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**CAPTURING NARRATIVES OF GRADUATE ENGINEERING ATTRITION
THROUGH QUALITATIVE ANALYSIS OF SOCIAL MEDIA FORUMS**

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by
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ABSTRACT

The pervasion of graduate student attrition, as Barbara Lovitts (2001) notes, is one of the best kept secrets of higher education. Attrition is “costly” both in monetary and emotional capital to multiple stakeholders, including funding agencies, universities, research advisors, and most importantly, to students themselves. While attrition within Science, Technology, Engineering, and Mathematics (STEM) programs is markedly lower than disciplines in the humanities, most figures still estimate STEM graduate attrition to be above 30% across the United States. Despite the undesirable common occurrence of attrition, it remains fundamentally understudied in STEM, and specifically in engineering disciplines. Literature frequently cites financial burden, among other social factors, as strong motivators for attrition in non-STEM fields; however, these findings cannot be universally applied to STEM students who often are well-funded. Beyond just funding, the structure of graduate programs across disciplines and even among STEM disciplines vary significantly which again suggests caution should be applied when attempting to apply broad generalizations about graduate student attrition across all fields. To fill this gap, and to more clearly understand of the causes of attrition for engineering disciplines, this work uses a multiple methods approach to explore the themes discussed by engineering graduate students considering leaving their programs. Data were collected through the use of an online web-scraping “bot” that searched the online forum of Reddit.com with specified constraints and search terms, collecting forum threads posed by anonymous subscribers to ask the wider community about decisions to stay or leave their graduate programs. The textual forum threads collected were analyzed through open-coding methods and descriptive statistics. Through the sociological theories of socialization theory and identity theory, and the psychological theories of expectancy-value theory and attribution theory, the findings from this research indicate that some themes presented in the general graduate

student attrition literature hold for graduate engineering attrition (such as advisor role, for example), while also illuminating nuanced facets of the psychosocial process of attrition that pertain to an individual's articulation of goals and their worries about how their decisions will be perceived by others. These themes expand upon what has been discussed previously in literature in engineering education specifically or in higher education literature more generally. Further, this literature informs practice, by suggesting topics, such as goal setting, that should be addressed earlier in the graduate student experience—or even earlier, in undergraduate education—to mitigate some of the effects of graduate attrition.

TABLE OF CONTENTS

List of Figures	vii
List of Tables	viii
Acknowledgements.....	ix
Chapter 1 Introduction	1
Background and Motivation for Discussion of Graduate Student Attrition.....	1
Research Purpose and Goals	3
Chapter 2 Literature Review	4
Graduate Student Attrition	4
Attrition from non-STEM Graduate Programs	4
Attrition from STEM Graduate Programs.....	9
Differences in Attrition for Under-Represented Groups	13
Gaps in the Literature.....	16
Theoretical Frameworks for Persistence and Attrition	18
Sociological Frameworks for Attrition.....	18
Psychological Frameworks for Attrition	21
Guiding Theoretical Frameworks and Research Questions	23
Chapter 3 Methods.....	25
Research Design.....	25
Method of Data Collection.....	25
Participants.....	29
Analysis Methods.....	31
Overcoming Limitations	32
Chapter 4 Results	33
Introduction.....	33
Thematic Results.....	35
Advisor Role and Relationship	35
Support Network	37
Perception by Others	38
Cost	39
Quality of Life and Work.....	42
Goals	47
Role of Confidence in Decision-Making Processes.....	50
Confidence in ability to complete degree.....	50
Confidence in ability to find employment.....	52
Connections Between Themes	54

Chapter 5 Discussion and Conclusions	57
Overview of Attrition in Engineering	57
Themes of Attrition in the Context of Sociological and Psychological Theory	59
Sociological Theory and Social Factors of Attrition.....	59
Psychological Theory and Psychological Factors of Attrition	62
Implications for Practice	65
Conclusions	67
Future Work	68
References	69
Appendix Web-Scraping Bot Code.....	80

LIST OF FIGURES

Figure 3-1. A sample Reddit post as viewed from the Reddit webpage27

Figure 3-2. A sample Reddit post as stored by the web-scraper bot.....27

Figure 4-1. Connections between themes54

Figure 4-2. Connections between themes and subthemes.....55

LIST OF TABLES

Table 2-1. Theoretical Frameworks for the Study	23
Table 3-1. Search Criteria.....	26
Table 3-2. Participant Demographic Information	29
Table 4-1. Themes and Sub-themes	33
Table 4-2. Number Students that Discussed Each Theme or Sub-theme.....	34
Table 4-3. Correlation Between Confidence in Ability to Complete Degree and Theme Discussion	50
Table 4-4. Correlation Between Confidence in Ability to Find Employment and Theme	52

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Chapter 1

Introduction

Background and Motivation for Discussion of Graduate Student Attrition

The United States is renowned for its higher education facilities. Recent years have seen an increase in graduate student enrollment across a number of fields likely due to the push for a more educated workforce and the associated benefits, such as higher wages and opportunities for professional mobility (Allum & Okahana, 2014; Altonji, Arcidiacono, & Maurel, 2016; Kang & Foundation, 2012; Litalien & Guay, 2015; Pan & Lee, 2011; Wendler et al., 2010). However, graduate student attrition rates remain unfathomably high across disciplines, nearing 50% in the humanities (Ampaw & Jaeger, 2012; Golde, 2005; Lovitts, 2001), and only slightly lower in Science, Technology, Engineering, and Mathematics (STEM) disciplines. (Lott II, Gardner, & Powers, 2010; Millett & Nettles, 2006). Graduate student attrition is not a new phenomenon, having continuously been a subject of research since the 1960s (Decker, 1973; Golde, 2005; Lott II, Gardner, & Powers, 2010; Lovitts, 1996; Mooney, 1968; Pauley, Cunningham, & Toth, 1999; Terrazas-Carrillo, Hong, Mcwhirter, Robbins, & Pace, 2017). Despite this, it is still considered a taboo subject among academics due to the social stigma of failure associated with attrition, and high graduate student attrition rates remain one of the most “well-known secrets” of higher education.

The majority of graduate attrition research is focused on the liberal arts and humanities, neglecting STEM. Though there may be generalizable causes for attrition across disciplines, such as mentorship issues, most attrition literature is relatively dated and does not explore attrition on specific disciplinary contexts. Non-STEM specific literature on graduate student education is

extensive but non-STEM models of research, funding, and department and professional settings are very different. As will be shown in Chapter 2, from the existing literature the motivations for graduate students leaving these programs differ. Furthermore, while STEM has become a popular catch-all for anything vaguely related to science or math, there are noticeable distinctions between graduate programs within the four separate broad fields (science vs. engineering, for example.) Attrition literature is also dated, with much of it conducted through the 1990s. Therefore, caution should be taken not to delve too deeply into dated literature, especially in regards to STEM, where scientific and technological advancements in the past several decades coupled with socio-economic changes has resulted in a shift of research foci, and a shift in methods of education (Allum & Okahana, 2014; Gardner, 2010).

Within engineering, there has been a significant shift to fast-paced research focused on energy efficiency and automation due to the concerns of global warming and the growing automation of industry. These factors, coupled with rapid advancements in artificial intelligence have encouraged many researchers to push technologies to their limits and apply them in as many fields as possible from advancing military capabilities to fighting cancer. In addition, technological advancements have resulted in a generation familiar with a vastly different understand and integration of technology into their lives. This includes their academic lives. Programs and languages such as Solidworks, MATLAB & Simulink, R, have change somewhat but more importantly better computing power has allowed these programs to be used more readily for a wider range of applications. This means that these are common tools used by both graduate and undergraduate students; skills which may not have been essential 10 years ago are now common knowledge and aspects of student curriculums. Applying outdated attrition studies from several decades ago may very well be outdated in terms of which concepts and causes are affecting graduate students' decisions to leave or persist in graduate school. Furthermore, the burgeoning costs of education in recent years have drastically impacted the landscape of higher

education and research in general. Therefore, though past attrition literature was valuable, the attrition numbers have not been reduced indicating that past studies must be validated in disciplinary contexts and updated as necessary for this rapidly changing and different education system.

Research Purpose and Goals

The goal of this study is to explicitly look at the reasons that engineering graduate students provide for leaving their graduate (Master's or PhD) programs. Sampling non-completers is difficult, and researchers generally find it difficult to collect nationwide narratives of attrition. This paper presents a novel method for studying attrition using publicly-available online forums, in this case, the platform Reddit.com, to collect first-hand accounts and uncensored, authentic narratives of attrition. These often- anonymous online discussions offer a unique view into the decision-making processes of engineering graduate students considering leaving their engineering program throughout the decision-making process. The objective of this study is to obtain a holistic view of the narratives surrounding attrition, which in turn allows researchers to capture meaningful, authentic, and credible emergent themes unbiased by social response bias.

Chapter 2

Literature Review

This literature review will closely examine all aspects of graduate student attrition. This literature review will first begin with a review of the existing sociological and psychological theories related to attrition and persistence. This will provide context for the existing literature and allow for discussion of the application of these theories specifically in graduate student attrition. Graduate student attrition will be further explored by examining the differences in attrition among different groups, namely STEM and non-STEM graduate programs. By understanding the existing state of theory and study of graduate student attrition, we then have the tools to identify areas where further study is needed, as well as the appropriate lens through which to study these underexplored areas.

Graduate Student Attrition

Attrition from non-STEM Graduate Programs

Attrition in non-STEM programs has been well-studied, in part due to the worryingly high attrition rate from these programs (topping 60% in some disciplines, according to the Council of Graduate Schools). Across non-STEM programs, there are a few key factors influencing graduate student attrition. However, it is important to note that in the literature many of these factors are inter-related, and that there usually isn't a single factor that determines a student's decision to leave their graduate program. Instead, it is often a culmination of several factors that ultimately lead to a student leaving their graduate program.

Of non-STEM students one of the most often cited reasons for students leaving their graduate programs is related to finances (Ampaw & Jaeger, 2012; Ehrenberg et al., 2016; Lovitts, 1996; Pauley et al., 1999; Xu, 2015). Many programs in the arts and humanities do not offer tuition waivers nor scholarships in great abundance, which has been shown to be negatively associated with persistence (Ampaw & Jaeger, 2012; Pauley et al., 1999; Zhou & Okahana, 2016). A solution sought by some students has been outside employment. Unfortunately, the literature suggests that students employed outside of the university have a greater likelihood of attrition (Ehrenberg et al., 2016) which is likely linked to a students' lack of social integration into a scholarly discipline.

Of those receiving financial aid, the majority of non-STEM students rely on teaching assistantships, adding to the number of commitments and roles that these students must fulfill. There is no consensus as to the benefit or detriment of teaching assistantships over other forms of university aid (Ampaw & Jaeger, 2012; Ehrenberg et al., 2016; Lovitts, 1996; Zhou & Okahana, 2016). However, there is general consensus that some form of financial aid from the institution is associated with a higher likelihood of persistence than external fellowships or aid (Ampaw & Jaeger, 2012; Lovitts, 1996; Zhou & Okahana, 2016). For others, there is the added financial stress of family financial obligations (Breckner, 2012; Pauley et al., 1999; Springer, Parker, & Leviten-Reid, 2009; Sweitzer, 2009; Xu, 2015). The literature notes beyond just the cost of tuition there are other associated costs with pursuing graduate school that affect a student's decision to persist or not. Several studies have cited the opportunity cost and consideration of future job prospects as motivating factors for leaving their graduate programs (Ampaw & Jaeger, 2012; Perna, 2004).

The detriment of these other "costs" can be linked to the support network a student has, which incidentally is another frequently cited factor affecting persistence (Barnes, 2010; Breckner, 2012; Curtin, Stewart, & Ostrove, 2013; Pauley et al., 1999; Ruud, Saclarides, George-

Jackson, & Lubienski, 2016; Sweitzer, 2009). Included in this is support from family members and spouses, and support here can extend from purely financial support into emotional support (Breckner, 2012; Gardner, 2010; Pauley et al., 1999). Emotional support has been documented in the literature, referring to spheres of both peers and advisors (Barnes, 2010; Ruud et al., 2016; Sweitzer, 2009), though the support role that advisors play is vastly different from that of the family or close friends (Gardner, 2010; Pauley et al., 1999; Weidman & Stein, 2003; Zhou & Okahana, 2016).

In general, the relationship between advisor and student is critical to persistence, however much of this falls within the realm of mismatch of expectations as will be discussed shortly. That is not to say that lack of support from advisors is not a factor in attrition. Zhou found that non-STEM departments were lacking in academic support for students in terms of providing them offices and work spaces, and this was tied to lower completion rates (Zhou & Okahana, 2016). In addition, Weidman found that without advisor support, students were less inclined to engage in integration activities (Sweitzer, 2009; Weidman & Stein, 2003). This was supported by Curtin and Ruud findings that general academic support from advisors was important to both domestic and international students, and related to their perception of integration into their departments (Barnes, 2010; Breckner, 2012; Curtin et al., 2013; Ruud et al., 2016; Terrazas-Carrillo, Hong, McWhirter, Robbins, & Pace, 2015; Weidman & Stein, 2003). Ruud (2016) in particular encapsulates the frustration faced by students with advisors, where students were able to express their frustrations with treatment from their advisors:

...described their advisors or faculty in the following ways: ‘unethical and abusive,’ ‘absolute lack of professionalism,’ ‘extremely controlling and not easy to work with,’ ‘overbearing,’ ‘harsh treatment from my adviser in the form of discouraging or inappropriate language,’ ‘demeaning comments by advisor and unwillingness of other faculty to improve the situation,’ and ‘I was made to feel like a bonded labor (sic).’ (p. 13)

Peer mentorship and peer support is also an important factor to success in the graduate attrition literature. Having a cohort of those with shared experience and similar trials and

tribulations can benefit those who are struggling at any given point in their program (Gardner, 2010; Pauley et al., 1999; Weidman, Twale, & Stein, 2001). In her groundbreaking studies, Barbara Lovitts notably explored peer relationships in-depth (Lovitts, 1996). An important finding from Lovitts was that, in order for students to build peer relationships, they have to overcome fears of being revealed as an imposter or being seen as inadequate (Lovitts, 1996). As she notes, ironically, this is difficult to do because of the competitive nature of the system effectively pitting the students against each other for scholarships, fellowships, and positions, thus forcing the students to always put on an appearance of the ideal student. It should be noted that in most literature, the type and quality of support received by students varies by department (Curtin et al., 2013; Gardner, 2010). Both Curtin and Gardner found that international students' expectations and experiences with faculty support differed from that of domestic students.

The support networks discussed above, especially related to those within the institution, are inextricably linked to a sense of integration. Integration into a graduate program has been broken down into several types throughout the literature though usually some variation of social integration and academic integration (Gardner, 2010; Lovitts & Nelson, 2000; Weidman et al., 2001). It is important to note that in the literature that the breadth of "social" and "academic" integration vary, and that often they may act as two sides of the same coin. Tinto was one of the first to explicitly distinguish between academic and social integration (Tinto, 1975). While Tinto's work mainly applies to attrition at the undergraduate level, his theories of belonging can be extended to include graduate students and their relationships with peers as well as the faculty and advisors under whom they study (Barnes, 2010; Gardner, 2010; Lovitts, 1996; Lovitts & Nelson, 2000; Ruud et al., 2016). Many studies show that both social and academic integration is critical for students to remain in their programs (Gardner, 2010; Lovitts, 1996; Ruud et al., 2016) and this is supported by identity theory (Stets & Burke, 2000; Sweitzer, 2009); if students are not able to become integrated and identify themselves as a researcher, then it becomes difficult for

them to persist in difficult graduate programs. Lovitts noted that in her large qualitative study of doctoral non-completers, her participants reported being well-integrated both socially and academically in their undergraduate programs, therefore positing that it is not lack of academic ability that causes attrition but rather disillusionment and lack of social integration (Lovitts, 1996). This lack of social integration directly relates to the idea of having a peer support network (Curtin et al., 2013; Gardner, 2010; Lovitts, 1996; Pauley et al., 1999; Xu, 2015).

However, it is not just a peer network which acts in the role of social integration but also advisors. Ruud importantly notes that students seek out a relationship with advisors beyond simple academic advising (Ruud et al., 2016). This is supported by the findings of a number of researchers (Barnes, 2010; Bieber & Worley, 2006; Gardner, 2010; Lovitts & Nelson, 2000; O'Meara, Knudsen, & Jones, 2013; Pauley et al., 1999; Tinto, 1975; Weidman & Stein, 2003). Bieber finds that across disciplines, students seek an advisor who fills an emotional role as well as academic, which he labels the "ideal advisor." Students effectively look to these faculty as mentors and role models, which becomes critical for under-represented groups as will be discussed later. Beyond this, it should be noted that academic and social integration does not guarantee persistence (Breckner, 2012). Breckner warns that other factors may out-weigh integration. This is supported by the previously mentioned works that discuss financial concerns and general cost-benefit analysis as discussed by Perna (Breckner, 2012; Perna, 2004; Springer et al., 2009; Xu, 2015).

Another factor which in some instances may be directly tied to lack of integration, is mismatch between expectations, usually student-advisor expectations. Poor advisor relationship is cited as one of the most common causes for attrition (Curtin et al., 2013; Gardner, 2010; Lovitts, 1996; Ruud et al., 2016). Even in works which explicitly explore the expectations of advisors and their perceptions of attrition, find that there is often a mismatch of expectations between advisor and student in addition to a mismatch of perceived most-important expectations (Barnes, 2010;

Curtin et al., 2013; Gardner, 2010; Pauley et al., 1999). Lovitts found that students who come from a well-integrated undergraduate setting with the expectation of a collegial and intimate relationship with their advisor, are often surprised by the competitive, hierarchical and all-consuming nature of graduate school and research, often lacking emotional connections between advisor and student (Lovitts & Nelson, 2000). This is associated with a lack of integration and ultimately attrition (Breckner, 2012; Gardner, 2010; Lovitts, 1996; Lovitts & Nelson, 2000; Pauley et al., 1999). Breckner (2012) corroborated the findings of Lovitts, confirming that politics and competitiveness caused students to lose interest in their program or graduate school entirely.

Beyond just advisor-student mismatch, the literature suggests that there is often a mismatch between program and student (Pauley et al., 1999; Ruud et al., 2016; Sweitzer, 2009), in some cases this stemming from a change in goals for students (Breckner, 2012). In some instances, this is also due to unclear presentation of information by the institutions in regards to research activities, course-work expectations, graduation timelines, or funding (Breckner, 2012; Gardner, 2010; Pauley et al., 1999; Ruud et al., 2016). Interestingly, Breckner found that a change in self-identity to fit a program and academic integration may counteract a general program-student mismatch. This is supported by Gardner (2008,2010), Sweitzer (2009) and Bieber & Worley (2006).

Attrition from STEM Graduate Programs

Attrition from STEM graduate programs shares some factors with non-STEM programs, however there are fewer studies focused explicitly on STEM graduate students. This is likely in part due to the “low” rate of attrition from these programs. Nonetheless attrition from these programs is still above 30% by most accounts (Lott II, Gardner, & Powers, 2010; Lovitts & Nelson, 2000; Millett & Nettles, 2006; Zhou & Okahana, 2016). As with non-STEM programs

the factors can very broadly be broken down into integration, support network, finances, and expectation mismatch.

In these programs tuition is far less of a concern for many of these students as STEM programs, with the exception of mathematics programs, often give tuition waivers and small stipends for their graduate students, usually in the form of research assistantships (Barnes & Randall, 2012; Maher, Wofford, Roksa, & Feldon, 2017; Zhou & Okahana, 2016). With respect to finances, more students cite the opportunity cost and job prospects as a motivation for leaving their programs rather than financial hardships due to tuition (Cintron & McGrath Cohoon, 2015; Maher et al., 2017). These fields often offer considerable pay for a bachelor's degree while the pay increase from obtaining a doctoral degree can be offset by work experience gained in that time (Maher et al., 2017). In addition, students cited that there were desirable jobs that did not require a doctorate (Golde, 1998; Maher et al., 2017). However, it should be acknowledged that many STEM students the perception that a graduate degree will advance their career or provide opportunities to which they otherwise may not have access (Cintron & McGrath Cohoon, 2015; Golde, 1998, 2005; Maher et al., 2017; Ruud et al., 2016; Spaulding & Rockinson-Szapkiw, 2012).

From the literature, it can be gathered that STEM students place greater importance on integration and matching of expectations than financial factors (Ruud et al., 2016; Zhou & Okahana, 2016). It is well cited in the literature that a substantial portion of STEM non-completers leave their institutions within the first two years (Gardner, 2010; Golde, 1998; Lott II, Gardner, & Powers, 2010; Lovitts, 2001). One potential argument for students following this attrition pathway is a lack of immediate academic and social integration if students are not participating in a research group immediately. The greater pressure for integration may occur due to the collaborative nature of research in these fields (Ampaw & Jaeger, 2012; Spaulding & Rockinson-Szapkiw, 2012). Often, STEM students work in groups and many work with other lab

groups and professors on more than one project at a time, which inherently results in more frequent contact with others in their fields and the impetus for students to be well integrated into these groups (Johnson, DeStefano, & Mustari, 2010; Kniola, Chang, & Olsen, 2012; Maher et al., 2017). However, as Spaulding notes, if these students do become well integrated they are more likely to succeed due to the added support network that this provides (Spaulding & Rockinson-Szapkiw, 2012). Both Zhou and Lott note that providing opportunities for social integration early on, improves persistence (Lott II, Gardner, & Powers, 2010; Zhou & Okahana, 2016). Just as important is improving early academic integration assisting students in transitioning from the role of undergraduate students to graduate researcher (Golde, 1998, 2005; Lott II, Gardner, & Powers, 2010; Ruud et al., 2016; Zhou & Okahana, 2016).

The literature suggests that in STEM fields in particular the department culture revolves heavily around long work hours and the “ideal researcher” (Bieber & Worley, 2006) whose sole commitment is their research (Barnes, 2010; Kniola et al., 2012; Spaulding & Rockinson-Szapkiw, 2012). Often this results in both a program-student and advisor-student mismatch of expectations (Golde, 2005; Kniola et al., 2012; Lott II, Gardner, & Powers, 2010). Interestingly, Golde and Bieber found that program-student mismatch in STEM was revealed when students had an idealized expectation of the research process: the expectation was for research to occur quickly with few failures, and to answer large, important application-based questions (Bieber & Worley, 2006; Golde, 2005; Herzig, 2004). It should be noted that Golde did not find this to be a common occurrence, as STEM students are often encouraged to pursue research in their undergraduate programs, allowing them to develop more realistic expectations of research (Golde, 2005).

Golde’s findings are tangentially related to Ruud’s and Maher’s findings of STEM students frequently citing concerns that they were not being adequately prepared for careers through their programs (Maher et al., 2017; Ruud et al., 2016). This is repeated in other studies

and refers to both academic and non-academic career preparation (Ampaw & Jaeger, 2012; Barnes & Randall, 2012; Golde, 2005; Johnson et al., 2010; Kniola et al., 2012). Golde also found that students tended to perceive that faculty were not supportive of non-academic careers (Golde, 2005). As Lovitts notes in her seminal book, *Leaving the Ivory Tower*, there appears to be a fundamental disconnect between institutions and advisors acknowledging their role in a student's departure. We can see there are fundamental differences between the key concerns and expectations of faculty (e.g., integrity, commitment to the degree and discipline, hard-working, clear degree progression, and productivity) (Barnes, 2010; Lovitts, 2001; Maher et al., 2017) and the concerns and expectations of students, such as guidance, integration, career preparation, and collegiality (Lovitts, 1996; Lovitts & Nelson, 2000; Maher et al., 2017; Ruud et al., 2016).

Several studies have also noted that STEM graduate students rely on a strong support network of not only family and peers, but also from their advisors. These relationships of both academic and emotional guidance can help integrate these students to their program, encouraging them to persist through their program (Ampaw & Jaeger, 2012; Golde, 2005; Kniola et al., 2012; Spaulding & Rockinson-Szapkiw, 2012). Conversely, a student's poor relationship with her or his advisor(s), as with non-STEM students, is a strong motivating factor for students to leave their programs (Ampaw & Jaeger, 2012; Barnes & Randall, 2012; Golde, 2005; Kniola et al., 2012; Lovitts, 1996, 2001; Lovitts & Nelson, 2000; Maher et al., 2017; Ruud et al., 2016). The literature suggests a concerning frequency with which students felt that their advisors were not only unsupportive but demeaning and disrespectful (Golde, 2005; Lovitts, 1996; Maher et al., 2017; Ruud et al., 2016). Beyond this, Golde and Maher note that students struggled to find support from their departments and advisors in respect to academic integration and specifically filling in gaps in their undergraduate education (Golde, 1998, 2005; Maher et al., 2017).

Differences in Attrition for Under-Represented Groups

Within both STEM and non-STEM graduate programs, the literature has found there to be significant differences in the likelihood and causes of attrition for under-represented groups including women (Carter, Blumenstein, & Cook, 2013; Crede & Borrego, 2014; Dabney, Chakraverty, Hutton, Warner, & Tai, 2016; Herzig, 2004; Lott II, Gardner, & Powers, 2010; Most, 2009; Springer et al., 2009; Vaquera, 2008).

The literature suggests that women tend to be more concerned with family and other obligations outside of academia than their male counter-parts in both STEM and non-STEM programs (Herzig, 2004; Lott II, Gardner, & Powers, 2010; Moyer, Salovey, & Casey-Cannon, 1999; Ruud et al., 2016; Xu, 2015). As Herzig and others note, family obligations is often tied to the traditional role of primary care-taker that mothers fulfill (Carter et al., 2013; Herzig, 2004; Ruud et al., 2016; Spaulding & Rockinson-Szapkiw, 2012; Xu, 2015). This results in individuals trying to balance the role of being the “ideal” academic as well as the “ideal” parent (Barnes, 2010; Carter et al., 2013; Moyer et al., 1999; Springer et al., 2009). These ideas are fundamentally incompatible, each requiring the individual to commit wholly and completely to that one role, as motherhood is not an interest or hobby that can simply be set aside while pursuing graduate school. Unfortunately, Herzig and others find inadequate support for graduate student parents, and this is a motivating factor for graduate student parents to leave their program (Herzig, 2004; Moyer et al., 1999; Springer et al., 2009; Xu, 2015). The literature also suggests that advisors are not understanding and unwilling to compromise for graduate student parents, as illustrated by Moyer et al. (1999):

‘My most pressing personal concern was always my relationship with my advisor... Our personality differences and professional differences led to several clashes over my personal life. These clashes were centered around my decision to have a child in the last year of my graduate career. That decision was questioned by my advisor as was my desire not to work with radioactivity during my pregnancy.’

Not only does parenthood require a more flexible schedule, especially for young children, but parenthood or having any form of dependent introduces additional financial burdens (Herzig, 2004; Moyer et al., 1999; Springer et al., 2009; Xu, 2015). Furthermore, motherhood and the need for flexibility reduces the likelihood and ability for these students to become well integrated to their programs both socially and academically (Herzig, 2004; Springer et al., 2009).

The literature cites a lack of integration as a strong motivator for these individuals to leave their programs (Crede & Borrego, 2014; Dabney et al., 2016; Lovitts, 2001; Lovitts & Nelson, 2000; Springer et al., 2009; Terrazas-Carrillo et al., 2015). Herzig argues that both women and other-under-represented groups are more likely to persist if they are well integrated (Ampaw & Jaeger, 2012; Herzig, 2004; Lovitts, 2001; Springer et al., 2009). Unfortunately, these groups are often faced with issues of identity due to differences in ethnicity, culture, or gender; these individuals do not fit the narrow idea of what others think a graduate student in a given field should be (Ampaw & Jaeger, 2012; Carter et al., 2013; Crede & Borrego, 2014; Dabney et al., 2016; Herzig, 2004; Lott II, Gardner, & Powers, 2010). This extends beyond academic circles and into social and family circles where the literature finds that cultural and family pressure of traditional roles can feed into attrition (Carter et al., 2013; Crede & Borrego, 2014; Moyer et al., 1999). However, Lott and Lovitts both acknowledge that when spouses and family are supportive of these individuals, they have an increased likelihood of persistence (Lott II, Gardner, & Powers, 2010; Lovitts, 1996, 2001; Lovitts & Nelson, 2000).

The perceptions of how a graduate student in a given field “should be,” can also lead to perceptions by others of inadequacy in terms of skills, abilities, or disposition due to misconceptions or preconceived notions and stereotypes about individuals belonging to these different groups (Carter et al., 2013; Litalien & Guay, 2015; Moyer et al., 1999; Vaquera, 2008). In some instances, the “ideal worker” conception breaches into the realm of discrimination (Carter et al., 2013; Johnson et al., 2010; Moyer et al., 1999; Vaquera, 2008). The literature finds

that under-represented groups experience tokenism and perceptions of incompetence from peers and faculty (Carter et al., 2013; Herzig, 2004; Moyer et al., 1999), which in turn may result in a mismatch of expectations and lack of support for these under-represented groups (Carter et al., 2013; Herzig, 2004; Moyer et al., 1999; Ruud et al., 2016; Vaquera, 2008).

As expected, individuals who fall into more than one category of under-represented group, face even greater challenges (Herzig, 2004). Both women and ethnic minorities cited a lack of role models and a lack of peers with similar backgrounds as a factor affecting persistence (Johnson et al., 2010; Moyer et al., 1999; Perna, 2004; Terrazas-Carrillo et al., 2015; Vaquera, 2008). Role models can provide motivation and demonstration that success is possible, as well as act as part of the support network for these under-represented groups, that understands the unique challenges the under-represented student group faces (Moyer et al., 1999; Prime, Bernstein, Wilkins, & Bekki, 2015; Vaquera, 2008). Specifically, these role models can reduce the social isolation faced by these individuals (Prime et al., 2015) and help reduce discrimination and projection of stereotypes by peers and faculty (Vaquera, 2008). As both Vaquera and Lott note for under-represented groups there is a “critical mass” of representation in faculty and peers that if met, increases persistence (Lott II, Gardner, & Powers, 2010; Vaquera, 2008).

None of this is to say that under-represented groups don't also experience similar concerns or factors that lead to attrition as their well-represented counterparts. In addition to factors and concerns explicit to under-represented groups the literature cites common concerns about opportunity cost and future employment opportunities (Moyer et al., 1999; Perna, 2004; Prime et al., 2015); finances and academic funding (Lott II, Gardner, & Powers, 2010; Moyer et al., 1999; Perna, 2004; Springer et al., 2009); career preparation (Golde, 2005; Moyer et al., 1999); work-life balance (Moyer et al., 1999; Perna, 2004; Ruud et al., 2016; Springer et al., 2009); advisor-student mismatch and lack of guidance (Moyer et al., 1999; Prime et al., 2015; Springer et al., 2009; Vaquera, 2008).

Gaps in the Literature

There are several gaps in the graduate engineering attrition literature pertaining to the foundational knowledge that is typically employed to study graduate attrition, and in terms of specific topic areas. Firstly, the majority of the work pertaining to persistence and attrition has been focused in developing and validating sociological theory. Unfortunately, this misses the opportunity to explore the decision-making process of individuals. Often attrition is conceptualized as a sudden singular event that occurs instantaneously, but in reality, the decision to abandon an academic identity is a decision-making process that occurs over time, as is evident by the reasons many students give for leaving their programs. Very few students cite a singular event which resulted in an immediate decision to leave their programs (Breckner, 2012; Lovitts, 1996, 2001; Lovitts & Nelson, 2000). As a result, there is a lack of mitigation methods that explicitly address student concerns and perceptions that lead to attrition from graduate programs.

Topically, there are two main areas that will be important in more thoroughly understanding the phenomenon of graduate engineering attrition. First, it is important to study attrition in a disciplinary context. Despite the popularity of the label of “STEM,” it is an ill-designed grouping for graduate programs. Graduate programs in the physical and biological sciences, engineering, and mathematics vary significantly from each other (Crede & Borrego, 2014; Dabney et al., 2016; Herzig, 2004). As a result, the challenges faced by students in these programs are vary significantly. Engineering students do not face the same funding challenges as mathematics students (Barnes & Randall, 2012; Herzig, 2004) nor do they usually face the rotational nature of biological science graduate students (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). These fundamental differences mean that graduate students in engineering are in fact an understudied group. And while undergraduate engineering

attrition is comparatively well-studied, there is again a fundamental difference between the challenges faced and priority of these students (Barnes & Randall, 2012; Crede & Borrego, 2013; Gardner, 2010). That is not to say that some of the causes of attrition in other fields or undergraduate programs do not translate to engineering graduate programs at all, but rather to say that engineering graduate programs are simply not studied well-enough to draw significant conclusions. For example, while paying tuition is a leading concern for undergraduate students and graduate mathematics students, these are not as common of a concern for engineering graduate students as doctoral programs in engineering usually are funded (Barnes & Randall, 2012; DesJardins, Kim, & Rzonca, 2003; Herzig, 2004; King, 2016).

Second, the phenomenon of “mastering out” is hardly discussed in the graduate education literature, even in engineering, where leaving with a master’s degree—for whatever reason—is a perfectly legitimate career path. It might be considered a form of “invisible attrition,” since students who change their degree objective and leave academia with a master’s degree are technically counted as “successes” in degree completion according to university statistics. While the concept of mastering out is discussed in some attrition literature (Golde, 1998; Maher et al., 2017), rarely is it explicitly studied. Often students who master out are instead grouped in with those who leave their doctoral programs without a degree (Golde, 1998, 2005; Lovitts, 2001; Xu, 2015) or it is not made clear whether a master’s was the initial goal of a student (Breckner, 2012; Golde, 2005; Herzig, 2004; Maher et al., 2017). Separating those who master out and those who leave their doctoral programs without a degree may provide unique insights and differences in motivation for leaving their programs. Of the limited studies that have observed the concept of “mastering out”, there has been an indication that there is a difference from those who leave without a degree (Golde, 1998, 2005). While Golde and Maher notes that a master’s can be seen as at least having something to show for time in graduate school, Lovitts notes that in some instances master’s programs are used as weed-out programs (Golde, 2005; Lovitts, 1996; Lovitts

& Nelson, 2000; Maher et al., 2017). This lack of clarity on mastering out from doctoral programs, whether voluntary or involuntary should be explored.

Theoretical Frameworks for Persistence and Attrition

Several sociological and psychological theories support and inform persistence and attrition of students at both the undergraduate and graduate level. In addition, there are several theories of study related to persistence and attrition outside of academia which have been applied in the context of student attrition. However, it is important to note that much of the literature on this subject does not rely on one particular unifying theory and in fact there is no unify theory for graduate student attrition. As a result, a wide variety of partial and incomplete theories have been used to study attrition and in some cases no specific theory is identified as a guiding principle for study(Crede & Borrego, 2013; Flake, 2012; Sweitzer, 2009; Tinto, 2017; Voigt & Hundreiser, 2008).

The majority of the literature studies attrition through a sociological lens, seeking to understand the external factors and social contexts that lead to a student choosing to persist or leave their program. However, there have also been attrition studies that apply psychological theories. This work relies on socialization and identity theories, as well as expectancy-value theory and attribution theory.

Sociological Frameworks for Attrition

With respect to student attrition a significant amount of work has gone into developing several sociological theories to explain, understand, and mitigate attrition. While the foremost theories are socialization and identity theory, several other theories have been used to study

attrition including Tinto's interactionist model (Tinto, 1975), communities of practice (Bunker et al., 2013; Herzig, 2004; Weidman & Stein, 2003), and academic literacy theory (Berdanier, 2016). All of these theories look and how students interact and become a part of their department and discipline in different ways.

Socialization is a broad theory that encompasses all or part of many other theories discussed in the literature. Socialization theory is concerned with the ways in which individuals learn to become a part of a particular group through language, skill-sets, and values (Haydarov, Moxley, & Anderson, 2013; Sweitzer, 2009; Weidman et al., 2001). As noted by Maher (2017), within STEM fields, the disciplinary "group" that an individual is joining often extends across multiple disciplines and communities. The exploration of these different groups is more readily addressed by the narrower theory of competing communities of practice (Berdanier, 2016; Herzig, 2004; Maher et al., 2017). However, this theory will not be covered here due to its narrow focus and the findings in the literature that particular groups and types of socialization are more critical to persistence than the broader set of groups (Devos et al., 2017; Golde, 1998; Weidman et al., 2001). Furthermore, this concept of multiple influencing groups is can be addressed in identity theory.

The primary groups of importance in the socialization literature are faculty and peers within an individual's discipline (Weidman & Stein, 2003; Weidman et al., 2001). Socialization within these groups predominantly occurs within the first few years of graduate programs as graduate students are still transitioning into disciplines and new roles as researchers (Ampaw & Jaeger, 2012; Gardner & Barnes, 2007; Maher et al., 2017; Weidman & Stein, 2003). This is strongly supported by Tinto's model for doctoral attrition (Breckner, 2012). This also falls in-line with Gardner's similar stages of integration (Gardner, 2008). It should be noted that Gardner's more recent stages of integration is a better reflection of current graduate programs as opposed to Tinto's older graduate attrition model assumes little to no research being performed by early

graduate students which is no longer the case (Gardner, 2008; Lott II, Gardner, & Powers, 2010). Nonetheless, from the literature it is clear that socialization theory is well-validated for studies of early graduate persistence and attrition (Gardner, 2008; Gardner & Barnes, 2007; Lott II, Gardner, & Powers, 2010; Maher et al., 2017; Sweitzer, 2009; Terrazas-Carrillo et al., 2015; Vaquera, 2008; Weidman & Stein, 2003).

Overlapping with socialization theory is identity theory. In referring to identity theory, this work is referring to the theory “whose goal is to understand and explain how social structures affect self” as defined by (Stryker & Burke, 2000, p. 4). Through this definition identity theory is more of a sociological theory than psychological, though it should be noted that other definitions of identity theory can be applied through a psychological theory lens (Berdanier, 2016; Stryker & Burke, 2000).

Unlike socialization theory, identity theory acknowledges that because there are multiple, competing external factors that an individual may have layered identities (for example, student, researcher, mother, spouse, and teaching assistant). In the identity literature this is addressed as identity salience (Stets & Burke, 2000; Stryker & Burke, 2000). When students are first entering their graduate programs, they are effectively being introduced to a new identity of researcher and knowledge develop which they must learn to fulfill (Berdanier, 2016; Moyer et al., 1999). This falls in line with Gardner’s stages of graduate socialization. Through several studies, Gardner repeatedly finds that transitions to new identities as one of the greatest hurdles faced by graduate students at multiple stages (Gardner, 2008, 2010; Gardner & Barnes, 2007). This is especially true of STEM graduate students who often have a greater number of identities to be filled due to the collaborative and often-cross-discipline research they pursue (Lott II, Gardner, & Powers, 2010; Maher et al., 2017). This concept of multiple, competing identities is also common among non-traditional (Maher et al., 2017; Pauley et al., 1999; Xu, 2015), under-represented groups (Good, Halpin, & Halpin, 2001; Herzig, 2004; Moyer et al., 1999), and international students (Gardner,

2010; Lott II, Gardner, & Powers, 2010; Terrazas-Carrillo et al., 2017). This conflict where the self differs from the role and identity to be-filled can affect the thought process and behaviors of an individual (Cech, Rubineau, Silbey, & Seron, 2011; Hall, Schmader, & Croft, 2015; Herzig, 2004; Stryker & Burke, 2000; Sweitzer, 2009). While this concept cannot be adequately covered by the sociological definition of identity theory, it can be covered if approached through a psychological framework in conjunction with role identity theory.

Psychological Frameworks for Attrition

Compared to the sociological literature on attrition, there is a relatively limited body of work that explores attrition through a psychological lens. Of the work that uses a psychological framework the prevailing theories are expectancy-value theory and attribution theory. It should be noted that just as significant is self-efficacy theory, however as will be discussed, certain aspects of this theory can be housed within expectancy-value theory and attribution theory without losing the insights provided by self-efficacy theory.

Expectancy-value theory (EVT) and attribution theory are highly complementary. The modern incarnate of expectancy-value theory as outlined by Eccles (Wigfield & Eccles, 2000) proposes that student decisions are made based on likelihood of success at a task, the perceived value added of succeeding at that task, and the cost of pursuing that task as opposed to another task (Flake, 2012; Weiner, 1985; Wigfield & Eccles, 2000). Importantly, student perceptions within expectancy-value are influenced by their sense of self. In this way, EVT houses theories such as self-efficacy, self-determination theory, and some aspects of Perna's modified econometric framework (Cross & Vick, 2001; Litalien & Guay, 2015; Maher et al., 2017; O'Meara et al., 2013; Perna, 2004; Xu, 2015). While Perna's modified econometric framework focuses more on sociological factors that affect attrition, it does apply the concept of weighted

cost benefit analysis from EVT (Perna, 2004). This aspect of EVT has been critical in identifying the motivations of individuals across a variety of socio-economic and cultural backgrounds (Perna, 2004; Xu, 2015, 2016).

Originally differing from EVT, attribution theory focused more heavily on the student perceptions of tasks and of their own abilities (Weiner, 1985; Wigfield & Eccles, 2000). With Eccles' updated version of EVT which includes these perceptions to some degree, there is great similarity between the two theories. While several works acknowledge attribution theory as a valid theory that can be applied to attrition research, very few works actually apply this theory directly. However, a number of works incidentally apply concepts from attribution theory due to its close link to self-efficacy theory and EVT (Breckner, 2012; Hunter & Devine, 2016; O'Meara et al., 2013). Lovitts explicitly applied attribution theory in the context of students' decisions to leave or remain in their programs (Lovitts, 1996; Lovitts & Nelson, 2000). Lovitts noted that attribution theory alone, is not substantial enough to understand attrition, because of its lack of consideration of external, social factors in addition to student perceptions. Nonetheless, she and others have validated the general principles of attribution theory, finding that there is a fundamental difference in perception of events and task between completers and non-completers (Curtin et al., 2013; Litalien & Guay, 2015; Lovitts, 1996; Lovitts & Nelson, 2000; O'Meara et al., 2013; Suresh, 2007). It should be noted that social cognitive career theory more effectively explores changes in perceptions of tasks, namely focused on changes in goals and interests (Dabney et al., 2016; Maher et al., 2017; Ruud et al., 2016). However, the important aspects of this theory, for the purpose of this work, is already housed within EVT and attribution theory.

Guiding Theoretical Frameworks and Research Questions

The theoretical frameworks that will guide this study are socialization theory and identity theory from a sociological perspective, and expectancy-value theory and attribution theory from a psychological perspective. The advantage of using both sociological and psychological theories is to allow a more wholistic understanding of engineering graduate student attrition from the perspective of the student accounting both for external factors in the development of identity in the academic setting and for internal perceptions of these external factors and how this affects identity development. Table 2.1 demonstrates the usefulness of each of these theories with respect to this study:

Table 2-1. Theoretical Frameworks for the Study

Framework	Relevance to Research Questions
Socialization Theory	Identifies the ways in which engineering graduate students learn to become a part of their academic community, including faculty and peer groups.
Identity Theory	Addresses the fluctuating and evolving roles students learn to fill as they become a part of the academic community and the social and external factors that affect how a student fills these roles
Expectancy-Value Theory	Posits that students use a form of cost-benefit analysis while consider things like self-efficacy when deciding whether or not to persist.
Attribution Theory	Focuses on student perceptions of own capabilities and how these correspond to perception of goal related tasks.

Based on the afore mentioned gaps in the literature for engineering graduate student attrition this work is guided by the following research questions:

1. What internal and external factors do students identify when considering attrition in graduate engineering programs, and how do students experience these factors?

2. What, if any, mitigating factors (both internal and external) do graduate engineering students identify that have or would have encouraged them to persist?
3. How does the phenomena of mastering out differ from other forms of engineering graduate student attrition?

Chapter 3

Methods

Research Design

This research is designed to study the disciplinary and psycho-social aspects of engineering graduate student attrition using a mixed methods approach of quantifying qualitative data. Data were collected from the online, public forums Reddit.com, where individuals publicly post questions and discussions about graduate school. This data set was selected to lend insight into the considerations that students make as they go through the decision process of attrition or persistence. The data were collected and analyzed through the constant comparative methods of open and axial coding through a constructivist framework. While this work could have been explored strictly through a sociological or psychological lens, combination of the two allows for a more wholistic understand of how internal and external factors as well as student perceptions of these factors affect their decision processes.

Method of Data Collection

This data set was collected from a public, online forum called Reddit. Reddit can be imagined as the general website that an individual goes to and then within this general website are subreddits. These subreddits are effectively different pages within reddit that host forums and discussions that can be posted by individual users, about a specific topic. For example, there exists a subreddit named “LadiesofScience” where women in science may go to discuss anything related to being a female in a science field ranging from venting, to questions, to advice. For each

subreddit there is at least one individual who is usually the founder of the subreddit, who acts as a moderator. These moderators design the layout for their subreddit’s specific page, curate content, and generally run the subreddit.

Data collection was accomplished through an automated web-scraping bot. The “bot” (short for robot) is effectively 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 occur, such as “graduate school” or “women in science”. The subreddits were initially chosen from the “popular” set of subreddits as determined by Reddit. A form of snowballing was used to gather the rest of the relevant subreddits by using the associated subreddits. The set of associated subreddits is determined by the moderators for each subreddit. Any subreddit without posts within the past 6 months related to graduate attrition were excluded from the set of subreddits.

From there the bot used a designated set of search terms to find relevant post for discussion by individual users within each chosen subreddit. This search criteria were set to search for terms related to graduate school and attrition; if only one set of search terms was found the post was excluded. Additionally, a set of exclusionary search terms were used to prevent unrelated posts from being found. For example, a post about “Leaving a game of dungeons and dragons because of the game master” would fall within the search without the exclusionary search terms. The search criteria can be found in Table 3-1.

Table 3-1. Search Criteria

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

These exclusionary terms were selected based on an initial trial run of the code. The search terms were designed to cast a wide net with the goal of not excluding searches that used different syntax and phrasing. The code for this bot can be found in Appendix A: Web-Scraper Code. For each subreddit up to 500 posts that met the search criteria were collected including username, date and time of submission, post title, and post submission text. An example is shown in the figures below:

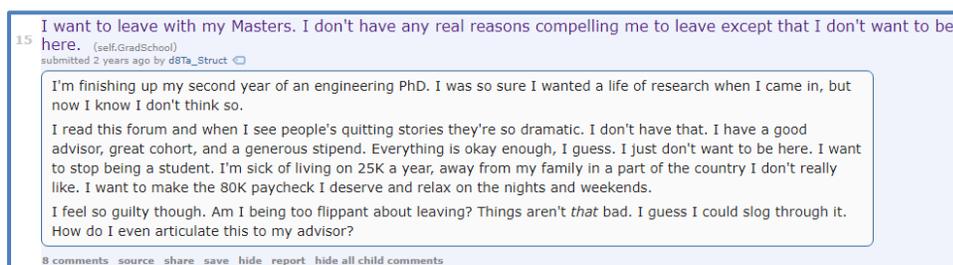


Figure 3-1. A sample Reddit post as viewed from the Reddit webpage

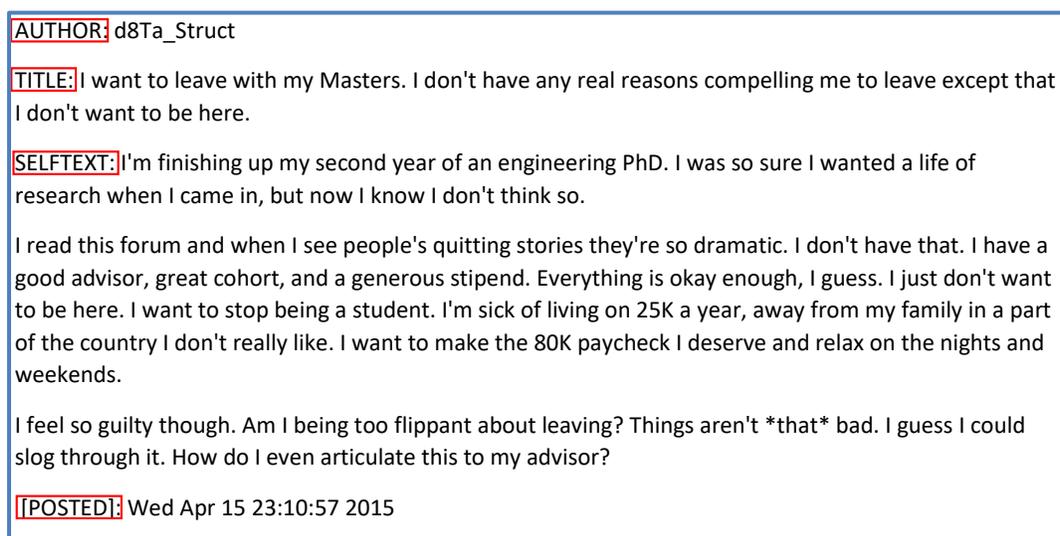


Figure 3-2. A sample Reddit post as stored by the web-scraper bot

The scraped threads were then gathered from the bot, which outputs the data as a text file that may be analyzed through qualitative techniques such as content analysis and open coding. This initial corpus was then sorted by hand to remove any post not related to graduate student

attrition. From there this corpus was then coded into posts related to engineering, STM (science, technology and mathematics) and non-STM. Of these, there were 28 discussions explicitly related to engineering graduate school attrition. Because this study was primarily qualitative and exploratory in nature, these numbers were found to be appropriate (Berdanier, 2016; Creswell & Plano-Clark, 2011; Gopaul, 2014; Spaulding & Rockinson-Szapkiw, 2012). We were prepared to perform another search with the web-scraping bot however, after analyzing this corpus, saturation of the themes appeared to be reached and therefore it was felt that another search was not necessary (Creswell & Plano-Clark, 2011; Marshall & Rossman, 2006). A significant number of posts mentioned that the author was in a STEM field, however 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 for quota sampling by gender, engineering field, or ethnicity. This one-time collection of data resulted in post-dates ranging from 2010 to 2017. There was also a limited number of posts by the same users. If these posts were simply the same post within separate subreddits, one of them was excluded. Otherwise they were grouped with the previous posts by that user in chronological order.

The above method of data collection was chosen for a number of reasons. The exploration of online forums has been used in a wide array of research studies ranging from political engagement to socialization to uses in distance-education (Beuchot & Bullen, 2005; Buckley, 2011; Dunne, 2010; Fayard & DeSanctis, 2010; Li & Wu, 2010; Yassine & Hajj, 2010). While these methods have not been applied to graduate education and attrition, the same benefits gained in other studies may be afforded to engineering education. By using an anonymous online forum, we are offered the opportunity to observe first-hand accounts and the decision-making process of engineering graduate students as they perceive the internal and external factors affecting their decision to persist or not. Because of the anonymous nature of these forums

without the risk of social or academic repercussions this allows us to capture meaningful and authentic themes unbiased by social response bias. This method of data collection is also easily repeatable and may be extended to other forums. Because the forum is publicly available it doesn't require the time-sensitive IRB approval. The search can also be extended to look at non-STEM programs, or even for different search criteria unrelated to graduate student attrition.

Participants

From the context of the posts a variety of demographic information was available, though not consistently for all posts. The available demographics are shown in the table below:

Table 3-2. Participant Demographic Information

Initial Graduate Degree Sought	Number	Percentage of Reported
Masters	9	36%
Doctorate	16	64%
Department (Program)	Number	Percentage of Reported
Electrical/Electronics Engineering	4	27%
Mechanical/Robotics Engineering	3	20%
Computer Engineering	2	13%
Civil Engineering	1	7%
Chemical Engineering	2	13%
Biomedical Engineering	1	7%
Mining Engineering	1	7%
Environmental	1	7%
Gender	Number	Percentage of Reported
Male	0	0%

Female	4	100%
Year in Graduate Program	Number	Percentage of Reported
0-1	10	42%
2	3	13%
3	5	21%
4	3	13%
5	0	0%
6+	3	13%

As can be seen from Table 3-2 of those that reported the initial graduate degree sought, it was split approximately two-thirds pursuing doctoral degrees and one-third pursuing Masters degrees in their respective programs. The majority of users were electrical and mechanical engineering students which is unsurprising, as these are the most commonly pursued engineering degrees (O'Shaughnessy, 2010; "The Most In Demand (And Aging) Engineering Jobs," 2014). It can be seen that of the participants that identified their gender, all identified as female. While this is not typical of engineering programs, where women tend to be under-represented (Cech et al., 2011; Hall et al., 2015; Lord, Layton, & Ohland, 2015; Prime et al., 2015; Xu, 2016), it is understandable as only 4 users identified their gender explicitly, and there was an entire subreddit dedicated to women in science where users were already identifying as such.

While there were several other identifying characteristics that were available for some participants, there was not a substantial number of those who identified this information (institution classification, advisor gender, marital status, ethnicity). However, some of these characteristics will be explored in the results as they are explicitly discussed in the context of attrition by several of the users.

Analysis Methods

After collecting and sorting the data submitted, submissions by 28 users were available to be analyzed. The primary approach for analysis in this work is through a constant comparative analysis of the initial submission by each user. In doing so we chose to follow the well-established procedures of open and axial coding, yet within the constructivist framework (Charmaz, 2005; Charmaz & Belgrave, 2012; Glaser, B.G., & Strauss, 1967; Marshall & Rossman, 2006). This approach allows us to search for emergent themes without pre-emptively 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 and very general themes were established through initial open coding and then these themes were further clarified and separated into sub-themes through several rounds of open coding. This allowed for the comparison of themes and their relationships as well as how these themes varied by user. These themes and subthemes were then related to existing knowledge and findings in graduate persistence and attrition literature.

Care was taken to avoid extending the researcher's personal views or experiences into the data. Credibility is given to the findings of this research by maintaining the original posts from the users; these texts were not modified or censored in any form. The decision to maintain the texts in whole, despite instances of vulgar language, stem from the goal of maintaining the integrity and authenticity of these texts (Creswell & Miller, 2000; Marshall & Rossman, 2006). This vulgar language for the users highlight where they choose to place emphasis on one factor related to their consideration of attrition over another.

Overcoming Limitations

As with all methods there are some limitations to the unique approach used in this work. 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. In addition, this anonymity may result in negativity bias or in users simply using these forums to vent their frustrations. However, unlike other social forums such as Twitter, there is not a limited character space so users have the opportunity to fully express themselves and their situation to whatever degree of detail they desire. Another limitation is that, as with any written exchange, certain emotions and sentiments may be difficult to convey without tone and social cues like facial expressions. Fortunately, some of this has been mitigated by certain online customs; for example, within reddit users often add a “/s” at the end of a sentence or post to indicate sarcasm or they use characters to effectively create emoji’s such as “=)” to indicate a friendly smile. These modes of discourse could be interesting to study in future work.

There may be self-selection bias present in this group of participants. Individuals who post on these forums are likely more willing to seek out help and discussion when facing a decision like graduate school attrition. This means that we may still be missing important themes of attrition from those who leave silently. However, the goal is to capture at least some narratives of individuals who may not feel comfortable talking to their departments but are comfortable speaking to anonymous strangers, as is mentioned in several of the Reddit posts.

Chapter 4

Results

Introduction

The goal of this work was to explore the internal and external factors that students identify when considering attrition from graduate engineering programs, and whether these students identify mitigating factors or if these experiences differ for students considering mastering-out. From the analyses of individual student posts six common themes emerged, several of which contained distinct sub-themes. These are listed in Table 4-1:

Table 4-1. Themes and Sub-themes

Perception by Others	
- How others will perceive the user's decision to stay, transfer, or leave their program	
Cost	
- The general cost associate with the user's decision to stay, transfer, or leave their program	
<i>Time</i>	<i>Money</i>
- The cost in terms of time including lost work experience time	- The cost in terms of money, including lost work wages/opportunities
Advisor	
- Advisor role and relationship	
Support Network	
- The network of friends, family, coworkers, counselors, faculty, etc. (excluding advisor)	
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 in order to obtain a specific job	
<i>Uncertain Goals</i>	<i>Change of Goals</i>
- Unclear or uncertain goals and motivations for pursuing graduate school	- A change of goals, whether determined by internal or external factors, during an individual's time in graduate school
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	

<p><i>Quality of Life</i></p> <ul style="list-style-type: none"> - General quality of life, including work-life balance 	<p><i>Work Type</i></p> <ul style="list-style-type: none"> - The type of work an individual is performing, outside of coursework, and including teaching assistantship work, grant writing, etc.
<p><i>Work Environment</i></p> <ul style="list-style-type: none"> - The work environment of an individual including department culture and location 	<p><i>Course Work</i></p> <ul style="list-style-type: none"> - Any discussion related to coursework, including the structure of courses, quality of teaching, the course requirements, etc.

These themes occurred within both the posts for masters and doctoral students, though to varying degrees. Unsurprisingly several of these themes were previously identified within the literature. The most notable differences between the existing literature and this study are housed within the themes of Perception by Others and Goals. These were not themes that were explored in previous works. The number of students that discussed each theme can be found in Table 4-2.

Table 4-2. Number Students that Discussed Each Theme or Sub-theme

Theme or Sub-Theme	Number of Students
Advisor	15
Support Network	17
Perception by Others	15
Time	12
Money	20
Quality of Life	16
Work Environment	11
Work Type	20
Course Work	8
Uncertain Goals	10
Change of Goals	9

As can be seen from the table above Work Type and Money were the most commonly discussed themes. Course Work was the least commonly discussed theme which would coincide with the decreased importance of coursework in graduate school, especially with respect to PhD

students as compared to undergraduate programs. The theme of Goals was discussed by a total of 17 individuals; however, there were two instances of overlap between the subthemes of Uncertain Goals and a Change of Goals. It should also be noted that the Support Network theme included explicit questions or searching of shared experiences through Reddit. Twelve students discussed the theme of Support Network outside of the context of explicitly asking reddit users for shared experiences.

In addition to analyzing the different themes for masters and doctoral students, the data was separated by students' self-described high or low confidences in two categories: Confidence in Ability to Complete Degree, and Confidence in Ability to Find Employment. Among those whose confidence levels in either category was reported, there was roughly an even split of high and low confidence users for both categories. There were too few users whose confidence in both categories were identifiable to draw any meaningful conclusions or correlations across these two categories.

Thematic Results

Advisor Role and Relationship

The theme of Advisor Role and Relationship is one which is well-discussed in the literature by both studies that take accounts from students' and others' perspectives. Often the advisor is grouped within or tangentially to the rest of a student's support network. However, here these two themes were separated. While advisors often play a support role, whether emotional or academic, their role is distinctly different from that of any other faculty member let alone a family member or friend who is not directly involved in the academics of a student. There is also a specific power differential between a graduate student and their advisor that doesn't necessarily

exist in the other contexts of support networks. These advisors act beyond a support role. An advisor's role which, unlike the role of others in the support network, may change as the student advances through their degree, especially for doctoral students. In these cases, advisors begin as a guide in the new world of graduate school. By the end of a student's degree, they likely have evolved into more of a colleague, though still maintaining the role of superior. These distinctions between outside support network and advisor are evident in the manners in which students in this study discussed the two groups.

The role of the advisor was a far more common theme discussed by PhD students than MS students. This can be understood through several considerations. PhD students tend to spend a greater amount of time with their advisors than MS students, due to research obligations and a longer graduate student timeline. PhD students are also likely to have their academic career depend more heavily on advisors than MS students who may only require coursework completion or a paper written. Discussion of this theme were in both positive and negative contexts, though a negative context was slightly more common. Only PhD students discussed advisor role in a positive context, namely the supportive nature of their advisor. This included being supportive of their potential decision to leave without their PhD. For example, one student noted the nature of support in terms of communication and professional development in that "he's been supportive and complimentary the couple of times we've spoken since I made the decision... [and he] 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."

These positive associations with the advisor correlated with generally positive discussions of Support Network and a balanced discussion (individual users discussed both positive and negative aspects) of the Cost subtheme of Money. This was distinctly different from negative discussions of advisors where both Money and Support Network were predominantly discussed in a negative context. In some instances, students expressed the sentiment that their

advisors were actively hindering their degree progression. For example, this student noted that he or she has difficulty in managing adviser expectations: “I've tried making my own schedules and keeping to them, only to have my adviser come in and disrupt my experiments so much so that I have to start over, wasting days of work. He undermines me at every turn and refuses to become organized or to think ahead.”

While such extremes were not common in the data, their occurrence is important to note. The majority of personality differences noted pertained to the advisor being “a jerk” or disorganized and uncommunicative. In addition, some students who spoke of their advisor in a negative context discussed disagreements in regards 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 would not be getting as much face time with the advisor as expected: “My advisor was a pretty busy professor so I didn't get all that much time to work with him, but I never could really get a topic I was all that interested in.” Those that discussed a difference in research goals and interests with their advisor also discussed the Quality of Life and Work subtheme of Work Type in a negative context.

Support Network

As previously mentioned, outside of seeking explicit support from Reddit users Support Network was not a common theme. However, nearly all posts had explicit questions from the users asking for advice, or if any other users had similar experiences. These students asked questions such as “Was it worth it to stick it out?” or “Has anyone else here been in a similar situation, or know someone who has?” Notably these users who explicitly asked other users if they had any similar experiences, were often users who expressed some aspect of the theme of Goals such as uncertainty. These users were searching for whether other students shared that

uncertainty, as one user asked “How did you know grad school was or wasn't the right thing for you?”. This uncertainty and search for shared experience seemed to tie to the fear of whether graduate school was “worth it”: “Is hating grad school normal? Did you want to quit so many times but then got your PhD and were so happy you didn't?”.

Outside of searching for shared experiences on reddit, the limited theme of Support Network, when negatively discussed, seemed to have a significant impact on the individual. These users often cited a loss of a critical relationship or isolation from important family and friends. One user, discussed how the ending of their engagement affected their ability to engage with and be passionate about their work:

“After she graduated we got engaged, but six months into our engagement she moved out, and I haven't heard from her since. It was a really tough time for me emotionally, and I didn't really feel excited about my research, or anything. I spent the next year realizing that grad school was a lonely place.”

This type of loss was not a common occurrence but again, these significant changes in support network seemed to act as a catalyst for re-evaluation of the student's situation. Some users even noted that the loss of a critical relationship, brought to light other issues such as the decision to attend a certain school to be near that person or the decision to push through because they had that one individual to support them or to distract them from the difficulties related to their graduate program.

Perception by Others

The theme of Perception by Others, while discussed in abstract and incidentally as an aspect of other themes, has not been discussed in its own right in the literature. For many users, this fear of how others would perceive their decision to leave their programs was of significant concern. As examples, one student expressed a fear of informing their advisor of their decision

because “the prof/student relationship is a bit more close and [my advisor] essentially did not benefit from having me as a student at all”, and others were worried about more generally perceptions by others and how this would affect their future: “How bad would it be to try to re-enter the work force now?”

These fears of negative perception by others occur within both high and low confidence users in both confidence categories. This indicates that confidence does not necessarily mitigate concerns of how others perceive the user’s accomplishments or lack thereof (as the users see it). However, there is a divide between MS and PhD students. MS students were concerned with whether leaving their program would hurt their future employment chances or “Would others understand where I’m coming from?” PhD students on the other hand, especially those considering transferring programs, were concerned with “How bad does leaving one program for another look?” and whether they would be able to obtain favorable letters of recommendation for other opportunities. In addition, every one of these PhD students who expressed concerns about how others view their decision to leave also expressed a fear of regretting a potential decision to leave. These PhD students express regret in the form of “wasting” something, whether that be time, money, or an opportunity. Several students expressed similar fears such as 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.” The way in which they discuss this demonstrated a fear of having let themselves, and others down. Notably, this regret is not present in the MS students.

Cost

The theme of Cost for this study was found to contain two distinct sub-themes: Time and Money. While the existing literature discusses other forms of cost such as opportunity cost, this

study finds that these other forms of cost are well-housed within the two Cost sub-themes identified in this study.

Time

MS and PhD students both discussed the theme of Time negatively. Specifically, they express frustration with the idea of wasting more time in school. From the users' discussions MS students were more likely to discuss being in school longer than they had explicitly planned for. As an example, one MS student noted that their professor "doesn't care about how long it will take me to graduate" and as a result their plan to graduate in two years would likely be extended to three. While not all MS students cited their advisor as a cause for delay, the frustration of spending more than planned, usually two years maximum, was echoed by the majority of these students.

In contrast to MS students, nearly all PhD students that expressed concerns about time had the more abstract sense of spending an indeterminate number of years still in school. For the majority of these individuals these are often the years that are considered the "prime of their lives", which corresponds with the manner in which these individuals discussed the fear of wasting time, or more explicitly wasting their 20s. One student noted, "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.

For several of the PhD students, this fear extended into continuing a career in academia or spending more time through a post-doc. This fear of spending more time within school is correlated with the theme of Goals. One student noted a sense of uncertainty in changing their

goals after experiencing academia: “I thought I wanted to go into academia, but the idea of doing a post doc makes my skin crawl... I love teaching, but don't want to write grants for a living, nor do I want the stress of leading a lab. Basically, I'm burnt out.” These students who discussed the theme of Goals in the context of wasting time, felt as though their time was not being put to good use nor working on what they felt was important. This concept is demonstrated throughout several themes and will be well noted within the discussion of the Quality of Life and Work themes and its respective sub-themes.

Money

The Cost subtheme of Money was one of the most frequently discussed concepts by both MS and PhD students. Money was discussed in several often, comparative contexts. The majority of these students discussed their graduate school funding in a positive context with only four students discussing funding itself in a negative context. Many discussed having both tuition covered, as well as receiving stipend: “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.” This aligns with the knowledge that the majority of engineering graduate students receive tuition assistance as well as other forms of funding such as stipends. Notably, several of these students won prestigious awards such as the DoD NDESG, NSF GRFP, and others. All individuals who explicitly discussed the cost of tuition, were MS students, who traditionally do not receive the same level of funding as PhD students and this was usually coupled with concerns over failed coursework, new financial concerns, or as discussed in the Time subtheme, spending more time than initial planned working towards their degree.

While funding itself was discussed positively, the majority of these students acknowledge that their stipends were far below what they could be making working in industry. One student

lamented “I want to make the 80K paycheck I deserve” while others discussed similar sentiments at the idea of “stability from a job, pay off loans, and reclaim a life/work balance.” This was a very common theme among these students. As with the Time sub-theme, this was viewed in a context of the venture of graduate school being worth it. Discussions of small stipends correlated with the concept of wasting time in graduate school. Money, when discussed in a positive context is not discussed as a motivator for remaining, however when discussed in in a negative context it is a strong motivator for leaving that is connected to other factors. Several students expressed frustrations when comparing themselves to friends and family who were not in graduate school and that they were “that person who spent the better part of a decade in graduate school while everyone else was making money and procreating.” Several others echoed this frustration especially when, instead of being allocated research hours and opportunities they were being forced to search for other means of funding like TA positions or going without funding. As noted by one student, and echoed by others, this poor quality of life and work resulted in the student wondering if there really was any monetary benefit to continuing their program: “I still had cold feet about going into the program. Partly because [a graduate degree] wouldn't help me a whole lot as my credentials with my bachelor's allowed me to find a well paying job. A master's would only make me specialize and potentially earn more. Experience working in industry would benefit me more than a master's.” While some of these sentiments may be disputed in terms of accuracy, it is important to note that ultimately these are considerations affecting student decisions to persist. These students are effectively considering these themes in a cost-benefit approach.

Quality of Life and Work

As discussed in the previous sections, this theme seems to be tied to several other themes. This is likely due to the broad nature of this theme, which in itself has four subthemes. These four

sub-themes were all grouped under this broader theme due to the unique, overlapping nature of academic life and work for engineering graduate students. The nature of this theme is predominantly a discussion of external factors that are affecting these students' decisions.

Quality of Life

The quality of life subtheme focuses on the student life outside of work. While these two areas of a graduate student's life are not explicitly separable, they can be considered two sides of the same coin. Individuals discussed this concept of quality of life in a different context from work, but in a manner where quality of life, could affect work-life and vice-versa. Specifically, this was regularly discussed negatively as a lack of "work-life balance". This concept was distinct from the Work Environment and Work Type sub-themes. Concerns like the ones expressed above were not unique to only PhD students or MS students. As previously mentioned, this negative expression of quality of life was tied to the money not being "worth it". As examples, one student question "whether or not its worth it to continue (cost of happiness) and 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." This concept of a better work-life balance outside of academia was justified by the idea that these individuals would no longer have unstructured work hours, nor the unpredictable work of courses and research, but instead would have "work 9 to 5 and... weekends off."

Work Environment

This subtheme was one of the most varied in discussions, though as with other themes and subthemes more related to research, this subtheme was primarily discussed by PhD students. In addition, all of these discussions of work environment occurred in a negative context. Several

students cite politics within their department as a motivating factor for considering leaving their program. This concept of politics was not well-defined by the individuals. Generally, it was in references to the department as a whole, though it was also referenced with respect to conflicts between the advisor and the rest of the department, which was negatively affecting the students. One student noted that as a result of their “dysfunctional department divided in to political hegemonies” they had no one that they could turn to for advice. This sentiment was expressed by others as well, more broadly as isolation. This isolation occurred in reference not only to social or academic isolation, but in some cases physical isolation as well due to isolated lab or work environments.

Students also discussed themes found in other literature such as the mentality of publish or perish that is prevalent throughout academia. Many of these students felt as though “academic research is driven by the cycle of papers and grants” and as a result the focus of their work was less about the quality of their research and advancement of science, and more about “pump[ing] out new figures for publication.” This publish or perish mentality extended so far for some students that they were concerned about the accuracy and ethics of the data that they were being pushed to publish by their advisors. While this ethical concern was not explicitly common, it is important to note as it did occur.

Work Type

Along with Money, Work Type was discussed by nearly all users. Work type was separated from the Work Environment subtheme based on the patterns that appeared within the data. Users frequently separated discussions about the work they were doing, usually research, from the general work environment of their lab or their department. This subtheme was present in both MS and PhD students’ discussions. While this topic was more common among PhD

students, MS students who were performing research also discussed this topic. As with work environment this was a varied theme, though unlike other themes and subthemes, it was not discussed in a strictly negative context. Interestingly many students made a distinction between research in general and research topic. As one student noted “Honestly, the only part of this program that I've enjoyed so far is my paid research, which is a programming project that is completely unrelated to the field I'm studying” while another noted that they were more motivated by developing software for their research or lab than the actual lab work, despite finding “the applications of [their research] interesting and important.” Another student even noted that they “believed” in their research area and wanted to “believe” in their specific research project but were struggling to do so. These conflicts between general research and specific topic were not indicative of all graduate students, though these nuanced feelings about work type were not uncommon, indicating complex sentiments about their work and distinctions between the somewhat nebulous idea of research as a whole and individual research projects or topics.

For those who discussed work type strictly in a negative sense, there were a variety of frustrations. Some individuals were not able to focus on their research as they had planned. The reasons for this ranged from teaching assistantship requirements to department or lab focus on publishing and presentations. These frustrations were regularly tied to the themes of Advisor or Work Environment which the individuals identified as the cause of these circumstances. Some lamented “The hundreds of hours spend working on power points” while others were frustrated with “not being allocated research hours” and “only TAing/lecturing.” Interestingly, these individuals were more likely to discuss the Cost subtheme of Money in a strictly positive context than their counter-parts with mixed-feelings about Work Type, who were more likely to discuss Money also in a mixed-feeling manner.

A very common discussion that occurred among these individuals was the concept of not performing meaningful research or performing researching which was too theoretical and

narrowly applicable. As examples, one student noted that “I’m an engineer not a mathematician” and another expressed “I feel like any contribution I will make will be so minute that I won't be satisfied with it”. This was more strongly echoed by students who expressed they wanted their work to be “The kind [of problems] that people care about” and that they “want to actually produce something useful that will end up in real people's hands and not wind up as a plaything for a half-dozen academics.” These students tended to express the previously discussed concept of wasting time, which is unsurprising if they feel that the work they are doing is not meaningful.

Course Work

While Course Work was the least commonly discussed of all themes and sub-themes, it was an important and distinct subtheme. The topic of course work appears to be of greater concern to MS students, which is understandable since their degree relies more heavily on coursework completion. However, this is not to say that this concern is unique to MS students. Several PhD students negatively discuss their classes. These negative discussions from PhD students focused around the structure of the coursework requirements and the quality of teaching of these courses, as expressed by one student:

“The program has a pretty rigid first year structure course-wise, and honestly, I'm starting to loathe most of my courses. The only course that I'm enjoying so far is the optional elective that we get to take. The main courses that all first years have to take are taught by the director of our lab, and he's turned it into what he likes to call "boot camp," where he makes all of our projects and tests (which are just literally just memorization and regurgitation of his several hundred lecture slides) due at the same time. I understand that he's trying to mold us into better students, but I'm not here to become a better student by learning how to manage my time memorizing slides, I'm here for a damn degree. The coursework is so bland and incompetently taught”

These negative sentiments were strongly echoed by MS students. In general, these students lamented the poor quality of teaching, which they cite as a disinterest in the course by

the individual teaching it, as well as the course requirements set forth by the department. For one student these course requirements left them “scrambling to find classes” that were relevant to their field while others were concerned “due to strict A/B requirements to pass classes”. As with other themes, this tied to the idea of wasting time on redundant courses or courses that were not beneficial to improving their skill-set. While less common, one student vehemently expressed frustration with the disinterest by professors in teaching classes and academic dishonesty by other graduate students:

“The graduate adviser is an academic fraud; I took one of his classes and it consisted of him pointing at poorly done powerpoints then going off on tangents about his previous experiences in undergrad. His homeworks were typed so badly that he would just blow off the assignments for us and give everyone a 100%. The homework solutions were even incorrect in many instances. He gets paid 120k a year and he's robbing students of their education. He stated to my lab partner and fellow grad student that if he was given a good review on one of his online classes, he would give my lab partner an A. The online class consisted of one assignment and a final. My lab partner turned in the final with every odd question removed. My lab partner got an A. He is not the only professor in the department doing this.”

In addition to negative discussions about the quality of course-work, both MS and PhD students were also considering leaving their programs due to failed coursework or candidacy exams. Unsurprisingly, these individuals also discussed the theme of Cost, reflecting that failing a course or candidacy potentially would result in loss of funding, as well as the need to spend more time in graduate school to retake a course. There was a total of five individuals who cited this reason, though interestingly, this was not necessarily reflected in their confidence in their ability to complete their degree.

Goals

The theme of goals, when discussed in previous literature was not necessarily explored in the context of how it affected considerations of attrition. There were distinctions between

individuals who entered graduate school and after a period of time experienced a change of goals and those who entered graduate school with uncertain or unclear goals of why they were pursuing this path.

Change in Goals

The Change of Goals sub-theme was predominantly found among PhD students with only one MS student expressing a change of goals. It should be noted that this particular MS student also failed coursework and expressed struggles with ongoing mental health issues. There was no correlation between the confidence categories and change of goals. Interestingly, the majority of these users also discussed support network, which itself was not a common theme. One student discussed a realization that they were only staying in their graduate program because they had their now ex-boyfriend there to distract them from the struggles of their program and that they were “not passionate about [research] right now”. This extended to a feeling of being unable to continue working in their current environment. While this situation was unique, certain elements, such as a lack of support network or loss of critical relationship resulting in a change of goals was echoed by others.

The majority of these students were also well funded but were not satisfied with the type of research they were performing 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" while another tried exploring multiple different projects and topics to no avail:

"Halfway through trying to research the topic I realized it was not what I wanted to do. In the interest of keeping this post kind of short, I basically switched research areas to something I thought would be more interesting but I decided again that it's not for me."

Uncertain Goals

Uncertain goals were present in both MS and PhD students. There was also a range of both high and low confidence individuals in both confidence categories that discussed uncertainty in their goals. All but two of the students who discussed uncertain goals, also expressed a fear of regret related to uncertainty in their persistence decision. They commonly discussed "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. This uncertainty in their decision was not related to work environment, however there were a wide range of other themes present for these individuals. As examples, one individual applied to graduate school "because of how hard the job market out there is" and another went back to school "on a whim because it was an easy option". While both of these individuals had no clear goal when entering graduate school other struggled with an "inability to come to a consensus" with their advisor which bled into concerns and questions over their future career and whether it was something they truly wanted.

As with students who discussed a change of goals, these students were more likely to discuss the theme of Support Network. Notably they were more likely than those who experience a change of goals to discuss a negative support network, though this was not the majority of individuals. For example, one student despite prestigious funding, was unclear in their initial goals and did not have the support network to aid them in clarifying their goals or options:

“I’m not even completely sure I know what I’m asking but I don’t have anyone to talk to about this stuff and I am just so overwhelmed with this decision...I was going to drop out of PhD for a non-thesis masters. Got the NSF GRFP so I might not drop out now. But I want to transfer schools, which I couldn’t do until the Spring, assuming I could get in. But I still don’t really know what I would want to research. Help?”

Unsurprisingly, those that discussed the subtheme of Uncertain Goals, frequently discussed the Cost subtheme of Time. One student expressed this succinctly as “I’m also not convinced that a PhD will be necessary for what I want to do.” This notion of wasting time on a path that they weren’t sure they wanted or weren’t sure would provide them the opportunities they wanted, resulted in the concern that graduate school wasn’t “worth the investment”.

Role of Confidence in Decision-Making Processes

Confidence in ability to complete degree

There was a clear split between MS and PhD students in confidence in ability to complete their respective degrees. A total of nine PhD students and four masters students expressed either high or low confidence in their ability to complete their degree. Of these all four masters students expressed low confidence in ability to complete degree while only two PhD students expressed low confidence, with the remaining eight PhD students expressing high confidence in their ability to complete degree. Table 4-2 shows the differences in concerns for high confidence and low confidence users. While these cannot be statistically generalizable from a low N qualitative study, they do lend insight to future research directions.

Table 4-3. Correlation Between Confidence in Ability to Complete Degree and Theme Discussion

Theme or Sub-Theme	High Confidence in Ability to Complete Degree (%)	Low Confidence in Ability to Complete Degree (%)
Advisor	75	20

Support Network	75	80
Perception by Others	38	60
Time	63	20
Money	88	60
Quality of Life	63	60
Work Environment	50	0
Work Type	88	40
Course Work	25	40
Uncertain Goals	50	20
Change of Goals	25	20

As can be seen in the table above the high confidence users, of which all but one were PhD students, were more likely to discuss the themes of Advisor and Time. The discussion of Advisor by PhD students is understandable in the context that advisors tend to have a greater role in the academic career of PhD students than undergraduate students and MS students. This is supported by Gardner (2010) and DesJardins et al. (2003) who note that advisors play roles in both academic and social support. The discussion of Time by the high confidence individuals, can be viewed in the context of the significant time commitment made by PhD students. As expressed by one student and echoed by others this fear of long term commitment, despite prestigious funding opportunities, was hindering their decision: “I recently won the DoD NDSEG fellowship, and have 3 years of funding to do a PhD. Part of me thinks if I don’t take this opportunity to do a PhD I will regret it. The other part of me doesn’t want to be miserable for 3 more years...” While these individuals are confident in their abilities to complete their degrees, there is a common thread of the degree not being worth it or that they could benefit from spending their time in another way. While this confidence in ability may not necessarily translate to actual ability, from the student perspective, it is not lack of ability that hinders them from completing their degree. Many of these students, across categories, note that they are in top schools and several of which also obtained prestigious fellowships such as NSF and DoD fellowships.

Both high and low confidence users discussed the theme of Monetary Cost, though there was no consistency in whether this was positive or negative in context. Both high and low

confidence users also discussed the Work Type sub-theme. Notably, high confidence individuals were more likely to have mixed, both positive and negative, discussions around work type, where-as low confidence individuals strictly spoke of work type negatively. Based on this difference between high and low confidence individuals, this may indicate a difference in work type or perception of work type associated with confidence in ability to complete degree. Low confidence in ability to complete degree is also associate with a discussion of the Perception by Others theme in a negative context. As one low confidence student noted there was a real fear of how others would perceive their decision to leave: “really the only reason I haven't quit is because I don't want to disappoint anyone.” Their decision to leave graduate school was never viewed in a positive context by these low confidence students; they did not discuss it as choosing another path but rather perceived it as “quitting” or their own inability to “stick it out”. In the case of the majority of low confidence individuals, this would be before obtaining any degree (as opposed to mastering out) which may have contributed to the negativity and sentiment of having nothing to “show”.

Confidence in ability to find employment

Students who discussed or expressed high or low confidence in ability to find employment were less clearly dividing by degree type than those who discussed confidence in ability to complete degree. Within this category three PhD students and two MS students expressed low confidence in their ability to find employment. The correlation between confidence in ability to find employment and the identified themes can be found in Table 4-3.

Table 4-4. Correlation Between Confidence in Ability to Find Employment and Theme

Theme or Sub-Theme	High Confidence in Ability to Find Employment (%)	Low Confidence in Ability to Find Employment (%)
Advisor	71	33

Support Network	71	50
Perception by Others	71	50
Time	57	17
Money	57	50
Quality of Life	71	33
Work Environment	57	33
Work Type	100	50
Course Work	29	33
Uncertain Goals	43	33
Change of Goals	14	33

For low confidence individuals, this concern over their ability to find a job seemed to weigh heavily as compared to six themes, which were relatively sparsely discussed by these individuals. One low confidence PhD candidate expressed that they were so concerned with employment that they were “considering staying in my PhD program just so I don't have to deal with the uncertainty of searching for a job.”

Surprisingly, this low confidence group was no more likely to discuss the theme of Perception by Others than the high confidence group. However, a notable difference was that the high confidence group was more concerned with perception by family, friends and faculty, while the low confidence group was more concerned with perception by potential employers. In general, this high confidence group discussed a wider array of themes than the low confidence group which may be indicative of the high confidence group having other concerns or considerations than the low confidence group which seemed to focus on their ability to obtain employment. The high confidence group contained five PhD students and two MS students, which may be the cause for the differences in discussion of perception by others by these groups. These individuals were more likely to discuss work type which potentially indicates a that they are not concerned with their ability to perform quality work, but rather do not enjoy the work they are currently doing.

Connections Between Themes

As discussed in the previous sections, there were numerous connections between the themes identified in this work both implied and explicitly discussed by the students. The connections between themes can be seen in Figure 4-1:

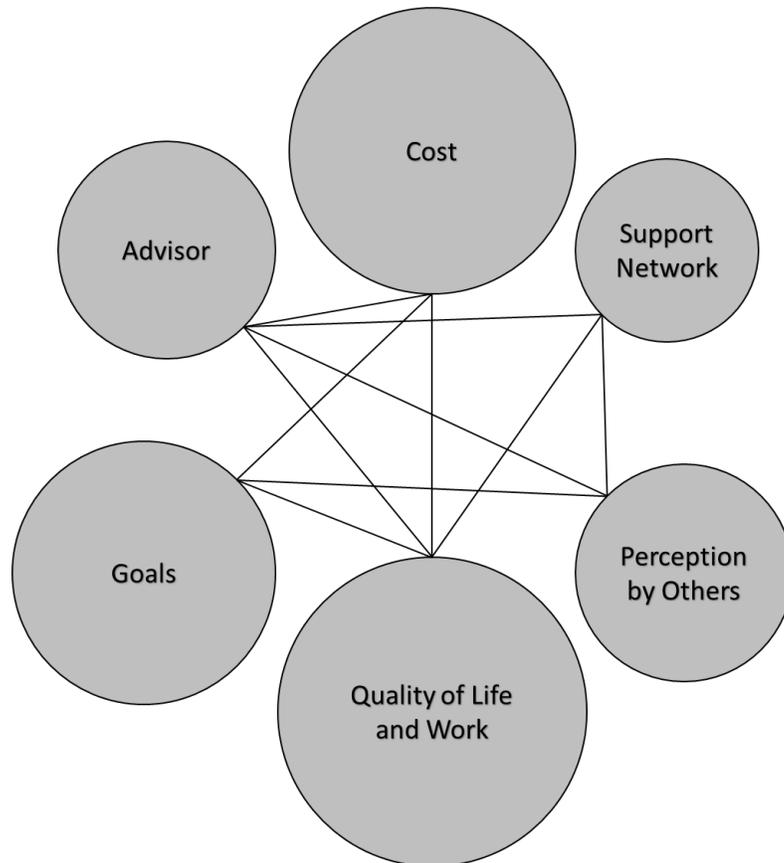


Figure 4-1. Connections between themes

Note that in Figure 4-1 the size of the circle for each theme corresponds to the frequency with which each theme was discussed. The Cost, and Quality of Life and Work were discussed far more frequently than the other themes. In addition, the Quality of Life and Work theme was the most likely theme to be discussed with and connected to, other themes. However, it should be noted that all of the other themes are also connected to multiple other themes. The new theme of Goals is prominent in this study, and is discussed more frequently than themes established by

previous literature such as Advisor and Support Network. This visual representation clearly demonstrates the interconnectedness of these themes and supports the notion that it usually not a single motivating theme that influences a student to leave their program, nor to stay in their program. These themes are not singular entities that are readily separated into individual problems to be addressed without consideration of the other themes. This is further demonstrated by Figure 4-2, which shows the connections between the themes and subthemes:

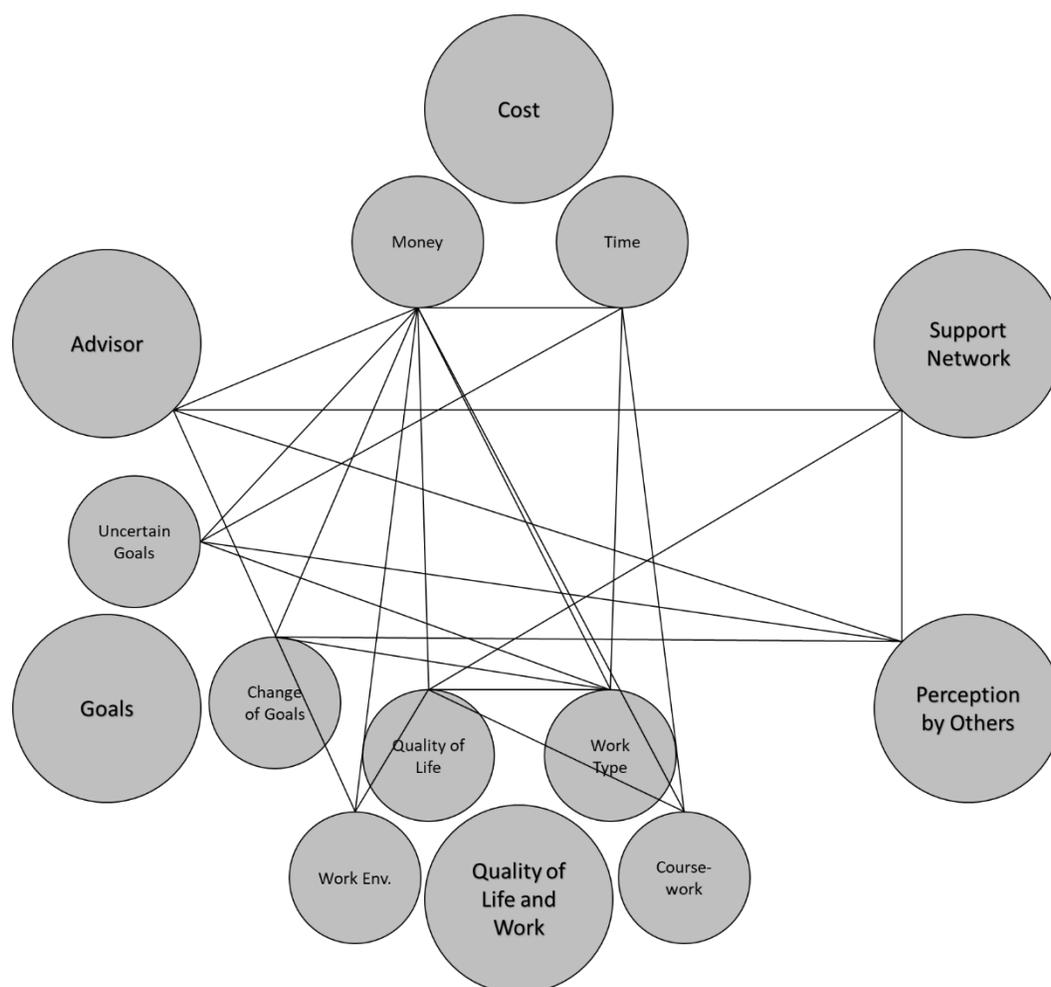


Figure 4-2. Connections between themes and subthemes.

As can be seen from Figure 4-2, many of the subthemes within an individual theme are connected. Notably the Money and Work Type subthemes, not only are the most commonly discussed themes as previously mentioned, but they are also the most likely to be discussed in

conjunction with other themes or subthemes. It should be noted several of these themes and subthemes, though they were not the most commonly discussed, were also discussed in the context of other themes with high frequency. For example, the Uncertain Goals subtheme was discussed in the context of four other themes or subthemes, as was Perception by Others. Some of these connections can be attributed to the connection between external factors such as work environment influencing internal motivations such as goal or how an individual perceives their relationship with others. This also is expected in the context of the cost-benefit analysis that many of these students employed, considering many of these themes and weighing them against each other in order to make a well-thought-out and informed decision. Again, as with the themes, the subthemes are inextricably connected, and taken into consideration simultaneously by the students.

Chapter 5

Discussion and Conclusions

Overview of Attrition in Engineering

Broadly speaking the results of this study were in agreement with the existing literature. The themes of Advisor, Support Network, Cost, and Quality of Life and Work are found throughout both STEM and non-STEM literature (Barnes & Randall, 2012; Curtin et al., 2013; Ehrenberg, Jakubson, Groen, So, & Price, 2007; Gardner, 2010; Herzig, 2004; Lott II, Gardner, Powers, et al., 2010; Maher et al., 2017; Ruud et al., 2016). In fact, Cost (specifically Money) and Quality of Life and Work (specifically Work Type) were the most commonly discussed of all themes and sub-themes in this study. However, it should be noted that there are nuances to the way in which engineering students discuss these two sub-themes as compared with non-STEM students.

As had been noted in previous studies, and as found in this one, the majority of engineering students are well-funded, especially compared to their non-STEM counterparts (Barnes & Randall, 2012; Zhou & Okahana, 2016). Yet these engineering students still considered finances when discussing attrition. All of these students were discussing potential job prospects as an alternative to graduate school. Unlike other fields, engineering students generally have strong work opportunities that pay well, even at the bachelor's level (Cintron & McGrath Cohoon, 2015; Ehrenberg et al., 2007; Golde, 1998; Lord et al., 2015; Ruud et al., 2016; Spaulding & Rockinson-Szapkiw, 2012). In the case of engineering students, instead of weighing the future benefits against the cost of graduate school currently, they are weighing the cost of lost work experience and opportunity to make more money in industry against the future benefit of

graduate school. In other words, the financial motivations for these students are different, and the same approach for attrition mitigation with respect to finances would not work for both non-STEM and engineering students. Because these engineering students are well funded, yet could be earning more money, these financial concerns are often strongly discussed in the context of other themes and coupled with frustrations pertaining to other themes. Specifically, this is often coupled with the sub-theme of Work Type. As seen in the previous chapter, these students, as is indicative of most engineering students, want their work to be meaningful and have a noticeable impact. This explicit idea of wanting research to be applicable outside of academia is not found in the non-STEM literature, again highlighting some of the difference in goals for graduate school for engineering vs non-STEM students.

Beyond, the shared themes with existing literature, this study found two themes which were not previously identified in their own right by the existing literature: Goals, and Perception by Others. As just discussed many engineering expressed dissatisfaction with their work. A number of students connected this dissatisfaction to either a change of personal goals, or an initial uncertainty in their goals when entering graduate school. This concept of goals can be tied to existing literatures' discussion of a mismatch of expectations, though they are distinct. The mismatch of expectations corresponds more so with uncertain goals than a change of goals. The students who expressed 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 this pertained more to a desired change in career path. While there were students who expressed a desire to change career path due to external factors such as difficulties with their advisor or program, several of them simply came to the realization that their field or research in general was not where their passion and interest lay, nor that pursuing graduate school would lead them to their desired career. The students who expressed uncertain in their goals, also expressed a dissatisfaction with their work which wasn't what they had thought it would be or that the quality

of life that graduate school offered was not what they had thought it would be. This directly correlates to a mismatch of expectations and indicates a fundamental lack of understanding of what graduate school will be like; a mismatch of expectations. This is not to say that this is the only factor that affected these particular students' decisions. As has been demonstrated throughout the previous chapter, these themes are inter-related.

The other theme that this study found that was not well-explored in the previous literature is Perception by Others. This theme may not have been present in the existing literature due to personal and fear-related nature of this theme. This theme likely wouldn't appear in survey data, and students may not have been willing to discuss this idea with those who were tied to the institutions they were considering leaving. Intrinsicly, this theme was an expression of fear and failure that others would perceive in their inability to complete their degree. Interestingly, this theme was present as a motivating factor to complete at least part of the graduate program, whether due to fear that an employer would see it as time wasted with no work experience gained, or whether it was a fear of letting down family, friends, or an advisor.

Themes of Attrition in the Context of Sociological and Psychological Theory

As previously discussed much of the literature on graduate student attrition is based in sociological theory. This work combines sociological and psychological frameworks in order to gain a more holistic understanding of the causes of attrition from the perspective of the student.

Sociological Theory and Social Factors of Attrition

From Socialization Theory and Identity Theory it is proposed that the ways in which an individual becomes a part of a new community, the ways in which they navigate their new roles,

and the external and social factors that affect this integration, play a role in attrition. This is well evidence in the existing literature and the presentation of common themes such as Support Network and Advisor (Gardner, 2010; Gardner & Barnes, 2007; Hunter & Devine, 2016; Litalien & Guay, 2015; Maher et al., 2017; O'Meara et al., 2013; Spaulding & Rockinson-Szapkiw, 2012; Springer et al., 2009; Zhou & Okahana, 2016), but also less obviously in the theme of Quality of Life and Work. While existing literature has established a more prominent discussion around Support Network than was found appropriate for this study, this study does note that these students were looking for that support network in a non-traditional manner; these students sought support through Reddit forums. For some, this is explicitly due to a lack of support network in their program. As discussed by numerous studies a sense of isolation and lack of integration can affect students desire to persist (Carter et al., 2013; Herzig, 2004; Lott II, Gardner, Powers, et al., 2010; Lovitts & Nelson, 2000; Pauley et al., 1999; Ruud et al., 2016; Spaulding & Rockinson-Szapkiw, 2012; Vaquera, 2008). This study is consistent with the afore mentioned studies in finding that support from close friends (not necessarily within the academic circle) and family members can be critical in a decision to persist, however this study does not indicate it is a prevalent concern or struggle. Due to the lack of discussion around peer groups this study may indicate a discrepancy with Spaulding & Rockinson-Szapkiw (2012) and Vaquera (2008) who emphasized the key role of integration into the academic peer group. However, this discrepancy could also be attributed to difference in perspectives, which is a discussion best left for the following section centered on psychological theory and attrition.

Within previous studies, the advisor was often grouped within the support network theme. While this study makes a distinction between the support networks of other persons in a student's life, it is acknowledged that advisors play a critical yet distinct support role. As expected this study found many discussions that centered on advisors as well as though who included the advisor as one of many factors in the discussion of attrition. This discussion,

predominantly negative, centered around advisors, is consistent throughout the graduate student attrition literature (Carter-Veale, Tull, Rutledge, & Joseph, 2016; Carter et al., 2013; Curtin et al., 2013; Lott II, Gardner, Powers, et al., 2010; Lovitts & Nelson, 2000; Ruud et al., 2016). Again, in keeping with the literature this study finds that the majority of the discussions around advisors, center on either a clash of personalities or differences in work styles. It should be noted however, that there were several instances of students discussing their relationship with their advisor in a positive manner. While there are studies that explore and discuss positive advisor relationships such as Barnes (2010), these are not often in the context of students already considering attrition. In the case of this study, there were several students, who despite a positive relationship with their advisor were still considering leaving their program. This, with the other findings of this study, continue to suggest that one factor alone is generally not enough to cause attrition, nor to prevent it. As with Support Network this can also be interpreted through the lens of a psychological framework, as will be done shortly, lending a different perspective into this common factor of attrition.

Within specific sub-themes of Quality of Life and Work, specifically Work Environment and Work Type, there are similar observations to be made through a sociological lens related to integration. The sub-theme of Work Environment is unique in this study in that it clearly demonstrates the findings of the literature that emphasize the importance of integration (Berdanier, 2016; Gardner, 2008, 2010; Herzig, 2004; Lovitts & Nelson, 2000; Pauley et al., 1999). As found in both the STEM and non-STEM literature this study finds that isolation and frustrations ranging from co-workers to the department as a whole, contribute to discussions of attrition. Many of these students are early in their graduate program who have not been exposed to this type of environment previously. This suggests that these students may not have had enough time in graduate school to become well-integrated to their programs. However, as it is not only early program students discussing this issue, there may also be a psychological aspect to this

negative perception of work environment that had previously been relatively unexplored in the literature. Interestingly this social integration is neither explicitly positively nor explicitly negatively associated with academic integration. This concept of academic integration is most prominently found within the Work Type sub-theme. Potentially indicative of engineering graduate programs, the majority of these students, despite being early in their programs, are well into the early stages of research. This beginning of research earlier than other programs or previous programs is also found within the existing literature (Allum & Okahana, 2014; Gardner, 2010). Within this theme there was a split of students who seemed well-integrated academically in that they felt comfortable and capable in performing research, though not all of these students necessarily enjoyed their work, and students who were not well integrated academically and negatively discussed their research. This nuance is not captured through a sociological framework and is best explored through a psychological framework.

While some aspects of the theme of Goals has the potential to fall within the sociological framework, these aspects were not demonstrated in this study. There were no explicit external factors forcing these students to change their goals with respect to graduate school. While students did discuss contributing factors to the uncertainty or change in goals, this again falls within the psychological framework as it is based on student attribution.

Psychological Theory and Psychological Factors of Attrition

From Attribution Theory and Expectancy-Value Theory it is proposed that students make decisions based generally on cost-benefit analysis of how they perceive their situation as well as the correlation between perception of their own capabilities and goal-related tasks. While a psychological framework is not well-employed in the literature, this study found that many of the themes discussed fall within this framework, as well as several themes containing both a

psychological and sociological component related to the decision-making process. Unsurprisingly the two themes uniquely identified in this study, Perception by Others and Goals, fall well within this psychological framework.

The Perception by Others theme explicitly stems from student fears of how others perceive their capabilities and accomplishments. Importantly, the majority of students do not base this discussion on actual, personal experiences of how others will perceive their decision to leave their program. This indicates that it is a student's own perception influencing this discussion and concern. While several studies discussed the idea of employment after attrition and that these students were motivated to some degree by employment opportunities to attend graduate school, it does not discuss these ideas in a psychological framework (Carter et al., 2013; Haydarov et al., 2013; Xu, 2015). Instead this fear of perception by others, namely fear of employability, is morphed into a truth rather than something that pertains more-so to the student and their own internal perceptions of the situation. Because engineering students have strong job prospects at all levels of education, unemployability is not necessarily an external truth for these students.

As with Perception by Others, Goals is theme that fall predominantly within the psychological framework. This is in part due to the way that this theme is defined in this paper. This theme focuses on either a student's unclear goals or a student's change of goals, which by nature are based in student perceptions of their goals, environment, and cost-benefit analysis of their situations. The lack of exploration of this theme may be a result of this lack of exploration of attrition within a psychological framework. Within this psychological framework Goals can be understood as the underpinning to most of the student's decisions. If they do not have strong convictions in the reason they chose the path of graduate school then, as is evident in this study, they may struggle to overcome other common obstacles such as those related to integration or difficult advisor relationships. If students perceive an external factor such as the applicability of their research as unsubstantial, then again as is evident in this study, these students may change

their goal of graduate school in order to continue pursuing the goal that they deem more important which is applicability of their work. In this instance it is important to note that this idea of applicability is not strictly objective, hence this concept falling within the psychological framework; undoubtedly the advisor that this student is working under would place higher value on the importance of this work than the student who finds this work lacking. This a direct connection to the Work Type sub-theme.

Beyond just a specific sub-theme many aspects of the Quality of Life and Work theme fall within the psychological framework. This theme along with Cost are well explored from cost-benefit perspective of Attribution theory, and in fact seem to be the approach that these engineering students take when discussing these two themes in the context of attrition. This is especially evident in the connections that students draw between the three sub-themes of Quality of Life, Time, and Money. This study finds that generally these students, especially PhD students, are not lacking in positive perceptions of their own abilities, which is supported by Devos et al. (2017), Curtin et al. (2013), and Cintron & McGrath Cohoon (2015). Rather for these students they consistently perceive time as a cost, and money from the perspective of an opportunity cost. These are weighed against the how they perceive their quality of life while in grad school, what they perceive their potential quality of life being with and without their graduate degree, and their own satisfaction with the type of work that they produce. As is supported by studies across STEM and non-STEM, these students perceive their current quality of life very poorly with lack of work-life balance and high stress. This perception feeds into the idea of cost. Furthermore, as has been discussed the perceived benefit of obtaining a graduate degree is somewhat mitigated by the comparatively high salaries that engineers of any level can have in industry. This coupling of costs quickly adds up to the point that these students consistently question whether graduate school is “worth it.” Outside of graduate school, many of these students are also young adults who have other life goals and concerns beyond career. Several of the studies in literature discuss

this concept but again it is through the focus of sociological framework focusing on retaining these students explicitly through external factors such as funding or daycare. This is explicitly addressing outside concerns for individuals who have already stepped into other roles in their adult lives whereas this study indicates that there are students who have not yet entered these other roles but who take these factors into consideration.

Beyond the themes that generally fall neatly within the psychological framework, as previously mentioned, there are some aspects of the Advisor theme that are best explored through this framework as well. Because this study focuses on the ways in which the students themselves discuss graduate school and attrition, rather than through the perspective of advisors or institutions, there is a unique perspective of how students perceive their advisors. In this study it was evident that many students perceive their advisors personality in a negative manner. Whether this perception is accurate or incomplete, doesn't matter from the student perspective, as ultimately, they are the ones making the decision to leave their programs. One student has the insight to identify that some of this conflict may stem from a difference in cultures and the ways in which the advisor-student relationship as well as communication are handled. This seems to be in agreeance with Lovitts (2001) and Barnes (2010) who note that students and advisors do seem to have different expectations.

Implications for Practice

As is evident from this research as well as existing literature, there are numerous factors that are non-universal that contribute to graduate student attrition across fields. Several of these factors can be readily addressed by institutions and departments as well as by students themselves.

From this study it appears that the most readily addressable theme is that of Goals. This would include addressing the existing literature's theme of "mismatch of expectations". Students themselves must clearly understand their own motivations in attending graduate school with a clear goal in mind. Especially with respect to engineering students, a clearer understanding of research and this concept of important and applicable work should be addressed. However, this is easier said than done and does not fall squarely on the shoulders of these students. In order for the students to truly understand their own goals of attending graduate school and obtaining a graduate degree, they should be well informed of what this process entails, and what the common results are for students who go through this process. Departments and institutions should be aiding these students in information gather not just for the students' sake but for the sake of the institution of obtaining interested students who goals truly align with that of the institution, allowing both parties to benefit from a successful and productive researcher rather than both parties suffer monetary, time, and other opportunity costs. Some institutions have implemented strong undergraduate research programs to introduce these students to research, however these may be too structured, narrow, and predefined preventing the students from being exposed to the less glamorous side of research that is failure, study design, and re-testing, uncertain, etc. Along this line is the tendency to expose potential incoming graduate students to the most exciting and best aspects of this program. This is understandable and shouldn't necessarily be discontinued. However, once these students have made a decision to attend a school's program, they should also be exposed to the expectations of the department and given some semblance of daily life in their graduate program. This would give the students opportunities to form more realistic expectations and understandings of graduate school as well as give them the opportunity to be more informed when making the decision to attend graduate school and whether or not this truly aligns with their goals.

With respect to engineering students specifically, from this study it is clear that these students place an emphasis on applicability of their research. While some of these students expressed discontentment with research as a whole there are also students who express discontentment with the specific type of research (or lack thereof) that they are performing. While some of this can be attributed to a change of goals or uncertain goals, this also indicates a breakdown of communication or understanding of the type of work these students will be performing, which is incredibly important to engineering students. In order to mitigate this lack of satisfaction with research as a whole and individual research projects, one method would be to expose students early to research to determine if it truly a path that they would like to pursue. As well it should be discussed determined by all parties whether or not a student's research goals and interest align with those predominantly explored at a given institution and whether any current faculty is working on more specific projects that align with their interests.

Conclusions

The goal of this work was to explore graduate engineering student attrition in a novel, and unfiltered manner. This was accomplished through relatively novel, and certainly novel to engineering education work, methods of data collection. Data was collected through a web-scraping bot that collected data from online posts by anonymous users as they discussed engineering graduate school and attrition. In addition, this work sought to expand the theoretical framework used to examine and understand engineering education, namely by including a psychological framework in addition to the more common sociological framework that is used to explain graduate student attrition. From this work it was evident that there is overlap between some of the themes and causes of attrition between non-STEM and engineering programs, but

importantly that there are also unique themes and causes of attrition within engineering programs that are not present in the non-STEM literature. This emphasizes the need for mitigation programs tailored to individual departments, in order to better accommodate the differences between graduate programs.

Future Work

A wide array of future studies ranging from method development to intervention methods and studies can stem from this work. Of these the most pressing future work would be the development and testing of new intervention methods to mitigate the causes of attrition. As found in this study and is supported by the literature, this is most needed at the pre-candidacy stage of graduate school. It would be ideal to develop methods to inform students about the experiences they will likely face in their engineering graduate programs, as well as inform the department and faculty of these causes and approaches to mitigate attrition. In addition, it would be beneficial to observe the effects of these intervention methods throughout the course of a cohort's time in graduate school, understanding that longitudinal studies are notoriously challenging.

Beyond intervention studies it would be ideal to repeat and expand on this specific study. It would be beneficial to obtain a larger sample size than was available for this study in order to further validate this study and potentially expand on the nuances in the themes found in this study. The themes found in this study may evolve over time as the academic, and socio-economic and socio-political climates change. Furthermore, it would be interesting to see the methods employed in this study improved, in terms of automated data collection and information sorting, and then have these improved methods applied to other graduate programs. This would allow for a more uniform comparison of the themes discussed through the relatively inhibited student perspective.

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Appendix

Web-Scraping Bot Code

```

import praw
import EngEduConfig
import datetime
import os
import errno
import numpy as np

r = praw.Reddit(username = EngEduConfig.username,
                password = EngEduConfig.password,
                client_id = EngEduConfig.client_id,
                client_secret = EngEduConfig.client_secret,
                user_agent = "EngEdu Grad Attr DCB v1")

set1 = "(grad OR graduate OR PhD OR doctoral OR doctorate OR masters
OR MS OR Msc)"
set2 = "(leave OR leaving OR 'dropping out' OR 'drop out' OR quit OR
quitting OR 'mastering out' OR left OR done OR withdraw OR
withdrew)"
set3 = "(NOT (Disney OR 'high school' OR highschool OR dungeon))"

search_query = [{"{} AND {} AND {}".format(set1,set2,set3)]

list_of_subreddits_to_search = ["AskAcademia","AskanEngineer",
"AskEngineers", "AskReddit", "AskScience", "Education",
"Engineering", "EngineeringGradSchool", ...
                                "GradSchool", "Grad_School",
"HigherEducation", "Jobs", "LadiesofScience", "Resumes", "Science"]

id_array = []
title_array = []
selftext_array = []
posttime_array = []
subreddit_array = []
comment_id_array = []
comment_author_array = []

for subreddit_name in list_of_subreddits_to_search:
    subreddit_being_searched =
r.subreddit(("{}".format(subreddit_name)).search(search_query, sort
= "relevance", syntax = "lucene", limit = 500)

        comment_array = []
        submission_array = []

```

```

    for submission in subreddit_being_searched:
        id_array.append(submission.id)
        title_array.append(submission.title)
        selftext_array.append(submission.selftext)
        posttime =
datetime.datetime.fromtimestamp(submission.created).strftime('%c')
        posttime_array.append(posttime)
        comment_array.append("\nSUBMISSION AUTHOR: " +
submission.author.name)
        comment_array.append("\nTITLE: " + submission.title)
        comment_array.append("\nSELFTXT: " + submission.selftext)
        submission_array.append("\nAUTHOR: " +
submission.author.name + "\nTITLE: " + submission.title +
"\nSELFTXT: " + submission.selftext + "\n [POSTED]: " ...
                                + posttime)
        print(submission.title)

        submission.comments.replace_more(limit = 800)

        try:

            for level_1_comment in submission.comments:
                comment_array.append('---L1---')
                comment_array.append("{} : " +
level_1_comment.body).format(level_1_comment.author))

        except:
            pass
        file_path =
os.path.join("C:\\Users\\Carey\\Desktop\\Research\\Eng Edu
Research\\Grad Eng Attr\\query")
        if not os.path.exists(file_path):
            try:
                os.makedirs(file_path)
            except OSError as exc:
                if exc.errno != errno.EEXIST:
                    raise

        with
open("{}\\{}_comments.txt").format(file_path,subreddit_name),'w+',e
ncoding = 'utf-8') as file1:
            for s in comment_array:
                file1.write(s + "\n")
        file1.close()

        with
open("{}\\{}_submission.txt").format(file_path,subreddit_name),'w+'
,encoding = 'utf-8') as file1:
            for s in submission_array:
                file1.write(s + "\n")
        file1.close()

```

```
    stacked_array = subreddit_array + id_array + posttime_array +
title_array
    with
open("{}\\{}_stacked.txt").format(file_path,subreddit_name),'w+',en
coding = 'utf-8') as file1:
    for s in stacked_array:
        file1.write(s + "\n")
file1.close()
```