to pursuing PhD work at another university, leveraging a highly competitive, transferrable fellowship. As such, *Harperssocks* continued to reach out to the Reddit network to ask advice on how others "tease out" complex important decisions.

5 | DISCUSSION

5.1 | Contributions of the GrAD model to current scholarship

While some themes resulting from this study agree with existing literature, our model of engineering graduate attrition highlights linkages between common themes of attrition. For example, themes of Advisor, Support Network, and Quality of Life and Work are found throughout both STEM and non-STEM literature (Barnes & Randall, 2012; Curtin et al., 2013; Gardner, 2009). However, rarely are the themes presented in relationship with one another to more clearly articulate the complexities involved in graduate attrition. The GrAD model is flexible in that it can illuminate potential

linkages that can push a student toward considering attrition, given that both psychological (e.g., goals, figurative cost) and sociological (e.g., advisorship, policies) facets are intertwined. While the data present a snapshot of the attrition narratives captured through the online forum Reddit, the links between themes show emergent potential areas of concern that promote a combined model of attrition, where the themes are not discrete but layer in complicated and personal ways. As imbalance or misfortune in one area occurs, the importance of success in other areas becomes more important in persistence. While this research does not place a priority on one theme over another, from a theoretical perspective, when a student does not feel that graduate studies are "worth *it*" (whatever *it* is for that particular individual), related areas are at risk to become unstable.

Two themes emerged that are a new contribution to the attrition literature: Goals and Perception by Others. While other scholars discuss a mismatch in expectations as to what graduate school will be like (e.g., Golde, 1998, 2005; Nerad & Cerny, 2000), we argue that the "expectations" conversation does not necessarily capture the examples of uncertain goals or changing goals described by the Reddit forum participants. Students expressing a change of goals did not discuss a difference of expectations from when they entered graduate school nor necessarily from the expectations set forth by their advisor, but rather a desired change in career path. While there were students who expressed a desire to change career path due to external factors (e.g., difficulties with their advisor or program), several of them simply realized that their field or a research-centric career was not their passion, or that pursuing graduate school would lead them to their desired career.

The other theme emerging from this study that has not been well explored in the previous literature is Perception by Others, which manifested in fearful, personal, and often hypothetical ways. As evidence of the fear-centric undertones to this theme, most participants (apart from *Harperssocks*) did not ground their fears in actual experiences in how others view them; rather, they forecast how they think others will view them. This is the first study to date that highlights students' thought processes with respect to how other people view their decisions to depart. In future work, a deep investigation into this theme would likely be fruitful as an addition to graduate education scholarship that would be applicable across disciplines. In engineering, we see great promise in linking this graduate education scholarship with Huff's emerging phenomenological scholarship on emerging adulthood (Huff, Smith, Jesiek, Zoltowski, & Oakes, 2018) and shame (Huff, Shanachilubwa, & Secules, 2018) in engineering and mental health in STEM graduate students (National Academies, 2018), topics that are timely and relevant, and have not been discussed in engineering graduate education literature to date.

5.2 | Confronting anecdotal narratives of graduate attrition

One topic of interest is a direct confrontation of competing narratives on attrition that occur between faculty and students. Researchers such as Lovitts (2001), Gardner (2008), and Barnes (2010) in a non-STEM context found that advisors of students who had not completed their graduate programs often attribute factors differently than the noncompleters themselves. Gilmore et al. (2016) found that STEM advisors attribute persistence to student intrinsic motivation and "getting involved" in research. However, these results are simplistic regarding the narratives and linked model for attrition that the research reported here illuminates. Indeed, the students posting these narratives of their decision-making processes were involved in research. While our Goals theme has elements of intrinsic motivation embedded within it, we posit there is a broader conversation missing in graduate engineering education (or graduate education in general) to help students navigate a changing identity and changing goals.

This work also presents some examples of counternarratives to common assumptions about graduate student attrition. One concern of ours in reporting this data is possible retorts from engineering faculty, exclaiming that "They might just be failing their classes" or "These students are so entitled," or musing "Well, what did you expect graduate school to be like?" or worse: "It's better than when I was a grad student." These narratives are unhelpful and ultimately, irrelevant to the topic of attrition in graduate school. The students represented by their narratives seemed to be well prepared for graduate school; many of them self-reported they had passed their qualifying exams or dissertation proposals, and several self-reported achieving prestigious awards. Three of the 28 participants reported being NSF-GRFP winners (one being *Harperssocks*), one was an NSF-GRFP honorable mention, and another a DoD NDSEG winner. These findings confirm findings across disciplines that map grit to academic persistence in graduate school rather than solely academic potential (Cross, 2014; Miller-Matero, Martinez, MacLean, Yaremchuk, & Ko, 2018; Pacheco, Noel, Porter, & Appleyard, 2017). Myths of problematic advisor relationships were both confirmed and dispelled: While some students felt supported by their advisors but still were considering departure, others reported emotional abuse from advisors. These accounts have to date been hidden in graduate engineering education literature. Ultimately, regardless

of the "reality" of the situation, these perceptions are the students' lived truths and likely represent the experiences of many graduate students.

From an EVT perspective (Eccles, 1983; Eccles, 2009; Eccles & Wigfield, 2002; Wigfield & Eccles, 1992), students' psychological tensions are evident in the connections that they draw between the three subthemes of Quality of Life, Time, and Money. This study finds that students perceived time and money (from the perspective of an opportunity lost) as costs that weigh against their quality of life while in graduate school. Additionally, these perceptions extended to students' discussions of their future quality of life with and without their graduate degree, and their satisfaction with the type of work they were producing. When drawing connections to EVT, we see that engineering graduate students' perceptions of cost served to undercut their goals both in the present and the future. Previous work has shown that the undercutting of goals leads students to feel like they do not belong in engineering (Foor, Walden, & Trytten, 2007; Oyserman, 2015; Oyserman, Destin, & Novin, 2015), reduces their intentions to persist (Husman & Lens, 1999; Oyserman & Destin, 2010), and limits their engagement in the deep learning (Kirn & Benson, 2018). These previous traits emerged in our work as part of the impassioned narratives and our model of attrition decisions.

In addition to considerations of costs, students discussed struggling to find the value across their graduate experiences. These considerations connect to and show implications for each of the value components of EVT: utility, attainment, and intrinsic value. Students' discussions of an inability to create change through their work directly reflects reduced utility value or perceived usefulness of tasks. Utility value has been connected to student engagement and deep learning in engineering (Kirn & Benson, 2018; Nelson, Husman, Cheng, & Harackiewicz, 2017). The graduate student narratives show the other side of this relationship, where limited utility led students to disengage from present tasks. Additionally, we see an undercutting of students' attainment value through the limited recognition or active undermining of their identities (e.g., a qualified PhD student). While positive recognition experiences foster student identity development (Godwin, 2016; Godwin, Potvin, Hazari, & Lock, 2016; Hazari & Cass, 2018), our work and the work of others demonstrates that graduate students' identities are not fixed, and through undermining one's identity, faculty and educational communities create barriers for those wanting to pursue graduate degrees (Miller et al., 2017; Perkins et al., 2017; Tsugawa-Nieves et al., 2017).

Cultural narratives of graduate education tend to discuss interest or intrinsic value as a binary trait where students have it or they do not (Gilmore et al., 2016). However, this cultural perception of interest development is fundamentally misaligned with theoretical perspectives that show interest must be developed and sustained (Hidi & Renninger, 2006; Renninger, 2009; Renninger, Hidi, & Krapp, 1994). The student narratives expressed earlier in this work reinforce the theoretical models of interest and explain the two goal-setting patterns expressed by students in their narratives. Those who entered graduate school with uncertain goals often did not find interest in their present tasks without guidance and struggled to set goals that could motivate them to persist through challenges. In contrast, those with goals that shifted expressed experiences that led to reduction in their interest and, thus, their goals for pursuing a graduate degree. Some students' experiences were ones where they realized there was an interest misalignment between graduate tasks and their goals. These students' interest deteriorated due to negative experiences propagated by others in the community. The second group of experiences showed a need to leverage existing interest interventions (Hidi & Renninger, 2006; Renninger et al., 1994) to foster engineering graduate student development and points to the usefulness of research in students' motivations to pursue graduate school (Borrego, Knight, Gibbs, & Crede, 2018).

Further, the narratives of students presented in this work highlight two identity-related experiences in graduate education that led to these motivational paths. The first group highlights a set of engineering graduate students who enter with uncertain identities around being in graduate school and pursuing an advanced degree. While these students are often encouraged by faculty to pursue graduate school, they struggle to internalize that they are the type of people who should pursue graduate education. This struggle leads to an identity mismatch between how the student views themselves and how the larger graduate education community expects them to be. When students experience identity mismatch in a specific context, they are more likely to leave that context (Landau, Oyserman, Keefer, & Smith, 2014; Oyserman, 2012, 2015; Oyserman & Destin, 2010). The second group of displayed a shift in their identities as a result of participating in graduate communities of practice. In realizing that who they wanted to be did not align with the goals and expectations of graduate education, they began the process of setting goals outside of academia and choose to leave their programs. The steps of identity formation and shift in engineering graduate education and the subsequent goals established by students highlight the ways that the sociological factors of one's experience can influence decisions to leave graduate school (Eccles, 2009; Oyserman, 2015). We have expanded on these existing theoretical foundations to highlight how all of the constructs discussed are interrelated and serve to shape a student's educational experience, as evidenced by the interconnected nature of the GrAD Model.

5.3 | Implications and future work

Returning to the GrAD model built in this work, we see that graduate student narratives about attrition are complex and interconnected. Specifically, the GrAD model highlights the interconnections between different constructs of motivation from a psychosocial perspective for engineering graduate students. While these frameworks have explored attrition elsewhere, the negative and chaining effects of these are exacerbated in graduate engineering education, as engineering graduate students already have a degree and could be readily employed in industry. As such, it is imperative that implications of this work move readily from recommendations into practice.

The first implication for research advisors and engineering administrators is to decouple the concepts of persistence and success and, similarly, the concepts of attrition and failure. The language of persistence and attrition is inherently value-laden and supports an academic version of success in one particular context. Some students represented in this corpus realized that they ultimately do not want to be researchers and do not want or need a PhD. In these cases, we posit that these students have succeeded in finding their purpose as an engineer, even if that does not include a terminal degree. Alternatively, our data show that qualified PhD students, who seem to be ready to accomplish their PhDs, are considering departure due to circumstances well outside scholarly activities, even as late-career graduate students. It is only a failure of the advisor and university that these students leave their programs and a success on the part of the students to escape unhealthy situations. Scholars conducting work in retention programs may consider using alternate language, particularly for attrition. Lovitts (2001) referred to her former doctoral student participants as "noncompleters" to negotiate this issue, and we encourage the use of other words that have nuances of agency to describe attrition, such as "departure."

The second implication is that as engineering educators, we should help graduate students find their callings as engineers and researchers. Of course, a PhD is difficult, but the consideration of a student's end goals—even if they may shift—should be an end goal of an advisor, who in many engineering graduate programs also fulfills mentorship roles. Advisors and mentors should be careful not to push students to apply for PhD programs if they are either unsure of their goals or may not want or need PhDs to accomplish their goals. Students who are eager to please may feel overwhelmed by well-meaning encouragement (note the narrative of *sadstudent15*, whose advisor's opinion could override years' worth of harmful emotions). Working with graduate students requires sensitivity, empathy, and a recognition that they are adults with agency over their own career trajectories. Additionally, once graduate students enter graduate programs, faculty need to work to support the development and maintenance of their students' identities. By working with their students to understand who they are and the skills they have, and helping to make connections to graduate contexts and goal-setting processes, we can help them develop identities that aid in persistence through difficulties that emerge in their program (Horowitz, Sorensen, Yoder, & Oyserman, 2018).

As a third implication, we posit that our interconnected model for engineering graduate attrition can serve both research advisors and graduate students as guiding language for having conversations about difficulties in graduate school. In particular, we hope that the narratives presented in this work can evoke reflection on the part of advisors and illuminate the invisible thought processes involved in the decision to leave graduate engineering programs such that we as faculty can empathize with graduate students, even ones who choose different paths than ours. Narratives of attrition may serve as excellent starting points to evoke reflection in graduate mentoring workshops for faculty. Although we have not yet tested this model as an intervention or conversational framework in student–advisor relationships, we propose that both graduate students and advisors can leverage the model to have language by which to communicate about potential issues. Further, this framework may provide language to advisors to better elicit students' expectations and help graduate students to articulate their own goals through their graduate degree rather than conforming solely to the goals of others.

Future work in this area includes confirming themes and connections in larger national studies with populations of students who are currently graduate students, who are questioning whether to depart, and who have departed from engineering graduate programs. These qualitative studies can be confirmed quantitatively to understand the generalizability of the framework and diagnose the strengths of the links among themes. Future work should also address the themes that, if damaged, irreversibly result in attrition, in contrast with those that may be remedied with triage through department interventions and student support resources. Critical policy research should also be conducted to develop policy modifications that reduce artificial power dynamics between students and professors (recalling *academic_nut*'s description of grad students as "serfs"). This perhaps includes reducing the priority that research-intensive universities place on graduating PhD students rather than master's students and calls attention to the educational role that a master's degree can play as a learning experience both toward and away from a PhD. The illumination of the Goals theme

highlights tensions related to the fundamental nature of doctoral engineering programs, which have been criticized for continuing to educate future faculty despite the fact that nearly 80% of engineering doctoral graduates go into industry careers (Schillebeeckx, Maricque, & Lewis, 2013). We also propose further exploring the connections in the GrAD model through multiple theoretical lenses and a variety of methods and by conducting longitudinal studies with departers years after their decision to depart to capture potential identity re-formation after the academy and to highlight the role of the master's degree as an off-ramp from the engineering doctorate.

6 | CONCLUSIONS

This study investigated the anonymous narratives of graduate engineering student decisions to depart their graduate programs through collection and analysis of Reddit forum posts. These unique data elicited six primary themes of attrition, but more importantly, the data uncovered important linkages and interconnections between the themes that add a deeper, more nuanced perspective to the process of attrition. An interconnected model allows the combination of both psychological and sociological aspects of a graduate student's decision to depart a graduate program and highlights the ways in which graduate students experiencing turmoil in one aspect may be more vulnerable to attrition if she or he experiences difficulties in other areas as well. Findings indicate that while advisor issues can be a driving source of tension for graduate students, not all graduate students considering leaving have problematic relationships with their research advisors. Further, most of the narratives presented in this study seem to represent high-performing graduate students, with some being winners of nationally competitive research fellowships. These findings dispel some common myths of attrition, but also point to the complicated nature of the process of graduate departure. A graduate student's goals through the PhD and their interpretation of how others will perceive their decisions to depart are novel additions to the graduate attrition literature. Graduate research advisors and administrators should consider using these findings to improve policies or consider using these findings as talking points for mentorship workshops or starting points for student–advisor conversations.

ENDNOTE

[1] The code for the bot is available upon request from the authors.

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