

“If I knew what else I should do, I would have left by now:” Two engineering PhD students’ experiences with Master’s-level departure

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Abstract— This Research Full Paper presents two examples of doctoral engineering attrition. To date, little research has been conducted on the many compounding factors that lead to attrition in graduate programs. In this paper, we present the narratives of two doctoral PhD students, Kelsey and Amy, who were deciding on departing from the engineering PhD. These narratives embody a deeper investigation of academic self-concept development through graduate school, with a focus on the decision-making processes to continue in the PhD program or decide to depart with a Master’s degree. At the time of the interviews, both participants were still enrolled in their programs, but one had definite plans to depart and left shortly after the interview. This study is one of the first that highlights the role of the Master’s degree as an off-ramp from the engineering doctorate and lends insight to narratives surrounding attrition in engineering: Despite academic success in their courses and successful research progress, these participants decided to depart even after passing significant milestones such as qualifying exams. This research presents the beginning of a larger research project with a goal of generating a more complete narrative of the attrition process for the students, with an explicit focus on Master’s-level departure.

Keywords—graduate students; attrition; pathways to engineering careers; women in engineering; academic self-concept

I. INTRODUCTION AND REVIEW OF RELEVANT LITERATURE

Graduate attrition is an understudied phenomenon, especially in engineering fields. While several studies of attrition in higher education in general have been published (see Bair and Haworth for a meta-analysis [1]), attrition numbers remain high across all disciplines—in some fields, upwards of 60%—indicating that mechanisms behind attrition are complex and still unknown. Aside from national reports (such as those by the Council of Graduate Schools [2]), arguably the most recognized research in higher education attrition is Barbara Lovitts’ Leaving the Ivory Tower, which analyzed the experiences of “non-completers” and their experiences in leaving their academic trajectories [3]. Other well-known work has been conducted by Gardner [4], [5], who studied the characteristics of high-, low-, fast-, and slow-completing disciplines. Engineering tends to be a high- and fast-completing discipline, likely due to industry funding and government

funding priority on STEM research. However, since the engineering doctoral attrition rates are still high—35% and 44% for men and women, respectively [2]—the mechanisms behind attrition represent a serious gap in the literature.

Attrition research in higher education generally revolves around the deep qualitative or small-scale quantitative investigation of student experiences that may lead to attrition. Overall, analyses of graduate attrition tend to point to advisor support [6]–[9], academic climate [10]–[13], personal traits (such as self-efficacy or self-regulation)[14]–[17], and funding [18]–[20] as factors of success. The importance of mentorship, in particular, is well documented. O’Meara’s [21] study highlights the advisor relationship in studying emotional competency in graduate students and their advisors, and Hunter and Devine’s [22] study of graduate student-advisor relationships employed leader-member exchange theory to illuminate the importance of advisor leadership. Narratives related to the feeling of “stuckness” in graduate school (exacerbated by maligned expectations, or an unsupportive advisor) are common [23].

Attrition has been studied through various theories and methods. Recently, Kelley and Salisbury-Glennon [14] studied All But Dissertation (ABD) graduate students across fields, correlating self-regulation with decreased time to completion, controlling for other factors, such as financial and social support, gender, and research self-efficacy. Similarly, Hunter and Devine [22] recently studied the psychological construct of “emotional exhaustion” as a predictive antecedent to leaving doctoral programs, using leader-member exchange theory to discuss the impacts of demanding workloads, ambiguity, and undervalue that graduate students undergo in relationship to students’ perceived potential for attrition. This method for studying dropout intentions was also conducted in research by Litalien and Guay [15], [24] as an attempt to predict future attrition. Studies such as these add value in interpreting students’ confidence in their abilities to persist.

In engineering education research, few researchers study graduate students or graduate attrition. Crede and Borrego are two main researchers in the field, performing mixed methods

and statistical work [8], [25], [26]. In engineering fields, attrition is complicated by the common practice of “mastering out” of PhD programs. Historically, this option was simply a backup plan for students who failed qualifying exams such that their coursework in the program would be rewarded. Today, this narrative is propagated by faculty, but new research [Authors, 2018, Authors, in press] finds that these incoming graduate students consider leaving with a Master’s degree for a variety of reasons and similarly apply to doctoral programs with a variety of intentions. The numbers of students departing with a masters (colloquially known as “mastering out”) from their programs—for any reason—are not captured through national surveys or through institutional data. Furthermore, most engineering departments, universities, or researchers have not rigorously sought to understand student rationales behind the decision to depart with a master’s degree.

This study employs academic self-concept theory, a motivational theory from social psychology. Academic self-concept is perception of one’s self as formed through interactions with people and the environment, defined through the factors of frames of reference, causal attributions, reflected appraisals from others, mastery experiences, and psychological centrality [27]. In application of Bong and Skaalvik’s definitions [27], graduate students are in a constant state of comparing one’s self against external milestones (e.g., department policies) and peers (frames of reference); can attribute success or failure to many different internal or external causes, some of which can be controlled and some which cannot, such as advisor relationship (causal attribution); are constantly worrying about how peers, professors, and research advisors view them or their potential (reflected appraisals); are continuously either meeting or not meeting authentic demonstrations of competence and mastery through their coursework or research (mastery experiences); and are affected by self-esteem issues related to their performance in relationship with topics they think to be talented in and the feeling they are in the correct discipline or career trajectory (psychological centrality).

Using academic self-concept theory, the purpose of this paper is to explore the decision-making processes of two women engineering doctoral students who, at the time of the interview, were considering departing with a master’s degree. As Golde [28], [29] notes, the extent of doctoral attrition is a well-kept secret in academia, and as the students silently leave, their stories so too disappear. However, while past literature presents narratives as stories of attrition as “dropping out” [28, p. 199] and “failure” [28, p. 203], we re-frame attrition from being a failure on the students’ part, instead focusing on the student achieving different goals, including finding the correct path for their life. We therefore re-frame the term “mastering out” or “dropping out” to departure. In engineering, many students depart the PhD after achieving a Master’s degree, which we term “Master’s-level departure.” The present work seeks to answer the following question: How do doctoral engineering students considering Master’s-level departure characterize their preparation for and experiences during graduate school?

II. METHODS

A. *Research Context*

This research was conducted as part of two larger IRB-approved studies, one studying the role that academic writing plays in engineering graduate students’ career trajectories, attrition, and persistence; and the other one studying students’ experiences with departure from the engineering PhD by taking a Master’s degree. The two projects have similar goals in understanding pathways to and through the engineering PhD. The interviews conducted that form the data for the present paper were collected as part of the first project, but the analysis and insight developed through this research aligns strongly with the specific purpose of the second to characterize Master’s-level departure.

Through the larger research project, we first surveyed a nationwide sample of graduate engineering students from research-focused institutions across the United States by contacting points of contact in each engineering department at each of the ten universities. The universities were selected to be geographically diverse with a strong reputation for producing engineering PhD students [30]. The request for participation included a link to a survey about career trajectories and writing attitudes and included an opportunity to indicate interest in participating in a follow-up interview. Thirty-eight participants were selected for a follow-up interview based on maximum variation sampling for gender, race, institution, and engineering department, such that no institution or discipline was overrepresented. All participants for this phase were U.S. citizens or permanent residents. Participants were incentivized with a \$5 and \$10 e-gift card for participation in the survey and interview, respectively.

Interviews with the selected participants occurred via Zoom online conferencing software. Audio-recordings of the interviews were sent to a professional transcription service, and then were checked by a member of the research team for accuracy and to fill in any blanks. The transcripts were analyzed through emergent open and axial coding methods [31] through a constructivist paradigm [32], [33] using an abductive analysis approach [34] to interpret findings. Abductive analysis does not seek to develop new theory but holds existing theory in mind while analyzing and interpreting data in order to note where data both upholds and deviates from existing theory.

B. *Methods for the Present Study*

The narratives of the two participants whose interviews comprise this study, Amy and Kelsey, were selected from the others because of their similarities in emergent themes and because they both were outliers from the other narratives of current graduate students. Each of these participants identified as white women. At the time of the interview, both women fell into the category of “questioner”—those who didn’t know whether they would complete their PhD or not. The two narratives of Amy and Kelsey were then analyzed through narrative analysis methods [35], [36] to understand stories, timelines, and participant accounts of experiences occurring over time, yielding a rich approach to understanding the stories and experiences in engineering doctoral students’ decisions to remain or depart from the Engineering PhD.

Both participants' names in this study are pseudonyms, and we have redacted information that would easily link these narratives to the women. Especially because women are so underrepresented at the graduate level in most engineering disciplines [30], any additional identifiers, such as engineering discipline would increase the chances of identifiability considerably. The confidentiality of our participants is of utmost importance; therefore, we have redacted identifying information.

C. Limitations

This study represents the experiences of only two women engineering PhD students as they considered Master's-level departure, and should not be extended or generalized to either all students or all women engineers. Rather, the themes that emerge may provide a more nuanced perspective on how students characterize their own decisions to remain or depart from their programs. We also note some limitations because, in order to make the data sufficiently de-identifiable, we chose to not include specifics that would make quote even richer.

III. RESULTS

A. Introduction to Participants Amy and Kelsey

Amy. Amy was first exposed to engineering in college through an extra-curricular robotics competition. The success and excitement from this robotics competition led her to pursue a graduate degree in engineering. Amy initially failed her qualifying exams but passed on her second attempt. She also was awarded the NSF GRFP and has earned her Master's degree. Her current work is in what she calls "good old-fashioned AI" (Artificial Intelligence). Her research advisor is very hands-off, which she believes contributes to a slow rate of graduation from her lab. Despite being in her fifth year, she had no plans to graduate soon, saying "if it takes me less than seven years... I will be floored." As such, she is undecided if she will stay in her program or depart at some point in the future.

Kelsey. Kelsey grew up in a family of engineers and enjoyed building things and conducting science experiments growing up. But admittedly, was never a "clear-cut STEM type." She loved Latin and was initially considering becoming a classics major in college. Her mind was changed after attending a summer program for women in engineering while in high school. After that she decided to pursue mechanical engineering. While her time as an undergraduate was initially tough, after an encouraging semester and internship, she decided to continue engineering in graduate school. Kelsey initially applied for the Master's program, but was mistakenly accepted into the PhD program. She decided to stay in the program. Similarly to Amy, Kelsey failed her first attempt at qualifying exams and passed the second. Now, three years into her program, she is seriously considering leaving graduate school.

B. Emergent Themes

Through the analysis of Amy and Kelsey's interviews, several main themes emerged that we consider to add value to existing graduate socialization theory and graduate-level engineering education research: Role of alternate identities and

talents before and during graduate school; Motivation for Continuing; and Outlooks toward the Future.

1) Role of Alternate Identities and Talents Before and During Graduate School

Both women had a piece of their identity in activities outside of their engineering graduate program, but the significance placed on and attitude towards these alternate identities contributed to their perspective on their time in the graduate school. When asked about how she dealt with the pressures of graduate school, Amy told us about the importance of being proud of things outside of research. Knitting has always been a hobby of hers, so she decided to start a class at the local craft store. In this class, she is considered the expert. That reverence is not something she experiences in graduate school, so she finds pride in her accomplishments with her hobby. The pride gained from her hobby does not demotivate her from her work, but rather encourages her on particularly difficult days.

Kelsey, on the other hand, struggled with a sense of lost-self because of her lack of ability to pursue her passion in Latin and literature in her time as an undergrad. She felt like she had to abandon the literature classes she enjoyed in order to focus more on her engineering courses.

"My major didn't get off to a great start sophomore year. And I did notice in many cases I was enjoying my single humanities class that I was able to take per semester more than my engineering classes, but was reminded by people I knew and had to keep telling myself, you know, 'I've chosen to study engineering. That needs to be what I prioritize.'"

This dichotomy of passions echoed in her time as a graduate student where she continued to study engineering. The tension ended up being a driving force behind her decision to look for alternate career paths.

2) Motivations for Continuing

In the interviews, both women mentioned multiple times that they could have left the program but had decided to stay. Kelsey was originally mistakenly admitted into the PhD program rather than the Master's track when she started graduate school. After talking with her advisor, she decided to stay in that program, rather than switching back to the Master's. Looking back, Kelsey felt like she was unprepared to make that decision.

"...I ended up deciding to just take the leap of faith and go for it, which was an interesting decision. I don't necessarily regret it, but I was not at all ready. I don't think I had enough information at the time to make that decision. ... And I had an understanding with [my advisor] that if it didn't go well, then I could always, as she put it, 'Cash out with a Master's' after two years."

In contrast, Amy's first decision junction happened when she failed her first attempt at her program's qualifying exams. After seriously considering leaving due to the difficulty she had been experiencing with classes already, she decided to rework her studying approach and passed them on the second attempt.

She considers the entire experience of failure and perseverance to be one of her biggest successes in graduate school. But currently Amy feels her research is unsatisfying. With little project direction from her advisor and no publications, she feels like most of her work is left unfinished.

"I do a lot of kind of boring stuff, which is fine. I'm totally fine with powering through some engineering, but I feel like I never get to finish anything. And this is probably true in terms of most academics, but I never get to finish a project and say like, 'Yes, I put that robot out on the soccer field and it's going to do stuff and it's awesome.' It's usually like, 'Oh, I collected enough data to maybe make a paper.' and it's kind of... 'But maybe someone will publish it. So, we're done.' I think that's the biggest thing that frustrates me and makes me sort of feel like I'm never quite getting to where I want to be."

Beyond feeling unsatisfied with her work, she is also disappointed with the academic culture and dislikes the notion of "selling your work" rather than have it speak for itself.

"I always pictured academia as being this thing where you write papers as this method of communicating to your academic peers, and there's this grand discussion, and it's very civilized. But that was really not the case. There's a lot more interpersonal stuff going on than I had really expected, like presentation is more important than I expected. And that was kind of... I don't know. I don't know if I want to say disappointing, but maybe disappointing."

Her lack of sense of purpose and presence in a community contribute to her considerations of leaving.

So how did both women get to the middle of their graduate careers with this doubt and uncertainty weighing on them? Both women believed that they should keep moving forward with engineering because that is what they knew how to do. Both women recognized that they did not know what to do with their Bachelor's degree after undergraduate, but they knew how to be students, so they continued on to graduate school. They both struggled in their first semesters and discussed that their mental health suffered for it, but they believed if they kept going, something might change. Kelsey admitted that engineering graduate school may have never been the right choice for her.

"...I've known for a pretty long time that I'm really not all that excited about the prospect of a career in engineering. I think to an extent it's never felt quite right, but it is the path that I've been on, its, I guess to an extent, what's been expected of me. And 90% of the people who have come into my life since I graduated high school are engineers, or at least are in STEM in some way. And I very much like those people and have a lot of respect for them. And I started thinking about just the identity issues of if I left engineering, how much of my own understanding of myself is built off of being an engineer or being a woman engineer."

Both women expected to find a reason to stay in their graduate programs, rather than have intrinsic motivation.

3) Participants Outlooks toward the Future

The tone of each interview shifted as the interviews progressed. Kelsey started out bleak, with discussions on her regret regarding abandoning her passion for literature and her difficulties with her advisor. But her tone shifted to hopeful when as she told us about considering leaving the program and pursuing a career in a related, but non-technical field that would require a significant amount of writing. She was interested in it as she felt that her STEM background would not go to waste, but she would still have a career where her job is to write, a skill she had found confidence in. She told us about her initial fears of telling her advisor and being labeled as a "drop-out" for the rest of her life. Kelsey's fears of telling her advisor were soothed when her advisor was supportive and encouraging of her choice to change career paths. Just because she was not pursuing a traditional engineering career, did not mean her graduate work was a waste of time. At the time of the interview, Kelsey was still enrolled and researching as a graduate student:

"I don't think there's any shame in wanting something different. And so, I've tried to be more open about, I'm doing a PhD and it might not be for the same reason as everyone else, but that doesn't make it any worse of a reason."

Kelsey's fears had since been soothed. Her mother and a friend had modeled successful career transitions and she was excited for the potential of this new career.

"Hearing that she had made that decision, it made me see that it's okay to change your mind, especially when you're 24. I shouldn't feel like I'm locked into a career path, just because of where I started."

Amy's interview shifted the opposite way. She began talking about how she had found a passion for engineering in undergrad and initially enjoyed the research in her lab. She then opened up about her disappointment with academic culture and discouragement with her lack of publications. She felt her work could not speak for itself and that presentation was more important. She felt directionless. At the time of the interview, Amy was five years into her program with no plans to graduate soon. She spoke about how earning her Master's came as a relief, because she could leave then with some sort of graduate degree.

"I did get my masters and was like, 'Well, I can leave now if I want.' That was sort of a relief. ...definitely after my prelims considered several times like, 'Hey, I've proven that I can do it, so I could get a job where I know what I'm doing.' Like, that would be wonderful. And so, I think... I think I actually go through the process of, 'Huh, maybe I should quit,' like once a month. And it's not idle, it's very serious."

Yet Amy remains in her doctoral program because, as she said, "If I knew what else I should do, I would have left by now." Her lack of direction motivated her to stay with what she knows, keeping her in a constant state of indecision.

IV. DISCUSSION AND IMPLICATIONS

A. *Relationships of Findings with Extant Literature*

There were a number of commonalities between the two women's experiences. Both struggled in their first semester of graduate level classes, both failed their first attempt at the doctorate qualifying exams, and both struggled with their mental health in that first year. It is a common assumption regarding graduate attrition that those who leave do so because they were not "cut-out" for the rigor of graduate school. Contrary to this, neither woman contributed their initial struggles with classes and qualifying exams as a major factor in their decision to leave. The fact that both women were multiple years into their studies (Amy for five and Kelsey for three), demonstrates that the level of work expected of them was not something they felt they could not handle. Amy herself believed she had already proven herself to be capable at the graduate level when she passed her qualifying exam the second time, was awarded a National Science Foundation Graduate Research Fellowship, and earned her Master's degree.

These findings contradict a common narrative in graduate education, which mistakenly attributes attrition to academic failure. Both successfully passed qualifying exams within the expectations of their departments, and one was awarded a prestigious national fellowship and earned a Master's degree. Therefore, this research aligns well with our research group's prior findings [Authors, in press] that attrition is typically not a result of academic failure, but a host of other factors related to internal and external issues.

Both women spoke highly of their advisors and said that they have enjoyed working with them. While there were some difficulties with her advisor along the way, Kelsey felt that after some communication, those issues were addressed. She appreciated that her advisor had been so supportive and understanding through the decision process. Amy mentioned how her advisor was "hands-off," possibly contributing to her lack of direction, but never attributed her indecision and doubts to her relationship with him. Graduate attrition and persistence literature commonly notes that the 'fit' between advisor and student and access to mentorship are crucial to the development of academic identity and persistence [6], [9], [37], [38]. Our findings add to this conversation in that even during the questioning process, students need to trust that their advisors are advocates for the person, not just the engineering side, as they journey in their development of professional identity. The relief that Kelsey felt when her advisor validated her career plans helped her make the correct decision for her own life, without adding worry that her decisions would be held against her. Hunter and Devine [22] posit through leader-member exchange theory that positive experiences with advisors will reduce emotional load, therefore decreasing attrition. However, in Kelsey's case, the advisor relationships did reduce emotional load—after she confided her misgivings with continuing and her advisor was gracious and supportive. Our findings, in combination with other recent findings, shows that advisor relationships are indeed important, but is not enough to override other elements of attrition.

These two narratives are also unique and add value to literature because both women also expressed having strong non-engineering identities. For Amy, it is an expertise in crafting and art, and for Kelsey, it is an interest in humanities and strong competency in writing. Not much is known in literature that explores the non-academic expertise or interests of graduate students in relationship to their professional identities, but literature does show that graduate students may struggle to align identities, such as teacher-scholar identities (as teaching is typically not viewed as highly as research in STEM) [39] or parent (usually motherhood)-scholar identities [40]. In the cases of Amy and Kelsey, the non-engineering identities served as a lifeboat to maintain balance and self-confidence while academics were difficult, but also served to complicate the issue of identifying the "right" path forward. Kelsey, for example, had to choose at a very early age of life—in early undergraduate—if she wanted to choose a career in humanities or engineering. Because she felt these two identities could not be reconciled, she abandoned one, and could not rely on it as a support, although her confidence in her writing abilities carried her through to have the agency to find alternative careers in which she could succeed. Upon finding a career path that seems to merge the two, she felt the freedom to leave and move forward with a goal in mind. For Amy, a lack of direction and disappointment with academic culture keeps her stuck in a state of indecision. There are many compounding factors that lead to graduate level attrition and these two examples highlight that those factors may not be what is assumed to be common.

B. *Relationship with Academic Self-Concept Theory*

The tensions of both Amy and Kelsey, and the subsequent decision-making processes each woman wrestles with in the decision to stay in an engineering PhD program or depart with a Master's degree can be viewed through academic self-concept theory. Each participant noted comparing themselves against various frames of reference: Although ultimately successful, they did not pass their qualifying exams the first time, thereby pressing against the standards and expectations of their respective departments and universities. Similarly, as Amy notes, she thought she would be publishing, but is caught in a continuous cycle of data analysis without being able to see any projects through to completion—another frame of reference. Each participant demonstrated causal attribution as she discussed the various facets of her pathway that led her to the place she was now, attributing various factors to the reasons for progressing through education in the way they did, including the winning of fellowships and awards. The facet of reflected appraisals manifests in the narratives (especially Kelsey's) of worrying about how others would view her if she admitted to considering departing from an academic career, and "what's expected" of her from others. They both have a great number of "mastery experiences" in their research milestones, but the continuous grind of data collection without end products (in Amy's story) can dilute the impact of mastery experiences on positive academic self-concept. Lastly, and likely the most evident theme, both participants in this narrative study struggled with aspect of psychological centrality, in that they didn't feel like their career trajectory was well aligned with

their non-academic identities and competencies, leading to a feeling that they were on the path to the “wrong” career. As a note, none of these facets in the journeys of Amy and Kelsey relate to failure in either an academic or motivational context. Instead, this theoretical framework elicits an understanding of the misalignments that underlie these two participants’ questioning processes in whether to remain or depart from graduate school, and potentially can add color to other studies of engineering attrition.

C. Implications and Future Work

Narratives like Amy’s and Kelsey’s highlight the need to clear communication between advisor and advisee about expectations and goals for graduate school. These conversations should happen early in the relationship to prevent feelings of lack of direction and purpose mid-way through the programs. Many graduate students, especially women, seek to maintain credibility by making non-academic identities invisible [40], an extension of ideal worker theory [41]. Perhaps a conversation about “conflicting” interests earlier could have led to a research project tailored for Kelsey, or perhaps an advisor could have leveraged her passion for writing by asking her to help with publications earlier in her career. Perhaps explicit discussions on expectations for timeline and research activities through graduate school could have given Amy a better sense of her advisor’s working style and the type of work from the beginning of her program, and she could have chosen if that was a good fit.

Ultimately, although these are the students’ decisions to make, about deciding which research advisor to join, faculty and departments should be quite aware that students are often anxious about these decisions and making decisions without understanding what graduate school is and how it differs from the undergraduate curriculum. Recently, Crede and Borrego [42] began to investigate how and why undergraduate students chose to pursue graduate school, calling to attention the role of undergraduate research experiences in preparing undergraduate students for future research. In our study, Amy wanted to pursue graduate school after positive experiences with extracurriculars and research experiences, in addition to not knowing what else to do after the Bachelor’s degree. Kelsey, conversely, pursued graduate school since it seemed to be the next step, rather than for a particular intrinsic or extrinsic reason. This lack of direction then compounded in a paralysis of sorts: Amy identified knowing that this wasn’t the right path, and that if she knew what the right path was, she would leave. Kelsey’s pathway takes a similar narrative: After finding a career trajectory that seemed to align with her strengths, she found the courage to leave her program. Research advisors should express genuine interest and support for students’ non-academic identities, past experiences, and reasons for pursuing graduate school—not as a way to judge or attribute more or less value to them—but to work to leverage students’ strengths and demystify the graduate education process for students.

Advisors and engineering educators should also be more open and supportive of alternate career paths, working with students as mentees rather than simply as research machines. In Kelsey’s story, much of her anxiety was relieved when her advisor continued to support her even after she “confessed”

considering alternate career paths. Even though her advisor had initially given her the ‘permission’ to “‘cash out’ with the Masters,” it still caused her extreme anxiety to discuss these dilemmas with her advisor. Research advisors and faculty should be aware that graduate students, through their academic identity process, may be feeling quite sensitive about graduate school and academic success, and forget that students may feel shameful about considering non-academic career paths, or changing goals and plans. Faculty should also remember that there is a severe power dynamic when discussing such issues with students, that they—even without saying anything—perceive their funding to be tied up with advisor approval.

Future work on this project includes a nationwide investigation of Master’s-level departure and the ways in which various factors impact students’ decision-making processes. In addition to broadening the research, we also anticipate comparing patterns of socialization and academic self-concept between completers, non-completers, questioners, and Master’s-level departers, and those that departed at various stages in their programs to characterize attrition from the doctoral engineering PhD.

V. CONCLUSION

This paper presented a narrative analysis of two women PhD students who, at the time of the data collection, were questioning whether or not they would stay in their PhD programs or depart with a Master’s degrees. The narratives had several themes in common; in particular, the fact that both the women had “non-academic” identities and competencies they held strongly; motivations for continuing that were grounded in the ambiguity of not knowing what other career trajectories were available; and outlooks on future steps as a result of these factors. We aligned the facets of academic self-concept theory to describe the tensions that these women reported in aligning and reconciling their goals and competencies outside of graduate school with their academic identities.

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REFERENCES

- [1] C. Bair and J. G. Haworth, *Doctoral Student Attrition and Persistence: A Meta-Synthesis*, no. 4. 1999.
- [2] Council of Graduate Schools, “Ph.D. Completion and Attrition: Analysis of Baseline Data,” 2008.
- [3] B. E. Lovitts, *Leaving the Ivory Tower: The Causes and Consequences of Departure from Doctoral Study*, vol. 32. 2001.
- [4] S. K. Gardner and S. K. Gardner, “Contrasting the Socialization Experiences of Doctoral Students in

High- and Low-Completing Departments: A Qualitative Analysis of Disciplinary Contexts at One Contrasting the Socialization Experiences of Doctoral Students in High- and Low- Completing Dep,” vol. 81, no. 1, pp. 61–81, 2017.

- [5] S. K. Gardner and B. J. Barnes, “Graduate Student Involvement: Socialization for the Professional Role,” *J. Coll. Stud. Dev.*, vol. 48, no. 4, pp. 369–387, 2007.
- [6] D. H. Mansson and S. a. Myers, “Using Mentoring Enactment Theory to Explore the Doctoral Student-Advisor Mentoring Relationship,” *Commun. Educ.*, vol. 61, no. 4, pp. 309–334, Oct. 2012.
- [7] N. Curtin, A. J. Stewart, and J. M. Ostrove, “Fostering Academic Self-Concept: Advisor Support and Sense of Belonging Among International and Domestic Graduate Students,” *Am. Educ. Res. J.*, vol. 50, no. 1, pp. 108–137, May 2012.
- [8] E. Crede and M. Borrego, “Learning in graduate engineering research groups of various sizes,” *J. Eng. Educ.*, vol. 101, no. 3, pp. 565–589, 2012.
- [9] B. J. Barnes, “The nature of exemplary doctoral advisors' expectations and the ways they may influence doctoral persistence,” vol. 11, no. 3, pp. 323–343, 2010.
- [10] D. Bilimoria and A. J. Stewart, “‘Don’t Ask, Don’t Tell’: The Academic Climate for Lesbian, Gay, Bisexual, and Transgender Faculty in Science and Engineering,” vol. 21, no. 2, 2009.
- [11] S. J. Ceci, W. M. Williams, and S. M. Barnett, “Women’s underrepresentation in science: sociocultural and biological considerations,” *Psychol. Bull.*, vol. 135, no. 2, pp. 218–61, Mar. 2009.
- [12] J. C. Weidman and E. L. Stein, “Socialization of doctoral students to academic norms,” *Res. High. Educ.*, vol. 44, no. 6, pp. 641–656, 2003.
- [13] E. C. Paschal, “Factors influencing attrition in U.S. universities: Examining transitional cognitive dissonance in a new meta-model for analysis,” *Diss. Abstr. Int. Sect. A Humanit. Soc. Sci.*, vol. 70, no. 2–A, p. 606, 2009.
- [14] M. J. M. Kelley and J. D. Salisbury-Glennon, “The Role of Self-regulation in Doctoral Students’ Status of All But Dissertation (ABD),” pp. 87–100, 2016.
- [15] D. Litalien, F. Guay, and A. J. S. Morin, “Motivation for PhD studies : Scale development and validation,” *Learn. Individ. Differ.*, vol. 41, pp. 1–13, 2015.
- [16] J. M. Braxton and L. L. Baird, “Preparation for professional self-regulation,” *Sci. Eng. Ethics*, vol. 7, no. 4, pp. 593–610, Jul. 2001.
- [17] V. L. Bieschke, K. J., Bishop, R. M., & Garcia, “The utility of the research self-efficacy scale,” *J. Career Assess.*, vol. 4, no. 1, pp. 59–75, 1996.
- [18] L. S. Spaulding and A. J. Rockinson-szapkiw, “Hearing their Voices : Factors Doctoral Candidates Attribute to their Persistence,” vol. 7, 2012.
- [19] P. Mendoza, P. Villarreal, and A. Gunderson, “Within-Year Retention Among Ph.D. Students: The Effect of Debt, Assistantships, and Fellowships,” *Res. High. Educ.*, vol. 55, no. 7, 2014.
- [20] J. C. Williams, T. Alon, and S. Bornstein, “Beyond the ‘Chilly Climate’: Eliminating Bias Against Women and Fathers in Academe,” *NEA High. Educ. J.*, pp. 79–96, 2006.
- [21] K. O’Meara and C. M. Campbell, “Faculty Sense of Agency in Decisions about Work and Family,” *Rev. High. Educ.*, vol. 34, no. 3, pp. 447–476, 2011.
- [22] K. H. Hunter and K. Devine, “Doctoral Students’ Emotional Exhaustion and Intentions to Leave Academia,” vol. 11, pp. 35–61, 2016.
- [23] M. Kiley, “Identifying threshold concepts and proposing strategies to support doctoral candidates,” *Innov. Educ. Teach. Int.*, vol. 46, no. 3, pp. 293–304, 2009.
- [24] D. Litalien and F. Guay, “Dropout intentions in PhD studies : A comprehensive model based on interpersonal relationships and motivational resources,” *Contemp. Educ. Psychol.*, vol. 41, pp. 218–231, 2015.
- [25] E. Crede and M. Borrego, “Understanding retention in US graduate programs by student nationality,” vol. 39, no. 9, pp. 1599–1616, 2014.
- [26] E. Crede and M. Borrego, “From Ethnography to Items : A Mixed Methods Approach to Developing a Survey to Examine Graduate Engineering Student Retention,” 2013.
- [27] M. Bong and E. M. Skaalvik, “Academic Self-Concept and Self-Efficacy : How Different Are They Really ?,” vol. 15, no. 1, pp. 1–40, 2003.
- [28] C. M. Golde, “Should I Stay or Should I Go? Student Descriptions of the Doctoral Attrition Process,” *Rev. High. Educ.*, vol. 23, no. 2, pp. 199–227, 2000.
- [29] C. M. Golde, “Beginning Graduate School : Explaining First-Year Doctoral Attrition,” no. 101, 1996.
- [30] B. L. Yoder, “Engineering by the Numbers 2014–2015,” 2016.
- [31] H. J. Rubin and I. S. Rubin, *Qualitative Interviewing: The Art of Hearing Data*. Sage, 2011.
- [32] K. Charmaz, *Constructing grounded theory: A practical guide through qualitative research*. London: SAGE Publications, Inc., 2006.
- [33] K. Charmaz and L. L. Belgrave, “Chapter 24: Qualitative Interviewing and Grounded Theory Analysis,” in *The SAGE Handbook of Interview Research: The Complexity of the Craft*, 2012, pp. 347–367.
- [34] S. Timmermans and I. Tavory, “Theory Construction in Qualitative Research: From Grounded Theory to Abductive Analysis,” *Sociol. Theory*, vol. 30, no. 3, pp. 167–186, Sep. 2012.
- [35] D. E. Polkinghorne, “Narrative configuration in qualitative analysis,” *Int. J. Qual. Stud. Educ.*, vol. 8, no. 1, pp. 5–23, 1995.
- [36] J. M. Case and G. Light, “Emerging research methodologies in engineering education research,” *J. Eng. Educ.*, vol. 100, no. 1, pp. 186–210, 2011.

- [37] B. J. Barnes and J. Randall, "Doctoral Student Satisfaction: An Examination of Disciplinary , Enrollment , and Institutional Differences," pp. 47–75, 2012.
- [38] C. G. P. Berdanier and K. Luchini Colbry, "The Care and Keeping of Graduate Students : An Interactive Panel Discussion for Novice Advisers of Graduate Students The Care and Keeping of Graduate Students : An Interactive Panel Discussion for Novice Advisors of Graduate Students," in *ASEE Annual Conference & Exposition*, 2017, pp. 1–9.
- [39] M. R. Connolly, Y. Lee, and L. B. Hill, "Building a Better Future STEM Faculty Can Improve Undergraduate Education," 2016.
- [40] S. Carter, M. Blumenstein, and C. Cook, "Different for women? The challenges of doctoral studies," vol. 18, no. 4, pp. 339–352, 2013.
- [41] I. L. Bleijenbergh, M. L. van Engen, and C. J. Vinkenburgh, "Othering women: fluid images of the ideal academic," *Equal. Divers. Incl. An Int. J.*, vol. 32, no. 1, pp. 22–35, 2012.
- [42] M. Borrego, D. B. Knight, K. Gibbs, and E. Crede, "Pursuing Graduate Study: Factors Underlying Undergraduate Engineering Students' Decisions," *J. Eng. Educ.*, vol. 107, no. 1, pp. 140–163, 2018.