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Decoding Doctoral Student Departure: A Mixed-Methods Study of Faculty Perceptions and Student Realities in Computing

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Decoding Doctoral Student Departure: A Mixed-Methods Study of Faculty Perceptions and Student Realities in Computing

A dissertation submitted in partial satisfaction of the requirements required for the degree of

Doctor of Philosophy in Education

by

Kari Lynn George

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ABSTRACT OF DISSERTATION

Decoding Doctoral Student Departure: A Mixed-Methods Study of Faculty Perceptions and Student Realities in Computing

by

Kari Lynn George

Doctor of Philosophy in Education

University of California, Los Angeles, 2020

Professor Linda J. Sax, Chair

Efforts to address the faculty shortage in computing disciplines and to diversify the technology workforce are hindered by high rates of doctoral student attrition. Yet, little is known about students' consideration of departure – an important psychological precursor to their decision to stay or leave. This purpose of this study was to investigate explanations for student's consideration of departure from both graduate student and faculty perspectives. I also examined how computing faculty conceptualize their role in shaping the doctoral student experience and outcomes.

Drawing from conceptual models of doctoral student degree progress and frameworks of institutional logics, this study used a sequential mixed-methods design to understand the individual and organizational factors that contribute to computing doctoral students' persistence and to their consideration of departure. The quantitative inquiry used survey data collected from

students in 2018 to examine student explanations for why they considered leaving their program and what helped them to continue, as well as factors that predicted students' consideration of departure. The qualitative inquiry relied upon in-depth interviews with 10 computer science faculty members recruited from institutions represented in the quantitative sample to examine faculty perceptions of students' consideration of departure and their role in student experiences and outcomes.

Quantitative results revealed that students primarily consider departure due to a lack of support and inclusion in the department; specifically, they reported feeling isolated and unsupported by faculty. Alternatively, faculty members primarily attributed consideration of departure to students' changing career interests and the intellectual and psychosocial struggles students often experience in the doctoral program. Evidence from both students and faculty suggests that the departmental environment and relationships with others (e.g., faculty and peers) have a strong influence on doctoral students' persistence, particularly in shaping students' beliefs about themselves and their abilities.

Despite acknowledging the rising pressures and challenges of pursing a PhD, faculty often held deficit perspectives and emphasized their role in bolstering students' ability to cope with the challenges, instead of addressing broader systemic issues in computing graduate environments. Accordingly, this study illuminates opportunities for interpersonal and organizational change that may bolster the computing pipeline and broaden participation in computing.

The dissertation of Kari Lynn George is approved by:

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2020

To all the teachers and mentors who sparked and encouraged my learning,

thank you for the inspiration.

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Publications and Select Presentations

Sax, L. J., **George, K. L.**, Harris, D., & Payton, F.C. (2020). Reframing the underrepresentation of Black students in undergraduate computing. *Journal of Women and Minorities in Science and Engineering, 26*(4), 325-356.

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George, K. L., Sax, L. J., & Sundar, S. (2019, May). Visualizing institutional data to measure success toward diversity. Discussion workshop presented at the 2019 Association for Institutional Research (AIR) Annual Conference, Denver, CO.

George, K. L. & Wofford, A. M. (2019, April). Relationships with faculty and self: Examining the factors that contribute to STEM graduate degree intentions. Paper presented at the 2019 American Educational Research Association (AERA) Annual Meeting, Toronto, ON.

Sax, L. J., Blaney, J., Lehman, K., Rodriguez, S., **George, K. L.**, & Zavala, C. (2018). Sense of belonging in computer science: The role of introductory courses for women and underrepresented minority students. *Social Sciences, 7*(8), 1-24.

George, K. L. (2017, November). The mental game of graduate school for women in science: Should I stay or go? Paper presented at the 2017 Association for the Study of Higher Education (ASHE) Conference, Houston, TX.

Sax, L. J., Blaney, J., Lehman, K. J., Rodriguez, S., **George, K. L.**, & Zavala, C. (2017, November). Sense of belonging in computer science: The role of introductory courses for women and underrepresented minority students. Paper presented at the 2017 Association for the Study of Higher Education (ASHE) Conference, Houston, TX.

George, K. L. (2017, April). Preparing college graduates for a global workforce: Examining predictors of pluralistic orientation. Paper presented at the 2017 American Educational Research Association (AERA) Annual Meeting, San Antonio, TX.

CHAPTER 1: INTRODUCTION

"It is certain that a student's commitment to earning a degree in a particular discipline is continually modified by his or her experiences in that department. What the faculty do to stimulate the student's interest and to strengthen the student's commitment may ultimately determine the level of degree progress achieved by students in that department."
– Girves and Wemmerus (1988)

Economic growth and expanding workforce opportunities highlight the need for more science, technology, engineering, and mathematics (STEM) graduate degree earners, particularly those with a doctoral degree who can contribute to knowledge production and fuel discovery in all sectors of society (National Academies of Science, Engineering, and Medicine [NASEM], 2018a). However, a lack of diversity within the STEM workforce stifles innovation and limits the creativity needed to support an increasingly diverse population (National Science Board [NSB], 2016). For example, while the majority of undergraduate and graduate degree earners are women, they represent less than 30% of the science and engineering workforce, with greater disparities in engineering, computer science, and the physical sciences (NSB, 2016). To ensure our economic competitiveness and bolster innovation, it is imperative that we expand the STEM workforce, to support traditionally underrepresented groups (i.e., women and Black, Hispanic, and Native American individuals) (Committee on Equal Opportunities in Science and Engineering [CEOSE], 2013).

A driving force contributing to the economic growth and global competitiveness of the United States is its robust computing and technology sector which has seen almost a 15% increase in total employment opportunities across all occupations (NSB, 2018). In the past several years, the tech industry has received a great deal of criticism for its lack of diversity. Women represent just 26% of the computing workforce (National Center for Women in Information Technology [NCWIT], 2019). Within Silicon Valley, a hub of the tech industry, the

representation of underrepresented racially minoritized (URM) employees (i.e., individuals who identify as Native American, Black, or Hispanic) is just 2-3% (Weise & Guynn, 2014). This severe lack of equity hinders economic mobility for women and employees of color, as computing jobs are among the highest paid occupations with a median income that is $50,000 higher than the annual median income of all other sectors (Bureau of Labor Statistics, 2018)

Further, this lack of diversity in computing stifles innovation and has technical and business consequences when homogenous teams build products or services that do not serve the broader population appropriately. Several recent examples of flawed product design reveal how gender and racial biases are perpetuated through the development of new technologies. Notably, Amazon's artificial intelligence (AI) recruiting tool showed a bias against women (Dastin, 2018), AI voice assistants (e.g., Apple's Siri and Amazon's Alexa) were found to reinforce harmful gender stereotypes (Sydell, 2018), and facial recognition software was less accurate in identifying people of color (Lohr, 2018). Indeed, the U.S. will have a difficult time remaining competitive without a more diverse workforce (Rodriguez & Lehman, 2017). The social justice case for diversity in the STEM and computing workforce (i.e., the social mobility imperative for underrepresented groups) and the economic case for diversity (i.e., that diverse teams develop better products and services, and are more profitable; Eaton-Cardone, 2018; Hunt et al.,2015) compel the urgent need to explore solutions to the lack of diversity in the workforce.

Focusing on graduate education may reveal opportunities to help address the need for a more diverse workforce. Since students' graduate experiences and environments affect their progress and shape their outcomes of completing or leaving their degree program (Nettles & Millet, 2006), identifying ways to enhance their persistence by addressing challenges or obstacles in graduate education will bolster the STEM workforce. Graduate enrollment has risen

steadily over the last decade, with more than 1.8 million graduate students enrolled in the Fall 2017 term (inclusive of master's, doctoral, and graduate certificate programs; Okahana & Zhou, 2018). Of those, 468,000 students are pursuing doctoral degrees (Okahana & Zhou, 2018). However, inequities in doctoral education, broadly, limit the production of PhDs degree earners and unevenly compromise the pursuit of a doctorate for certain groups of students. Notably, inequities exist in admission (Posselt, 2016), financial support and debt load (Ampaw & Jaeger, 2012; NSB, 2018;), time to degree (Bair & Haworth, 1999; Ferrer de Valero, 2001), and completion rates (Bowen & Rudenstein, 1992; Lovitts, 2001; Zhou & Okahana, 2019). While there have been slight improvements in the last twenty years, the fact remains that nearly half of students who begin their doctoral degrees do not finish (Council of Graduate Schools [CGS], 2008; Zhou & Okahana, 2019).

Though completion rates vary across fields (Golde, 2005; Sowell, Allum, & Okahana, 2015), the substantial attrition problem in doctoral education is worse for certain student groups – namely women and URM students who leave their programs at higher rates than their white and Asian male counterparts (Denecke et al., 2007). This contributes to the persistent underrepresentation of these groups among doctoral degree earners in disciplines which desperately need greater diversity. For example, in computing, women earned just 18.3% of computer science and 10.9% of computer engineering doctoral degrees in 2017, while URM students earned less than 3% of doctoral degrees in computer science (Zweben & Bizot, 2018).

The effects of this critical attrition problem in computing doctoral education are acutely felt by computing departments experiencing a severe faculty shortage in light of unprecedented enrollment growth in undergraduate computing courses and majors (Computing Research Association [CRA], 2017). For example, as of 2016, only 63% of the estimated 540 open tenure

track positions in computer science could have been filled by new PhD recipients (NASEM, 2018b). Given the faculty shortage, issues of doctoral attrition must be addressed in order to broaden participation in computing. Since little is known about the unique context of computing doctoral programs, it is helpful to understand the factors that support or threaten student departure in graduate education more broadly.

Doctoral Attrition and the Role of Faculty

Early studies of doctoral attrition across all fields focused on students' socialization to their program of study, their department, and their discipline (Gardner, 2008; Lovitts, 2001). Other studies considered students' demographic characteristics (Maher et al., 2004) and experiences in graduate school (Golde, 1998, 2000) in explaining why students completed or left their degree program. However, Lovitts (2001) argued that, instead of the often relied upon explanation for student attrition – students' dispositions and behaviors – the cause of attrition is "in the social structure and organizational culture of graduate education" (Lovitts, 2001, p. 255). Additional research explored the influence of institutional factors and organizational processes that shape environments and doctoral persistence or attrition. Specifically, size of the program (Bowen & Rudenstein, 1992), relationships in the department (Girves & Wemmerus, 1988), financial support (Ampaw & Jaeger, 2012; Ferrer deValero, 2001), and departmental academic support (Zhou & Okahana, 2019) were found to predict student attrition or completion.

The strongest factor in predicting student experiences and outcomes has repeatedly been the students' relationship with their advisor (e.g., Barnes & Austin, 2009; Joy et al., 2015). O'Meara, Knudsen, and Jones (2013) noted that this relationship is "most directly correlated with retention, timely completion, sense of inclusion, career aspirations, and overall satisfaction with her or his graduate experience" (p. 105). Accordingly, researchers have suggested the need

for more careful examination of the role faculty members play in promoting (or obstructing) growth in degree attainment for underrepresented populations (Perna et al., 2010), particularly through the ways in which faculty and doctoral students interact (O'Meara et al., 2013).

Adding to the complexity of the student-advisor relationship is the mismatch between the incentives that determine faculty priorities and behaviors and the educational and career needs of an increasingly diverse STEM doctoral population (NASEM, 2018a). The changing financial landscape of higher education has altered the professoriate (Altbach, 2005). The rise of market logics – briefly defined here as interpretive frames that guide individual action through expected behaviors (Guillén, 2001) – driven by the need to secure extramural funding, has shifted faculty responsibilities with a heavier emphasis on research productivity compared to teaching and advising (Schuster & Finkelstein, 2006). Further, the tenure promotion system also rewards research productivity, often at the expense of teaching, advising, and mentoring that would support students' educational development and success (NASEM, 2018a). Of increasing concern is that graduate education currently does not meet the needs of an expanding graduate student population which is more diverse than ever (NASEM, 2018a). Since a majority of doctoral student attrition occurs in the early stages of the doctoral program (Bowen & Rudenstein, 1992; Golde, 1998), faculty advisors have a substantial opportunity to support student degree completion through their contact in coursework and in shaping the students' socialization to the program and the discipline. Specifically, research has demonstrated that students whose faculty develop close, caring, and honest relationships with them have a shorter time to completion (Ferrer de Valero, 2001). Faculty who exhibit behaviors consistent with good advising practices, including fostering more frequent (Girves & Wemmerus, 1998), and friendly, collegial, and supportive interactions with students (Barnes & Austin, 2009), better facilitate positive student

outcomes. Engaging in these types of behaviors –where faculty are visible, responsive, downplay their status, and cultivate trust – allows faculty to provide meaningful psychosocial support to students (Posselt, 2018). Additionally, good advising includes developing students' research abilities, which can be done by providing clear direction and timely feedback, helping students cope with unexpected findings, encouraging students to attend professional conferences, and collaborating with them on publications (Barnes & Austin, 2009). Unfortunately, when faculty are faced with multiple demands including teaching, research, and service in the academy (Colbeck, 1998; Gonzales & Rincones, 2011), it may be difficult for graduate students to get the time, support, and development they need to be successful. Although, one opportunity for alignment here is that faculty pressures to conduct research may provide unique opportunities for students to develop as scholars. Indeed, in a study of exemplary advisors who had supported many students to degree completion, Barnes and Austin (2009) found that faculty encouraged students to attend scholarly and professional conferences and co-authored research publications with their advisees.

Importantly, student and faculty perceptions of the causes of student attrition differ (Gardner, 2009b; Lovitts, 2001). While students signal issues in their program, department, or institution as contributing to attrition, faculty rarely consider the faculty-student relationship as a contributing factor in student attrition despite the integral role faculty play in the student experience (Gardner, 2009b; Gilmore et al., 2016). Instead, faculty attribute student attrition to students' lack of ability (e.g., drive, focus, motivation, or initiative), personal problems, or simply believing that the student should not have gone to graduate school in the first place (Gardner, 2009b).

Regardless of the inconsistency between faculty and students' perceptions, faculty members' perceptions influence their behavior (van den Berg & Ros, 1999). Given their role in admitting students, designing curricular requirements, developing educational policy, communicating expectations, socializing students to the discipline, and guiding the culture of the department, I argue that faculty are the architects of the doctoral experience. Thus, faculty conceptualizations of student attrition or success are central to informing how they structure programs, services, and experiences for doctoral students (Gardner, 2009b). In other words, faculty opinions and perceptions matter, particularly because they have the capacity to shape student experiences and outcomes.

Purpose

Despite growing enrollments in computing at all levels of higher education, the ability of higher education to address the faculty shortage in computing and to enhance and diversify the doctoral pipeline is threatened by high rates of doctoral student attrition. While existing research on student attrition addresses some of the student and institutional factors that affect doctoral students' thoughts and behaviors about leaving their program, little is known about the experiences of doctoral students in computing disciplines specifically. This study will examine the experiences of computing doctoral students and faculty to better understand the actual and perceived factors that contribute to students' consideration of departure. By focusing on the experiences that threaten or support students' persistence, this study will illuminate opportunities to bolster the computing pipeline. Specifically, this study explores the following research questions:

1. What are the demographic and background characteristics (e.g., gender, race/ethnicity, citizenship) of students who have considered departure?

2. Among students who have considered departure, what explanations do they give for why they considered leaving? What supports do they attribute to helping them continue in their program? How do these explanations vary by gender and race/ethnicity?
3. What factors predict students' consideration of leaving their doctoral program prior to earning a degree? How does this vary between women and men?
4. How do computing faculty conceptualize reasons for students' consideration of departure in computing doctoral programs?
5. What role do computing faculty believe they have in shaping experiences and outcomes for computing doctoral students?

This study uses a sequential mixed-methods design (Creswell, 2009). I rely on data from the Computing Research Association's Center for Evaluating the Research Pipeline (CERP) gathered on the 2018 graduate student Data Buddies Survey (DBS). The primary outcome of interest of the quantitative inquiry is students' consideration of departure from their program prior to earning a degree. Girves and Wemmerus's (1988) conceptual model of student degree progress is used to organize variables for a binary logistic regression. Specifically, Girves and Wemmerus (1988) posited that students' degree progress is shaped by department characteristics, perceptions of faculty, financial support, and student involvement. Further descriptive analyses will be conducted to examine the factors students identify as most salient in threatening or supporting doctoral student degree completion.

Next, the qualitative inquiry is guided by the microfoundations of institutional logics theory (Thornton et al., 2012) to understand the practices and norms that guide faculty decision making and individual and organizational behavior. Specifically, this study examines how faculty members' goals and identities shape their conceptualization of their role and their

influence on student outcomes in doctoral education. Further, given their role as architects in doctoral education, this study explores their perceptions of what contributes to student departure. Using a phenomenological approach, I conduct individual interviews with faculty members in computing doctoral programs. Faculty perceptions of explanations for students' consideration departure are compared to the student survey responses regarding the threats to degree completion. In doing so, this mixed-methods design aims to uncover the extent to which faculty and student perceptions align or diverge.

Significance

Research

This study will increase the knowledge base regarding doctoral students' consideration of departure across multiple institutions. It will expand what is known about the doctoral student experience across an entire academic discipline – computing. Additionally, findings from this study will help us to better understand the factors that contribute to student doubt and consideration of departure, which is an important psychological precursor to the behavioral choice to stay or leave. Further, much of the existing literature on doctoral attrition is outdated, with datasets that are 20-30 years old. This study will provide a much-needed update to the literature by using data gathered in 2018 from current computing doctoral students, thereby accounting for demographic changes in student populations and situating student departure considerations in the relevant social, cultural, and economic contexts.

Additionally, the mixed-methods approach will promote new ways of examining the graduate experience by investigating the perceptions of faculty, and perhaps more importantly, the role faculty perceive they have in shaping the graduate student experience and student outcomes. In doing so, I promote an anti-deficit approach to research on graduate student

persistence by focusing on experiences in the department and the key stakeholders who shape those experiences. Given the level of influence faculty have in doctoral education, understanding their perceptions and how they guide their attention may generate critical insights to inform the other side of the faculty-student relationship.

Theory

By testing aspects of Girves and Wemmerus's (1988) conceptual model of degree progress, I examine the relevance and accuracy of the model for computing doctoral students specifically. Given that Girves and Wemmerus offered their theory more than 30 years ago, findings may reveal critical updates to extend or clarify our current understanding of the psychosocial, institutional, and departmental factors that contribute to doctoral student degree progress and ultimately completion. This study will also add to our understanding of the differential experiences of men and women in the context of computing doctoral programs and whether existing theories of doctoral degree progress apply to women and men in the same ways.

Additionally, few studies have used theories of institutional logics to investigate the influence of macro-level forces on micro-level interactions. In using theories of institutional logics, this study will contribute to our theoretical understanding about how faculty focus their attention and how their goals and priorities shape their communications and interactions with students.

Practice

Despite the importance of expanding the faculty pipeline and diversifying the computing workforce, little is known about why computing students consider leaving their doctoral programs. The practical implications for identifying the most salient supports and threats to student completion will be immediately relevant to computing doctoral programs across the

country in their efforts to expand and diversify the computing pipeline. Findings from this sample of current students will also be useful in guiding departmental intervention efforts now and into the future. Further, graduate departments looking to improve their environment or culture may be interested in findings from this study, which could inform necessary organizational changes.

Additionally, by drawing attention to the roles and experiences of faculty, the proposed study will provide critical knowledge which may inform faculty advising and mentorship expectations and practices, including how they socialize students to the computing discipline. Further, findings from this study may inform decisions about policies and practices for graduate deans, department chairs, faculty, and students. Given the importance of disciplinary culture in doctoral education, this study may also provide guidance for professional associations in their efforts to broaden participation in computing.

Outline of this Study

This study seeks to address gaps in the literature related to computing doctoral student attrition and the role faculty have in shaping the graduate experience. This study will explore the explanations for student's consideration of departure from both student and faculty perspectives. In this chapter I have reviewed the broader problem to be addressed, as well as the significance of this study. In chapter two, I position the present inquiry in the relevant literature and also discuss the conceptual and theoretical frameworks guiding this study. Then, Chapter 3 elaborates on the research design and methodologies, including details about data collection, samples, and analytic procedures. Chapters 4 and 5 will review the quantitative and qualitative research findings, respectively. Finally, Chapter 6 will integrate findings and will address implications for theory, research, and practice.

CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMEWORKS

The purpose of this study is to understand the current realities of doctoral students and faculty within computing graduate programs. This study contains two key inquiries that examine both the doctoral computing student experience – specifically the environments and influences that support or threaten doctoral persistence – as well as computing faculty perceptions of doctoral student departure and their role in shaping and supporting the doctoral experience and student outcomes.

As such, the primary objective of this chapter is to establish a framework for understanding the doctoral experience and specifically the faculty-student relationship. Over the past few decades, scholars (e.g., Bair & Haworth, 1999; Baird, 1990, 1993; CGS, 2009, 2010; Dorn & Papalewis, 1997; Golde, 1998; 2005; Lovitts, 2001) have studied issues in graduate education, primarily focusing on student attrition and time-to-degree. However, more recent work (e.g., Barnes & Randall, 2012; Gardner, 2010; Joy et al., 2015; Zhou & Okahana, 2019) has focused on the role of academic departments and faculty in creating the conditions of the graduate experience. Additionally, several scholars and organizations (e.g., Cassuto, 2015; NASEM, 2018a) have called for a more student-centered focus and a critical examination of the roles and responsibilities of faculty and institutions in supporting doctoral success given the high rates of attrition in doctoral education.

To address problematic elements of graduate education, it is necessary to understand the current student experience, including the extent of students' consideration of departure, and the factors that support or threaten students' persistence to the degree. Additionally, while some studies (Gardner, 2009a, 2010) have examined faculty perceptions of doctoral success and

socialization, few studies (Barnes & Austin, 2009; Lechuga, 2011) have explored the extent to which faculty understand their responsibility to contribute to student outcomes.

The first half of this chapter will begin with a synthesis of the relevant literature regarding graduate education and STEM disciplines broadly, including a discussion of the state of doctoral persistence and attrition and the role of faculty. Then, I will discuss what is known about the doctoral experience in computing disciplines. The second half of the chapter will draw upon two key theories to frame areas of inquiry. Namely, Girves and Wemmerus's (1988) conceptual model of graduate student degree progress informs the quantitative inquiry into the computing doctoral student experience and factors that support or threaten student persistence. The qualitative examination of faculty perceptions of student struggle and their role in student outcomes will be informed by Thornton, Ocasio, and Lounsbury's (2012) microfoundations of institutional logics. Finally, this chapter will conclude with a summary of the literature and theoretical frameworks and will preview the methodology which will be reviewed in greater detail in Chapter 3.

Part I: Literature Review

Graduate Education

Graduate education plays a key role in national social and economic advancement (NASEM, 2018a; NSB, 2018). As jobs have become increasingly complex and specialized, requirements and competitive advantages have drawn more students to pursue master's and doctoral degrees (NASEM, 2018a). From 2000 to 2015, science and engineering graduate enrollment increased by 35% to a high of 668,000, though larger increases were seen in a few disciplines (e.g., computer science, engineering, and medical science) (NSB, 2018).

While the number of students pursuing graduate degrees is increasing, there is still a relative shortage of diverse graduates, particularly in STEM fields (NASEM, 2018a). Increasing diversity and improving outcomes and success for all students, especially those from historically underrepresented groups in STEM, is critical to cultivating a diverse talent pool to fuel the discovery and application of knowledge that drives social and economic advancement (NASEM, 2018a). However, environmental challenges in graduate school and inequities, such as funding type and amount, result in longer time-to-degree and higher rates of attrition for women and underrepresented minority (URM) students who identify as Native Americans/Alaskans, Black, or Hispanic (CGS, 2008). That is, women and URM students are more likely than their white or Asian male counterparts to leave their program without a degree (CGS, 2008; Denecke et al.,2007; Nerad & Cerny, 1993).

As a result, disparities in the representation of women and URM students among doctoral degree recipients in STEM fields persist. In fact, while women have earned the majority of doctoral degrees since 2002, reaching 51.8% in 2015, they are proportionally underrepresented in science and engineering fields, earning less than one-third of degrees in some disciplines (e.g., mathematics and engineering) with only modest changes to close the gap in the last decade (NSB, 2015, 2016, 2018; Okahana et al., 2016;). Similarly, URM students remain underrepresented among science and engineering doctoral degree recipients, having earned just 9% of degrees in those fields in 2015 (NSB, 2018).

Inequities in Student Outcomes

Even with increasing research and programmatic efforts focused on graduate education over the last two decades, particularly for doctoral education (e.g., Carnegie Initiative on the Doctorate, Ph.D. Completion Project, Preparing Future Faculty project), several student

outcomes remain problematic. Most notably, doctoral attrition rates today are quite similar to what they were nearly 20 years ago when Lovitts (2001) published her findings on the first large-scale study of attrition. Lovitts (2001) reported that approximately 50% of doctoral students leave their program before earning their degree. More recently, as part of a six-year, grant funded initiative, the Council of Graduate Schools (CGS) examined doctoral completion and attrition at 21 universities (2010). Researchers from CGS reported seven- and ten-year completion rates for a cohort of students who began their doctoral studies between 1992-1995. They noted that, while completion rates improved slightly to an estimated 57% average across all disciplines, meaning that attrition has decreased slightly to 43%, "universities still exhibit rates and patterns of attrition that should be a matter of concern" (Denecke et al., 2009). More recently, Zhou and Okahana (2019) examined National Research Council data from 212 research universities and more than 5,000 doctoral programs in the 2005-2006 academic year, reporting an average completion rate of 45%, meaning that 55% of capable students are not completing their degrees. These fluctuating completion rates, which can partially be explained by differences in the samples of institutions, reflect that the persistently low completion rates have not changed much across decades and cohorts of students.

However, disaggregation by discipline, gender, racial/ethnic group, and citizenship status reveals disparaging differences in completion rates. Consistent with Lovitts's (2001) findings, higher completion rates are found in STEM fields, such as engineering, which has a 64% 10-year completion rate, whereas lower completion rates are seen in the social sciences (56%) and humanities (49%) (CGS, 2008). Completion rates also vary by gender, with women completing at lower rates than men across all broad academic disciplines, except for the social science (CGS, 2008). Further, URM student completion rates vary widely by academic field – for example,

African Americans' completion ranges from 37% in math and physical sciences to 60% in the life sciences (CGS, 2008). Additionally, international students completed their degrees at higher rates (67%) compared to their domestic counterparts (54%), meaning that the growing number of international students[1] are actually raising the average completion rate across the board (CGS, 2008). While there have been slight improvements, the fact remains that nearly half of students who pursue and begin their doctoral degrees do not finish. Even when there is comparable degree attainment, educational inequities persist in the form of longer time to completion.

Beyond attrition or completion rates, inequities in time-to-degree, funding sources, and loan debt adversely affect women and underrepresented minority students. The National Science Board (2018) reported that, among doctoral degree earners in science and engineering fields, the median time-to-degree for women was 7.7 years compared to 7.2 years for men. Among domestic students, white students finish faster than their peers from underrepresented minority groups (NSB, 2018). Examining this by gender - a higher proportion of women, compared to men, who do complete their degree within 10 years do so after year 7, meaning that women take longer to complete (CGS, 2008). Further, differences in funding support perpetuate structural inequities. Male doctoral students are more likely to be supported by research assistantships while women and URM students are more likely to rely on personal sources of funding, which increases their likelihood and amount of student debt (NSB, 2018). URM doctoral recipients, regardless of field, were more likely to have more than $30,000 in graduate school debt than

[1] One element driving the increase in doctoral completion found in the CGS study is that an increasing number of international students are pursuing and earning doctoral degrees at U.S. institutions. On average, international doctoral students also complete their programs more quickly (CGS, 2008), which may be due to regulations on student visas. The rising number of international doctoral students reflects the changing landscape of graduate education in the U.S.

their white and Asian peers (NSB, 2018). Additionally, the type of funding can affect student outcomes. For example, students with research assistantships are more likely to complete their degree compared to students with other types of funding support (Ampaw & Jaeger, 2012), but students with teaching assistantships may increase their time-to-degree (Bowen & Rudenstein, 1992; Kim & Otts, 2010). Thus, women and URM doctoral students are completing at lower rates, while taking longer to do so, and incurring more debt along the way.

Job Market Realities for Doctoral Students

Economic and social changes, combined with the increasing interest in graduate programs, have shed light on two key issues that reflect new realities that present challenges to institutions and academia broadly. First, the growth of the knowledge economy has supported more diverse career opportunities for doctoral students outside of the traditional academic researcher route. Xue and Larson (2015) noted that the number of tenure track positions available in most STEM fields has remained steady as the number of students earning PhDs in STEM fields has continued to climb. This means that fewer doctoral graduates will be able to secure a tenure track job – which is primarily what their training prepares them for. Only 17.7% of PhDs across all STEM fields had secured an academic tenure track position within five years of earning their degree, which represents a 10% decline from the 27% that had secured positions in 1993 (NASEM, 2018a). Further, when examining the nearly one million STEM PhDs in the U.S., almost 57% of them worked in business, industry, or government in 2015 (NASEM, 2018a).

Given that most doctoral students will not get a job in academia, institutions and faculty are facing criticism for inadequately preparing doctoral students for the realities of the job market and addressing their potentially different professional goals (NASEM, 2018a). Golde and

Dore (2001) reported that "the training doctoral students receive is not what they want, nor does it prepare them for the jobs they take" (p. 7). Students interested in pursuing academic careers at research universities – which is largely what their training prepares them for – may find faculty positions at those institutions limited and are then not sufficiently prepared for faculty roles at other institutional types, nor do they have a clear understanding of careers outside of academic research (Golde & Dore, 2001). In light of these realities, the National Academies have called for universities and faculty in graduate education to adjust the mindset that the PhD is meant to prepare students for academic research careers and recommend more student-centered practices and improvements to mentorship and advising to better prepare doctoral students for a broader array of job opportunities (NASEM, 2018a).

Rise of Mental Health Issues

Secondly, the prevalence of mental health disorders among graduate students, such as anxiety and depression, has garnered more attention in recent years, both in popular media coverage (e.g., Flaherty, 2018b; Puri, 2019; Shorr, 2017; Walker, 2015) and in research (e.g., Barreira et al., 2018; Evans, et al., 2018; Garcia-Williams et al.,2014; Levecque et al., 2017). Graduate students are more than six times as likely to experience depression and anxiety as compared to the general population (Evans et al., 2018). Researchers who conducted this recent study of nearly 2,300 doctoral students, most of them candidates, across 234 institutions also reported that 39% of respondents scored in the moderate to severe depression range and 41% scored at a similar level for anxiety, though rates were higher for women, gender-nonconforming, and transgender students (Evans et al., 2018). These findings are consistent with those from a Belgian study that reported 32% of PhD students were at risk of having or developing a psychiatric disorder (Levecque et al., 2017) and with a study of UC Berkeley

students which found that 47% of graduate students suffered from depression (Graduate Assembly, 2014). Notably, the prevalence of mental health problems increased with time in the program (Barreira et al., 2018), meaning that more advanced students had a higher likelihood of contending with mental health issues.

In addition to these high rates of anxiety and depression, researchers have also examined other mental health challenges, including isolation, imposter syndrome, and suicidal thoughts. Isolation during doctoral studies contributes to the high rates of mental health issues (Barreira et al., 2018; Graduate Assembly, 2014; Walker, 2015). In fact, Barreira et al. (2018) reported that the average economics PhD student feels considerably lonelier and more isolated than a retired American. Further, imposter syndrome – the common belief or fear of not being good enough, or attributing accomplishments to luck rather than ability (Clance & Imes, 1978) – often accompanies anxiety and depression (Weir, 2013). Women and students of color experience imposter syndrome at higher rates than their white male counterparts (Anderson-Rowland et al., 2007; Clance & Imes, 1978). Imposter feelings were actually a stronger predictor of mental health than stress students felt from their racial minority status (Cokley et al., 2013). The severity of challenges some students face may also be manifested in thoughts of suicide. Garcia-Williams and colleagues (2014) noted that 7.3% of students at one research university reported thoughts of suicide while another study reported an even higher number – 11% – of economics doctoral students across eight elite universities that had experienced suicidal thoughts in the last two weeks (Barreira et al., 2018). The alarming numbers speak to the mental health crisis in graduate education today.

To better understand what may be contributing to this mental health crisis, researchers and other stakeholders have begun examining the culture and environments within graduate

school. The National Academies noted that "high pressure environments, cloudy career prospects, an imbalance of work and life, and leadership style of one's advisor also contribute to health problems or unhealthy mental status of graduate students" (NASEM, 2018a, p. 72). Kaylynn Glover, who serves on the Board of Directors for the National Association of Graduate-Professional Students, indicated that graduate student mental health struggles are due to "poor relationships with their advisors and program directors. They feel overburdened, with little to no allowance for a life outside of work" (as quoted in Flaherty, 2018). This is supported by evidence from Evans et al. (2018), who reported that more than half of graduate students experiencing anxiety or depression did not agree that their advisers were an asset to their career, did not feel valued by their mentor, and did not think their advisors provided ample support. Further, strong, supportive, and positive mentoring relationships between graduate students and advisors was significantly correlated with less anxiety and depression (Evans et al., 2018). Thus, the increasing prevalence of these mental health challenges among graduate students has critical implications for how faculty advisers interact with their students. Consequently, the National Academies (NASEM, 2018a) has emphasized the need for greater awareness of mental health issues for graduate students and greater interventions and prevention measures to support students' needs.

Importance of Academic Departments and Disciplines

Taken together, students' lack of preparation for the realities of the job market and the increasing mental health challenges have fueled the focus and conversation around issues in graduate education. Cassuto (2015) noted that "discontent with graduate school is rising fast" (p. 2). However, despite increasing amounts of research focus and programmatic initiatives, little has improved, and in the case of students' mental health, is getting worse. Harvard President

Derek Bok (2015, p. 230) commented that "grad schools are among the most poorly administered and badly designed of all advanced degree programs."

Indeed, graduate schools are complex organizations with decentralized and loosely coupled academic departments. Decision making power concerning graduate education – from recruitment practices and admissions criteria, to curriculum and degree requirements, student training, and socialization – is largely decentralized and located within individual academic units (Hirt & Muffo, 1998; Lovitts, 2001). This allows each department to organize graduate education into the norms of their disciplinary cultures, models of thought, and styles of interaction (Lovitts, 2001).

Consequently, researchers (e.g., Austin, 2002; Gardner, 2009a, 2010; Golde, 2005) have identified the importance of disciplinary differences in graduate education, which affect students' experiences, training, and outcomes. Girves and Wemmerus (1988) noted that doctoral students' primary reference groups are their fellow students and faculty within their program and department. Departmental culture contributes to students' socialization (Gilmore et al., 2016) to their field and profession (Nerad et al., 1997), which ultimately shapes their experiences and retention or attrition (Ferrer de Valero, 2001; Nora & Cabrera, 1993; Zhou & Okahana, 2019).

The central role of academic departments presents several challenges for researchers and partially explains the dearth of comprehensive research on graduate education. Studies often focus on a single department or a few departments or programs, with a few notable exceptions (e.g., Bowen & Rudenstein, 1992; Lovitts, 2001; Nettles & Millet, 2006; Posselt, 2016). Further, departments and institutions may not collect or track comparable data, such as student enrollments or attrition rates. Unlike undergraduate education, very little data is aggregated at higher levels – either institutionally or nationally. A notable exception is degree attainment data

reported to the Integrated Postsecondary Education System (IPEDS). Thus, with little oversight or accountability, departments and individual faculty members yield immense power and control to shape graduate requirements, interactions, and outcomes. The variation of student experiences within and between departments complicates our ability to understand all student persistence and attrition, or student struggle and thriving.

However, in order to improve the landscape and educational outcomes for an increasingly diverse population of doctoral students, we must strive to understand and address the most problematic elements of graduate education. Given the unique disciplinary differences in graduate education (e.g.., Gardner, 2009a; Girves & Wemmerus, 1988; Lovitts, 2001), one approach that informs the present study is to broaden the scope of understanding by examining the experience of students and faculty across an entire discipline. A specific focus on the factors that support or threaten doctoral student persistence and success could generate meaningful insights to ultimately encourage the diversification of degree recipients.

Factors Affecting Persistence and Attrition

The persistently high attrition rate in doctoral programs– approximately 40-60% depending on the discipline (CGS, 2008; Lovitts, 2001; Nerad & Cerny, 1993; Ostriker et al., 2011) – warrants a review of the multitude of factors affecting student persistence and attrition. This section of the literature review will address several key areas researchers have identified as integral to the student experience and attrition: student-level and institutional- or departmental-level, and student-faculty relationships. Then, I will discuss why faculty perceptions of the doctoral experience matter and will make the case for studying psychological processes as distinct from educational outcomes such as completion or departure.

To provide some background information, doctoral persistence has been conceptualized in three stages: (1) transition and adjustment, (2) advancing to candidacy, and conducting independent research (Tinto, 1993). Researchers have estimated that approximately one-third of students who leave prior to earning their degree do so in their first year (Bowen & Rudenstein, 1992, Golde, 1996), with another third leaving before achieving candidacy, and a full-third of students leaving after earning candidacy, also known as ABD (all but dissertation), though departure time points vary by disciplines (Golde, 1998). As many as two-thirds of doctoral student departures occur before students advance to candidacy (Bowen & Rudenstein, 1992; Golde, 1995; Nerad & Cerny, 1993), signaling the importance of their early years and experiences in their doctoral program. The responsibility for student attrition or persistence across these stages was initially presumed to rest with the student, though researchers have shifted their focus toward departmental and institutional factors. In the next section, I review literature that focuses on the variety of factors that shape student outcomes.

Student-Level Factors

Guided by retention theories (Tinto, 1975, 1993), early research on student departure and completion emphasized students' integration into their doctoral program, with more emphasis on their academic socialization. Students' socialization experiences – either positive or negative – have strong implications for their performance, satisfaction, and success (Millett & Nettles, 2009). Students who failed to properly acclimate, socialize, and integrate into their new academic environments were viewed as not "fitting the mold" of graduate school (Gardner, 2008). Students falling outside the mold of traditional graduate students – namely anyone who did not identify as a young, white male – were more likely to experience negative interactions and structural barriers (Gardner, 2008). The extent to which a student integrated shaped their

satisfaction and thereby increased their likelihood of earning a degree (Girves & Wemmerus, 1998; Lovitts, 1996). Additionally, students' fit with their advisor was also shown to affect students' persistence (Golde, 2005). These studies reveal the expectation that students, regardless of their personal characteristics or goals, were to adapt to the circumstances and environment of their doctoral program.

Though early studies of doctoral attrition (e.g., Girves & Wemmerus, 1988; Lovitts, 2001) have informed ongoing research into doctoral outcomes, their use of Tinto's (1975, 1993) frameworks for attrition limit the scope of factors considered. While individual students are most affected by attrition (Lovitts, 2001), a common critique of Tinto (Tierney, 1992) cites the need for examination of factors aside from individualistic student factors to explain retention, which will be explained in the next section.

Lovitts (1996) argued that attrition had less to do with student characteristics and more to do with their experiences once they arrive to the university. Pointing to the complexity and socialization experiences in graduate school, Lovitts' (2001) reported four primary reasons why students fail to integrate into their program, including (1) a lack of information on the nature of doctoral study and how to navigate the system, (2) a lack of community (social support), (3) disappointment with the learning experience, and (4) an unsatisfactory advisor relationship. Findings from this foundational work encouraged a shift in the discourse around student attrition to examine departmental and institutional characteristics that influenced student persistence and attrition.

Departmental and Institutional Characteristics

Broadening doctoral persistence research to include structural and experiential factors beyond the student revealed the importance of the environment in shaping student outcomes.

First, and perhaps most importantly is the funding students receive during their doctoral studies. The impact of student funding has been the subject of extensive research, with 80% of students who had left their program reporting that financial support was the biggest barrier to their completion (CGS, 2008). Additionally, Nerad et al. (1997) found that the form or type of funding, along with the amount of timing of funding, made a difference in student persistence. Students with research assistantships, teaching assistantships, or fellowships are more likely to complete their degree than those who are self-funded (Ampaw & Jaeger, 2012; Nerad et al., 1997). Further, secure funding – in addition to allowing for better planning – also reduces time to degree (Nerad et al., 1997). Though, even within secure funding sources, variations in the type of funding can have an impact on student completion and time to degree (Bair & Haworth, 1999). For instance, students with research assistantships complete their degree in less time than students with teaching (TA) positions (Bowen & Rudenstein, 1992).

Next, researchers considered the influence of departmental characteristics on student attrition or completion. Bowen and Rudenstein's (1992) study was the first to report how differences in size, field of study, and communication of requirements shaped student outcomes. Specifically, students in smaller cohorts have higher completion rates and lower time to degree (Bowen & Rudenstein, 1992). Disciplinary differences in the structure of programs shape student outcomes, with students in more structured programs, such as biological and life sciences, completing at higher rates than students in less structured programs such as the humanities (Nerad & Cerny, 1993). Additionally, Golde (2005) found that programs with more procedures and policies, such as orientation, core coursework, reviews of progress, and matched advisors, had enhanced graduate student progress and lower attrition rates.

Further, departmental context and behaviors have been shown to be highly influential in students' decisions to stay or leave. The culture and nature of both faculty and peer relationships within a department shapes student behavior (Ferrer de Valero, 2001). Additionally, the transparency and timing of departmental communication regarding rules, structures, and processes matter to support the academic and social integration of students (Golde, 1996). The persistent and problematic rates of completion in doctoral education continue to fuel researchers' examination of departmental supports and influences on student outcomes (Zhou & Okahana, 2019), though most salient to student outcomes is the relationships they have with faculty advisors.

Student-Faculty Relationships

The faculty-student relationship is the most central and influential external influence on students' experiences in graduate school (Barnes & Austin, 2009; Lovitts, 2001; Millett & Nettles, 2009; Zhao et al., 2007). Research has overwhelmingly demonstrated its influence on student experiences and outcomes (e.g., Girves & Wemmerus, 1988; Lovitts, 2001). Student-faculty relationships affect student socialization (Golde, 1998; Weidman et al., 2001), satisfaction (Gardner, 2007), career aspirations (Golde, 2005; Zhao et al., 2007), and time to degree (Ferrer de Valero, 2001). Notably, the single most frequently occurring finding in separate meta-analyses of graduate education (Bair & Haworth, 1999; Sverdlik et al., 2018) is "the degree and quality of the relationship between doctoral student and advisor or faculty [which] has a strong positive relationship to successful completion of the doctorate" (Bair & Haworth, 1999, p. 9). Thus, faculty advisors are instrumental in students' socialization, development of skills and competencies, and ultimately impact doctoral student retention (Ferrer de Valero, 2001; Golde, 2005; Lovitts, 2001; Nettles & Millett, 2006; Zhou & Okahana, 2019).

The nature of the faculty-student relationship can foster a mutually beneficial and longstanding relationship that helps students acquire skills and competency, contribute to new research, socialize to a discipline and a profession, and secure a job (Nettles & Millett, 2006). Positive advising relationships are characterized by friendly and collegial interactions (Barnes & Austin, 2009), timely and constructive feedback (Seagram et al.,1998), and clear communication about expectations (Fairbanks, 2016). Ferrer de Valero (2001) noted that students who developed close relationships with their faculty advisors actually completed their degree in less time than their peers with more distant relationships. Additionally, students who are treated as junior colleagues are more likely to be retained and to complete their degree (Girves & Wemmerus, 1988; Nerad & Cerny, 1993).

However, when the student advisor relationship is poorly handled, it can be very damaging and even destructive for students. Concerns about relationships with advisors were shown to be the top reason students considered departure (Ruud et al., 2018). In fact, attrition literature points to incompatibilities in students' relationships with advisors, including their unrealistic expectations and working styles, as a common cause of student departure (Bair & Haworth, 1999; Girves & Wemmerus, 1988, Golde, 1996; 1998). Reflecting back on their experiences, students who did in fact leave their doctoral program reported that they might have stayed if their advisor was more supportive (Lovitts, 2001). This highlights the critical influence faculty have on student outcomes.

Faculty-doctoral student relationships may be more complex for women, particularly in STEM fields. A greater proportion of women – 39% compared to 30% of men – described incompatible, negative, or abusive relationships with their faculty advisors (Ruud et al., 2018). Further, men and women perceive mentoring relationships differently (Wilde & Schau, 1991).

While both men and women desired a psychological or intellectual component encompassing skill development and professional socialization, women also perceived a social component to mentoring (Wilde & Schau, 1991). Lacking this sense of connection, women may feel dismissed or ignored by male faculty members. Further, men in STEM fields appear more satisfied with their advising relationships than women. Male doctoral students reported higher levels of satisfaction, compared to women, with advising, career preparation, and knowledge of formal and informal program requirements (Ruud et al., 2018). A contributing factor to this discrepancy may be the hostile climates and even sexism particularly found in fields with less gender equity (Herzig, 2004; NASEM, 2018a). The gender dynamics, faculty beliefs, and power differentials in these fields may diminish a students' ability to advocate for themselves (NASEM, 2018a), leading to potentially damaging experiences and negative student outcomes.

Faculty Perceptions

Despite the abundance of research on the influence of faculty and departmental environments, faculty often fail to see their role in shaping the student experience, and instead point to the student as the responsible party in attrition (Lovitts, 2001). Faculty play an integral role – as teachers, advisors, and role models – in the student experience, so regardless of the accuracy, faculty perceptions exist and influence their behavior (van den Berg & Ros, 1999). Faculty conceptualizations of student attrition or success are critical to informing how they structure programs, services, and experiences for doctoral students (Gardner, 2009b). In other words, faculty opinions and perceptions matter, particularly because they have the capacity to shape student experiences and outcomes.

Gardner (2009b) first examined faculty and student attributions of attrition, noting that faculty are often unaware of their potentially contributing role in student departure. Instead,

faculty attributed attrition to students' lacking essential skills and motivation, or to life complications that interfered with their doctoral studies (Gardner, 2009b). Faculty were not even certain of specific reasons students leave and "most determinedly did not attribute any reasons for departure resting on their or the department's shoulders" (Gardner, 2009b, p. 110). Despite the influential role faculty supervisors have in students' overall dissatisfaction with their program (Gardner, 2009b), faculty still attribute student failure to individual shortcomings. While Gardner's (2009b) 34 faculty respondents failed to take any responsibility, the 60 students interviewed easily identified a multitude of programmatic, departmental, and institutional issues that contributed to student departure.

More recently, Gilmore, Wofford, and Maher (2016) examined faculty perceptions of factors that contribute to graduate student success. Using qualitative interviews with 38 STEM faculty at a single institution, Gilmore et al. (2016) reported that faculty most commonly attributed student success to motivated student behaviors, along with formative learning experiences, and gaining essential knowledge and skills. Consistent with Gardner's (2009) study, faculty seemed to ignore the role they have in creating or influencing the environment of graduate study. Researchers noted that faculty failed to discuss how their actions or inactions might influence graduate student motivation in positive or negative ways (Gilmore et al., 2016). In fact, these researchers reported, "it appears that the [faculty] expectation is that graduate students will arrive at their program highly motivated, and will remain highly motivated, regardless of what occurs in their training environment" (Gilmore et al., 2016, p. 433). This study, they argued, substantiated claims that faculty are unaware of the breakdowns in the environment and culture of their departments.

The portrait of faculty as unaware, passive actors in graduate education raises questions of their accountability and the extent to which their departments even engage in discourse around the graduate experience. This lack of awareness and the high expectations for students to sustain their interests and motivations, despite challenges in the environment, ignores the influence of external conditions on individual feelings and behaviors, though faculty are easily able to identify ways in which their own environment and responsibilities present challenges for them (Gardner, 2009b). The extent to which faculty conceptualize their role and responsibility in the student experience is essential to informing how they behave and interact with students, which shapes student outcomes. However, literature on this specific issue is lacking, which compels a central line of inquiry in the present study. Other researchers (e.g., Cassuto, 2015; Okahana et al., 2016) have called for qualitative inquiry into how efforts to support doctoral student experiences are perceived by stakeholders who have the power and autonomy to actually make changes to impact student outcomes.

Thinking About Leaving

Many of the studies discussed earlier have examined the specific behavioral outcome of a student completing or not completing their program, or they have used this outcome to inform their sample of study. For example, Golde's (2000) work, appropriately titled "Should I stay or should I go?", relied upon interviews with students who had left their doctoral program. However, fewer studies have examined departure decisions as a psychological process, or even as an intermediary step prior to the behavioral outcome.

Cabrera, Nora, and Castaneda (1993) noted that prior research using student attrition models from Tinto (1975) and Bean (1985) operated on the assumption that behavioral intentions (i.e., staying or leaving a program) are shaped by beliefs and attitudes – both of which are

affected by students' experiences in graduate school. The doctoral experience encompasses a variety of psychological and social challenges. For example, students must navigate the complex relationships and power dynamics with faculty (Lovitts, 1996), negotiate the balance of graduate studies and research with other areas of their lives (Offstein et al.,2004), consider career preparation (Ampaw & Jaeger, 2012; Herzig, 2004), juggle the expectations of their program and advisor (Lechuga, 2011), contend with the common challenge of imposter syndrome (Shorr, 2017; Walker, 2015; Weir, 2013), and grapple with cognitive or emotional blocks – including thoughts and feelings that may prevent them from making progress on their doctorate (Kearns et al., 2007). Depending on a students' prior experiences, goals, coping mechanisms, and systems of support, these challenges may coalesce into deliberations about the cost and benefits or return on investment of continuing or leaving their program. In fact, Frasier (1993, as cited in Bair & Haworth, 1999) found that "emotional stress due to fear of failure, stress or role conflict" was one of the most prevalent reasons for student departure. Further, Sverdlik et al.'s (2018) analysis revealed that a lack of social support and challenges related to work-life conflict coincided with diminished well-being and a greater prevalence of mental health concerns among doctoral students. The disruptions in students' psychological well-being can then negatively affect their motivation and degree attainment (Geraniou, 2010). Thus, how students navigate these challenges informs their behavioral choice to stay or leave.

However, little attention is paid to the psychological consideration of departure. In fact, Bair and Haworth (1999) even suggest the need for future research that qualitatively examines students' thoughts, feelings, and behaviors regarding continuation or attrition. One recent study, critical in informing the present study, quantitatively examined this using recent data from 2013-2014 at a single institution. Ruud et al.'s (2018) work draws attention to the factors that shape

how students make decisions to stay or leave, which is crucial to identifying support mechanisms, interventions, and organizational changes that could support students. Ruud and colleagues (2018) argued that examining the reasons students *considered* departure – while still in their program – would help identify the "tipping points" where positive or negative experiences could influence their departure or continuation decision. This study advances the literature on doctoral departure with its use of more recent data and the timeliness of examining enrolled students' consideration of departure, whereas prior studies (e.g., Golde, 1998, 2000) relied upon retroactive accounts from students who had already left their program.

In support of some prior literature, Ruud et al. (2018) reported three critical factors that reduced the likelihood of students' consideration of departure, including strong relationships with faculty and advisors, a collegial program environment, and satisfaction with career preparation. However, researchers found differences by sex and STEM affiliation. Not surprisingly, non-STEM students considered departure at higher rates than STEM students. Further, within STEM disciplines, women were more likely than men to consider leaving and were less satisfied with both the quality of advising and career preparation they received compared to their male counterparts. These findings give possible explanations for gender gaps in attrition in some STEM fields.

The Role of Faculty

As seen above, faculty play a central role in graduate education – from admitting students, to developing curriculum, shaping the experience, and consequently either supporting or threatening student completion. Prior research (Posselt, 2016) has characterized faculty as gatekeepers, though I argue that, given their influence throughout the course of a student's doctoral trajectory, they truly serve as architects of the doctoral experience – yielding immense

power and autonomy for influencing students' experiences, requirements, and outcomes. However, advising graduate students is only one component of an increasingly complex role.

Schuster and Finkelstein (2006) characterize the professoriate as an institution in flux. Market forces have significantly altered the landscape of higher education, forcing the evolution of the faculty role (Altbach, 2005). Specifically, declines in state funding have increased the importance of pursuing extramural funding for research (Altbach, 2005; Gormley & Kennerly, 2010; Stohl, 2007). Consequently, faculty are entrenched in a juggling act to balance their expanding role (Fairweather, 2002a; Musselin, 2007) inclusive of research, teaching, and service responsibilities (O'Meara et al., 2013) while seeking clarity on what is expected of them in their role (Gormley & Kennerly, 2010).

By examining tenure decisions and salary outcomes, faculty can infer what their institution and department value (Fairweather, 2002b), which then may inform their own priorities for the professoriate role (DeAngelo et al., 2009). In other words, faculty reward systems and expectations influence how faculty allocate their time. With widespread emphasis on research across higher education institutions (Schuster & Finkelstein, 2006), research productivity has become a condition of tenure and promotion (Martin, 2011). Since teaching is not as central to the mission of research universities where doctoral students are trained, faculty spend a greater portion of their discretionary time on research activities at the expense of teaching (Fairweather, 1993, 1996, 2002b). Thus, the high research orientation of graduate faculty compromises the time and attention spent on teaching and individualized advising that characterizes a classic model of apprenticeship (Walker et al., 2008), thereby potentially affecting faculty-student interactions and outcomes including student attrition and persistence.

The ways in which faculty carry out their work is a reflection of several factors – including their own student experiences, personality preferences, and the balance of teaching and research culture at their institution (Barnes & Austin, 2009). Additionally, disciplinary cultures can differentially shape faculty work and faculty-student interactions (Austin, 2002; Stohl, 2007). Faculty, then, use organizational scripts from their department or institution to construct and make sense of their role (Gonzales & Rincones, 2011). This social reproduction and subjective interpretation can lead to vastly different experiences for both students and faculty which, given the decentralized nature of graduate education, presents a challenge for ensuring faculty accountability. Recognizing differences in faculty culture, Stohl (2007) asserted the importance of focusing on how faculty demonstrate institutional commitment by paying attention to who gets what, when, where, and how.

The competing demands of faculty and the variation in how faculty allocate their time, along with the expanding challenges faced by students in graduate education today, raise the question of whether faculty can provide students with what they need to succeed. In a recent report, *Graduate STEM Education for the 21st Century*, the National Academies of Science, Engineering, and Medicine (2018a) argue that a mismatch of incentives which inform faculty priorities and the diverse education and career needs of students can compromise students' development and success. The authors of the report commented that "the main obstacles to responding to the needs of both master's and Ph.D. students are largely tied to the academic culture and the current tenure and promotion system that rewards research output over the quality of education, advising, and mentoring." (NASEM, 2018a, p. 22). Indeed, recommendations for improving STEM graduate education include providing faculty with more training and resources

to improve their skills as mentors and advisors, and actually rewarding them for effective teaching and mentoring (NASEM, 2018a).

Understanding what faculty give their attention to, how they understand the student experience, and their role in it can inform practical and policy recommendations to support more engaging, positive, and mutually beneficial relationships between faculty advisors and doctoral students. Literature on the role of the doctoral advisor rarely examines it from the perspective of the faculty advisor. However, two studies advance the literature by examining the perceived roles and responsibilities in doctoral advising (Barnes & Austin, 2009) and mentoring (Lechuga, 2011). In both studies, faculty discussed their role in preparing students as researchers and professionals, and as socializing agents. Lechuga (2011) characterized faculty roles in relationships with students in three ways – (1) as allies who support students, (2) as master-apprentices that aim to develop graduate students into researchers, or (3) as ambassadors who develop students' sense of professional responsibility and introduce them to academic culture. Relatedly, Barnes and Austin (2009) characterized the advising relationship and advisor behaviors as friendly/professional, collegial, supportive/caring, accessible, and honest. These styles could be adapted and tailored to what the student needed in different circumstances (Barnes & Austin, 2009). Both studies point to the importance of cognitive, intellectual, and affective dimensions in fostering productive and developmental relationships with students.

While Lechuga (2011) and Barnes and Austin's (2009) studies help to fill a bit of the gap on the perceived roles of faculty in doctoral education, their sampling choices limit the generalizability of their findings to a broader faculty audience. First, Barnes and Austin (2009) only interviewed "exemplary" faculty who had graduated many students and had, on average, been at their institution for nearly 10 years. While this is valid criteria for the purposes of their

study, it may indicate that their sample was comprised of faculty who were more socialized into the institutional culture and role. Next, Lechuga's (2011) reliance upon a small and racially homogeneous sample of Latina/o faculty spread across different disciplines makes generalization to other faculty groups and academic cultures difficult.

Computing Disciplinary Context

In the previous sections I provided a synthesis of some of the complex issues in doctoral education that affect the student and faculty experience. Given the workforce and academic needs for more and diverse doctoral degree earners in computing, this study focuses specifically on computing disciplines within doctoral education. Sax and Newhouse (2019) noted critical disciplinary differences, calling for researchers to disaggregate broad STEM fields to study individual disciplines. In this section I will provide an overview to define the computing fields, discuss the composition of doctoral students and faculty in computing, challenges to the faculty role, and the graduate experience in computing.

Defining the Computing Subfields

The computing field and academic discipline has evolved considerably in the last few decades with technological advancements and the expansion of the global knowledge economy. Computing is comprised of several sub-disciplines, which can present challenges when interpreting or discussing trends in computing. In their study of baccalaureate computing degree trends, Zweben and Bizot (2015) define the computing sub-disciplines as computer science, computer engineering, software engineering, information systems, information technology, information sciences, security, and interdisciplinary majors. At a graduate level, the Society for Industrial and Applied Mathematics (SIAM) (2001) discussed computational science and engineering (CSE) as a multidisciplinary field with connections to the sciences, engineering,

mathematics, and computer science. As an applied field, CSE "focuses on the development of problem-solving methodologies and robust tools for the solution of scientific and engineering problems" (SIAM, 2001). Further, the Computing Research Association's (CRA) Taulbee Survey – the principal source of information on the enrollment, production, and employment of PhDs in computing – defines computing as computer science, computer engineering, and information disciplines (CRA, 2019). This study relies upon the computing subfield definition given by CRA and the Taulbee survey.

Composition of Computing Doctoral Students

Computer science, mathematics, and engineering account for a substantial portion of the growth in graduate enrollments and degree attainment from 2000 to 2015 (NSB, 2018). Enrollment in computer science graduate programs (both master's and doctoral) had gradually increased or remained stable until 2012 when it drastically jumped to 86,000 students in just three years, though international students on temporary visas accounted for much of this growth (NSB, 2018).

While interest in computing has increased substantially, an examination by gender reveals mixed trends. Women's enrollment in computing doctoral programs has slightly increased to 22.1% compared to the prior year (Zweben & Bizot, 2018). Though women's representation has generally been increasing since 1990 (Zweben & Bizot, 2016), less than one-third of doctoral degrees conferred in mathematics, computer science, and engineering disciplines are awarded to women (NSB, 2018). Disaggregating women's degree attainment by sub-discipline reveals substantial and worrisome gaps. Notably, women's enrollment and degree

attainment in computer science[2] (21.1% and 18.3% respectively), computer engineering (17.9% and 10.9% respectively), and information (39.3% and 39.1% respectively) programs reveals both the gender imbalance by field, but also higher rates of attrition in computer science and computer engineering as their representation decreases from enrollment to degree attainment (Zweben & Bizot, 2018). Thus, the persistent and significant underrepresentation of women in CSE academic departments (Cuny & Aspray, 2002) illustrates the slow progress that has been made toward broadening participation in computing.

Despite increases in doctoral enrollment and degree attainment in computing, little has changed in the representation of underrepresented minority (URM) groups. Zweben and Bizot (2018) noted that URM students earned less than 3% of doctoral degrees in computer science. Similarly, Jackson, Charleston, George, and Gilbert (2012) reported that African Americans have never earned more than 2% of doctoral degrees in computer science. Looking across all three computing disciplines – computer science, computer engineering, and information – nearly 60% of degrees were awarded to international students, 9.6% to Asian students, nearly 27% to white students, only 3.2% to Black students and just 2% to Hispanic students (Zweben & Bizot, 2018). The challenges of diversifying computing graduate education are exacerbated when women and URM students complete at lower rates than their white and Asian peers (Denecke et al., 2007). The low representation of women and URM students among computing doctoral degree earners is especially problematic because computing is the only STEM field where current degree production fails to meet future job projections (NASEM, 2018b), leaving a talent gap.

[2] A higher proportion of women's doctoral degrees in computer science were earned by international students compared to international students among men's computer science doctoral degree recipients (Zweben & Bizot, 2018).

Composition of Computing Faculty

The lack of diversity among doctoral students and degree earners is mirrored in the composition of the faculty. Among newly hired faculty, women accounted for 20.8% of tenure track hires and 32.5% of teaching hires (Zweben & Bizot, 2018). Examining the gender composition of faculty at all ranks highlights the widening gender gap as only 15% of full professors in computing are women (Zweben & Bizot, 2018). Faculty positions continue to be dominated by white and Asian scholars, and at lower levels such as post-docs, by international scholars (Zweben & Bizot, 2018). In fact, URM faculty hold just 4.5% of all positions from post-docs to full professors (0.2% American Indian/Alaska Native, 1.9% Black, and 2.4% Hispanic) (Zweben & Bizot, 2018).

As institutions aim to increase diversity within undergraduate computing (Barker & Cohoon, 2009), a lack of diversity among faculty is particularly problematic since undergraduate students may lack role models (Tamer & Stout, 2016), which could compromise the ability or desire for women and URM students to persist in computing (NASEM, 2018b). This problem is timely as undergraduate enrollments in computing disciplines are booming and are expected to continue growing in the next several years (NASEM, 2018b). While this might signal an opportunity for additional growth in doctoral education in the future, it presently has amplified pressure on computing faculty workloads with the most significant strain on computer science departments (CRA, 2017; NASEM, 2018b). The enrollment boom in undergraduate education has already increased the number of tenure track positions (Xue & Larson, 2015) and continues to fuel future 2-year growth projections that estimate a 10.6% increase in tenure track positions, 16.6% in teaching positions, and 18.5% in post-doc positions (Zweben & Bizot, 2018). However, even with increasing degree attainment, only 63% of the estimated 540 open tenure track

positions in 2016 could have been filled by new PhD recipients in computer science (NASEM, 2018b). Thus, computing disciplines – unlike other STEM disciplines – are facing a unique critical shortage of faculty to meet the demand for growth in undergraduate computing courses and majors (CRA, 2017).

Further, recent computing PhD degree recipients are leaving academia at high rates, with a majority, 60%, pursuing jobs in industry (Zweben & Bizot, 2018). The high demand for PhDs in industry positions (NASEM, 2018b), particularly in CSE disciplines that play an important and potentially dominating role in scientific discovery and engineering design (SIAM, 2001), detracts from the candidate pool for faculty hiring. In fact, recent Taulbee Survey data revealed that 17.3% of tenure track and 12.1% of teaching positions were not filled (Zweben & Bizot, 2018).

Considering the substantial faculty shortages and the workforce demand for computing PhD recipients, I turn my attention to the high rates of attrition or departure from computing doctoral programs. Enhancing completion rates for students – particularly women and those from underrepresented minority groups – may help fill the gaps in hiring needs and could possibly diversify both industry and academia. Though completion rates are not available specifically for computing disciplines, an available proxy based on the computing fields' relatedness to other disciplines is possible. The Council of Graduate Schools (2008) reported that approximately 64% of engineering and 55% of math and physical science doctoral students complete their degree within ten years. Departure, particularly at the graduate level, represents a substantial loss to computing as students, faculty, and institutions have invested a great deal of time and energy into developing students (Cohoon et al., 2011). The substantial room for improvement to increase doctoral completion rates in computing disciplines warrants a closer examination of the

experiences of doctoral students that threaten or support their degree completion. This motivates the present study and compels a closer review of what is currently known about the graduate experience in computing.

Problematic Elements of Computing Culture

Women and students of color admitted to doctoral programs in computing have demonstrated their abilities, talents, and resilience to have already overcome numerous barriers in their K-12 and college education (Gürer & Camp, 2002; Margolis & Fisher, 2002; Margolis et al., 2008). Persistent problems within academic and computing culture threaten the success of women and students of color. Below I describe specific elements of that culture, informed by research from undergraduate computing.

Notably, the image of computing as a male-dominated discipline (Singh et al., 2007) can foster beliefs of who belongs in computing, creating an unfriendly, hostile, or chilly climate for those that do not fit the stereotypical image of a computing person. The lack of women role models and mentors (Anderson-Rowland et al., 2007) combined with the prevalence of men in computing majors, postdoctoral, and faculty positions (CRA, 2017) bolsters this perception of computing as a masculine field. The common stereotype of computing as a thing "geeky guys" do can make women feel they do not fit in (Stout & Camp, 2014). Indeed, the belief that women do not fit into computing as men do (Cheryan et al., 2013) is evidenced through gender gaps in students' sense of belonging (e.g., Blaney & Stout, 2017; Lewis et al., 2017; Sax et al., 2017).

Further, women and underrepresented minority students face negative stereotypes about their technical abilities (Miller et al., 2015; Stout et al., 2017). People's implicit theories, or their everyday beliefs about the self in relation to the world, often provide a grounding for and exacerbate stereotypes. For example, those who espouse entity theories believe that intelligence,

in this case having the technical ability to succeed in computing, is an innate and immutable skill, meaning that some people are better at it than others (Dweck, 2006). Entity theories like this one, are now commonly known as a fixed mindset (Dweck, 2015). When combined with the stereotypes of computing as a masculine discipline, this belief in an unchanging intelligence or aptitude for computing can manifest in the form of gender or racial biases which threaten students' sense of belonging and performance. Underrepresented groups, such as women and racially minoritized students in computing disciplines, can experience a stereotype threat emerging from being outnumbered (Steele, 1997). This has been shown to produce a psychological effect or threat – born out of fear that they will affirm prevailing negative stereotypes – that actually diminishes their performance and acts as a self-fulfilling prophecy (Steele, 1997).

An overarching consequence of these stereotypes, stereotype threats, and diminished sense of belonging is that underrepresented groups can be discouraged from continuing on their educational or career trajectories (Bunderson & Christensen, 1995; Cheryan et al., 2009). Women rely on belonging, more so than men, to feel engaged in their computing careers (Diekman et al., 2010; Lewis et al., 2017). The empirical evidence for a gender gap in sense of belonging, along with the tendency of women in computing to self-report lower confidence in both cognitive (e.g., academic ability, intellectual self-confidence) and affective domains (e.g., drive to achieve, social self-confidence) (Sax & Newhouse, 2019) illustrates the complex psychological variables that play a role in women's academic decisions (Singh et al., 2007). While women who have made it to their doctoral program have already endured despite these challenges, the attitudes and culture within computing – particularly the beliefs shared by their peers and potentially faculty – may continue to be problematic in graduate school.

Graduate Experiences in Computing

The experiences of doctoral students in computing have not been widely studied, though select literature does offer insight into specific challenges and supports in the student experience. Despite low representation of both women and underrepresented minority groups in computing disciplines, research on the graduate experience in computing primarily focuses on gender (e.g., Anderson-Rowland et al., 2007; Cohoon, 2007; Cohoon et al., 2011; Hassoun & Bana, 2001; Stout & Camp, 2014; Stout et al., 2017) rather than race, though recently researchers have focused on the experiences of African American students in computing (e.g., Charleston, 2012; Charleston et al., 2014; Lewis, 2018).

Some empirical research has sought to understand the gendered experiences of students in computing graduate programs. Two key studies, both from 2007, highlight the differences in men's and women's experiences. First, Anderson-Rowland et al. (2007) conducted four focus groups with engineering and computer science doctoral students at a single university, separating students by gender and international/domestic student status, with the aim of uncovering the encouragers and discouragers experienced by each group, which could affect their completion. Interestingly, researchers reported that the women's focus groups were "charged with personal struggles and a sense of relief that at last someone was interested in their problems and trying to do something to help them" (p. 4) while men – who largely participated out of curiosity – were more relaxed (Anderson-Rowland et al., 2007).

The focus groups of international and domestic women depicted a bleak and isolating experience in their doctoral programs, heavily influenced by the masculine culture of engineering and computer science. Women reported feeling put down by male peers who felt they were there to fill a quota and did not have the skills to succeed. They viewed that male

faculty advisors took male students more seriously, thus creating pressure to prove they were as good as men. Women also indicated feeling invisible and marginalized in a hostile peer environment they did not fit in with which was dominated by the competitiveness, interest, and hierarchy of the lab (Anderson-Rowland et al., 2007).

Women expressed a variety of personal discouragers, including feeling alone with little emotional support, conflict between family and career goals, and the burden of domestic labor and childcare, which when paired with their low self-esteem, imposter syndrome, guilt arising from conflicts between their family and student roles, and feeling that they had to give up their lives to be successful in their doctoral studies. This left them wondering if the PhD is worth it (Anderson-Rowland et al., 2007). In contrast, men reported discouragers such as not having control in the lab, uncertainty of requirements, and academia/industry differences. A few men also admitted to experiencing imposter syndrome early on but that it was no longer an issue for them (Anderson-Rowland et al., 2007). The researchers commented that "the atmosphere for all the women's groups was that they were being stressed unnecessarily as women beyond the general stress of being a graduate student" (Anderson-Rowland et al., 2007, p. 11). Findings from this study align with prior research gender differences in science and engineering graduate programs that are associated with unequal treatment of men and women (Fox, 2001).

Cohoon's (2007) study of computing faculty and graduate students further supports the gendered experiences of students. Using survey data from faculty and students at 41 CSE doctoral programs, Cohoon (2007) reported that women felt less favorably than men on a number of items, noting statistically significant differences on levels of comfort, encouragement and publishing with faculty, and faculty availability. Further, Cohoon (2007) found that faculty perceptions that efforts to diversify the graduate student body would diminish the academic

quality of incoming student were found to have a detrimental effect on women's student experiences and outcomes. Namely, the prevalence of faculty's diversity-quality beliefs reduced women's comfort in asking questions in class, which ultimately diminished their confidence to achieve their educational goals (Cohoon, 2007).

Given the struggles faced by women, programmatic efforts such as the Grad Cohort program put on by the Computing Research Association's Committee on the Status of Women in Computing Research (CRA-W) – were developed to support women's sense of belonging and to foster their computing identity. These workshops, and other supportive and female-friendly environments, have been shown to have positive impacts on women (Cohoon et al., 2011; Stout et al., 2017), resulting in greater confidence in their ability to be leaders in their field (Stout & Wright, 2015), stronger computing identity (Wright & Stout, 2016), and a stronger display of growth mindset (Stout & Wright, 2015), which is the view of intelligence as a muscle that can develop with time and effort (Dweck, 2015). Social coping mechanisms such as these are important to undergraduate computing persistence outcomes (Morganson et al., 2010) and are likely important to graduate outcomes, as students participating in the Grad Cohort program felt more prepared to face hurdles head on (Stout et al., 2017).

Both the Anderson et al. (2007) and Cohoon (2007) studies demonstrate the gendered and sexist environments that compound challenges women face in doctoral programs. The prevailing sense is that women need to fit in or find ways to manage their conflicts or challenges. In fact, Anderson et al.'s (2007) was part of a broader National Science Foundation funded project to develop an online intervention and support program for women. This research lacks a critical focus on the need to change the environment within computing, not simply to bolster women's ability to endure an unequal and unjust struggle.

Computing Faculty and Departments

Cuny and Aspray (2002) emphasized the importance of the academic department, particularly at the graduate level, in affecting recruitment and retention of women. They reported that departments could provide more positive role models and mentors in visible positions (Cuny & Aspray, 2002). In addition to diligent mentoring (Cuny & Aspray, 2002), departments can also create peer communities of support which can have a significant impact on persistence in CSE education (Hassoun & Bana, 2001; Cohoon, 2001). Further, reports from discussions on the retention of URM students emphasized the need to reinforce students' sense of belonging by getting them involved in teaching and research activities as well as teaching faculty to be effective mentors (Aspray & Bernat, 2000). Several best practices were suggested in a recent report to enhance the recruitment, retention, and success of diverse students in undergraduate computing, though these practices may also apply to graduate studies in computing. Specifically, minimizing the presence of stereotypes in the classroom, building relationships with peers and faculty, and cultivating a diverse team of faculty and instructors (NASEM, 2018b).

Clearly, the systemic issues in the academy and in computing disciplinary culture persist. Placing responsibility on women to combat or endure these challenges neglects the critical role faculty play in graduate education. In fact, gender bias in faculty attitudes and behaviors discourages women's persistence in computing (Bunderson & Christensen, 1995). Evidence from studies of undergraduate computing demonstrates that despite their best intentions, even faculty involved in an undergraduate research mentorship program, "are unaware or unreflective of how their behavior can negatively affect student outcomes" (Barker & Cohoon, 2009, p. 25). At the graduate level, faculty conceptualizations of student success point to a similar lack of awareness among faculty. Three of the 38 participants in Gardner's (2009) study were computer

science faculty members who reported that student' success was due to inherent traits (e.g., intelligence, required training, and motivation) they had prior to entering a doctoral program rather than traits they acquired in the program. While lacking at the graduate level, research has shown a statistically significant correlation between undergraduate departments that explicitly chose to assist with diversity goals and see a higher percentage of women and URM students (CRA, 2017). This reveals that when intentional efforts are made, the composition of the department changes, potentially reducing the isolation and threats to belonging often felt by women and URM students.

Part II: Theoretical and Conceptual Frameworks

Since no prior literature has looked specifically at the experiences of students and faculty in computing doctoral programs, this study relies on two broader frameworks from higher education. The quantitative inquiry into the experiences of computing doctoral students and their consideration of departure is guided by Girves and Wemmerus's (1988) model of doctoral student degree progress and the qualitative inquiry into faculty understanding of students' struggle and their role in shaping the graduate experience is guided by the theory of microfoundations of institutional logics offered by Thornton, Ocasio, and Lounsbury (2012).

Conceptual Model of Doctoral Student Degree Progress

In one of the earlier contributions to graduate education literature, Girves and Wemmerus (1988) sought to understand the factors that influence graduate student retention and degree progress. Motivated by differences in dropout rates among women, men, minorities, and non-minorities, they developed and tested a conceptual model for graduate student progress. While they also examined master's student progress, this study relies upon their model of doctoral

student degree progress to understand what happens to students once they enroll, and specifically what factors influence student progress toward the degree.

Girves and Wemmerus were informed by earlier works on undergraduate retention from Tinto (1975) and Bean (1985). Tinto's (1975) emphasis on the academic and social integration of students and Bean's (1985) reliance on socialization served as a foundation for Girves and Wemmerus's model, though they added two fundamental elements more central to graduate education – the student/adviser relationship and financial support. According to their model, two sets of variables predict students' degree progress. First, Girves and Wemmerus (1988) posited that department (e.g., size, percent women, basic or applied disciplines) and student characteristics (e.g., age, gender, ethnic group, marital status, citizenship), along with financial support, and student perceptions of the faculty (e.g., adviser quality, usefulness, and students' treatment as a junior colleague) were important to student degree progress. These stage one variables, they considered, would then relate to stage two intervening variables, namely students' grades, involvement in the program (beyond the classroom), satisfaction with the department, and alienation, to predict progress toward degrees. Lacking a set definition of success or progress in graduate education, Girves and Wemmerus (1988) defined doctoral progress in three milestones: (1) completion of coursework beyond the master's, (2) completion of the general exam and student advancement to candidacy, and (3) earning the doctoral degree.

Girves and Wemmerus then tested this model at a single institution, examining the records for 948 students who first entered their doctoral program in 1977 and participated in a survey in 1985. Using hierarchical regression, Girves and Wemmerus were able to see the extent to which stage one variables contributed to the intervening stage two variables, and ultimately to degree progress. Empirical findings allowed for adjustment of the model, the updated model

contended doctoral degree progress was shaped by four factors: department characteristics, perceptions of faculty, financial support, and student involvement. See Figure 2.1 below for the empirical model of doctoral degree progress.

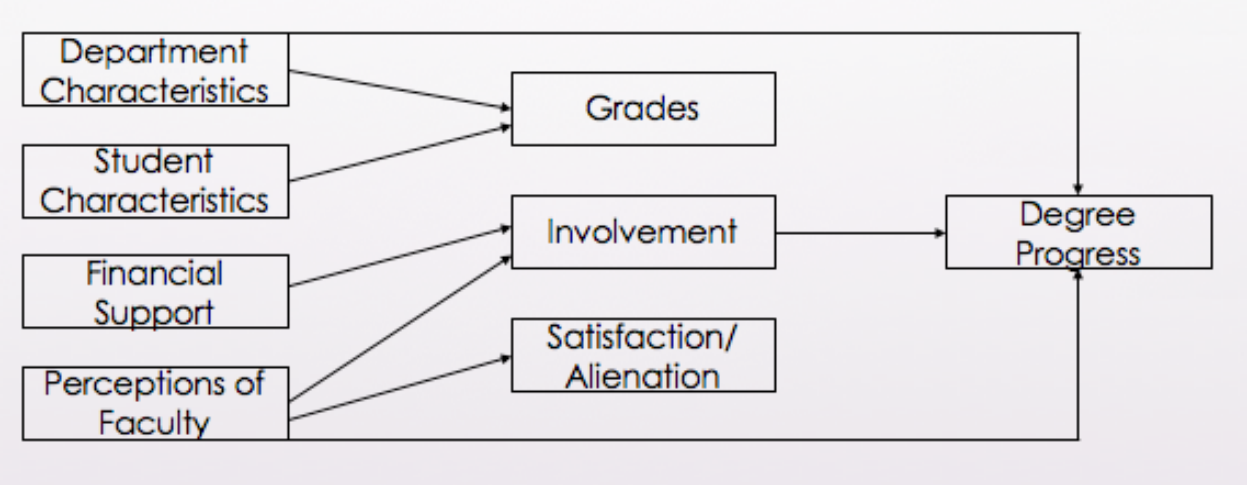

Figure 2.1. Empirical model of doctoral degree progress (Girves & Wemmerus, 1988)

Girves and Wemmerus (1988) acknowledge that they did not conduct a goodness-of-fit test for the empirical model, and while few studies have also tested their model, the factors identified as critical to degree progress in this model have since been supported by literature in graduate education (e.g., Ampaw & Jaeger, 2012; Bowen & Rudenstein, 1992; Ferrer de Valero, 2001; Gardner, 2007, 2009; Ehrenberg et al., 2007;; Mendoza et al., 2014; Zhou & Okahana, 2019). Girves and Wemmerus's (1988) original empirical study examined students as the unit of analysis, though more recent work from Zhou and Okahana (2019) applied this framework to their study with departments as the unit of analysis. By expanding the application of Girves and Wemmerus's (1988) model to a large national, multi-institutional dataset, representing 5,001 departments at 212 doctoral research universities, Zhou and Okahana (2019) offered a more robust test of the model. They affirmed elements of the model, specifically how departmental financial and academic support related to completion rates and time-to-degree.

Girves and Wemmerus (1988) noted that, “it is certain that a student's commitment to earning a degree in a particular discipline is continually modified by his or her experiences in that department. What the faculty do to stimulate the student's interest to strengthen the student's commitment may ultimately determine the level of degree progress achieved by students in that department” (p. 186). Accordingly, I complement this study’s investigation into the student experience with an inquiry into faculty perspectives and priorities.

Microfoundations of Institutional Logics

Originating from new institutional theory, which emphasizes the influence of cognitive, cultural, and historical contexts on organizational behavior (Meyer & Rowan, 1977; Powell & DiMaggio, 1991), logics – briefly defined here as interpretive frames that guide individual action through expected behaviors (Guillén, 2001) – can be used to understand the practices and norms that guide decision making by both individual and organizations. Friedland and Alford (1991) considered logics to span three nested levels of behavior—the individual, organizational, and institutional—to shape social structure and action. Advanced by Thornton, Ocasio, and Lounsbury (2012), the concept of logics evolved into a metatheoretical framework known as the institutional logics perspective, which is useful for examining the relationships among the three nested levels of behavior. Applying these levels to the study of graduate education, the individual level then represents the behaviors of faculty and graduate students, the organizational level represents academic departments or specific universities, and the institution level represents the academic discipline and the notion of higher education broadly.

Thornton and Ocasio (1999) formally defined institutional logics as “the socially constructed, historical patterns of cultural symbols and material practices, including assumptions, values, and beliefs, by which individuals and organizations provide meaning to their daily

activity, organize time and space, and provide meaning to their social reality" (p. 804). Logics, therefore, serve as sensemaking frames that provide expectations about actions through "an understanding of what is legitimate, reasonable and effective in a given context" (Guillén, 2001, p. 14). The institutional logics framework considers that social actors can either conform to and reproduce dominant logics by acting as expected, or, recognizing that their actions may be constrained by the logic, take a risk to challenge the logics by going against expected behavior, thereby demonstrating their embedded agency.

Advancements in institutional theory led to the expansion of institutional logics to include vocabularies of practice, which are the theories, frames, narratives, and behaviors that support a common language for sensemaking, decision making, and individual action (Thornton et al., 2012). These processes are evident in their (2012) integrative model of the microfoundations of institutional logics (see Figure 2.2 below) which highlights the ways in which macro and micro levels of logics influence one another. Consequently, this theoretical framework allows researchers to answer questions regarding how individual and organizational

actors are influenced at both levels of analysis.

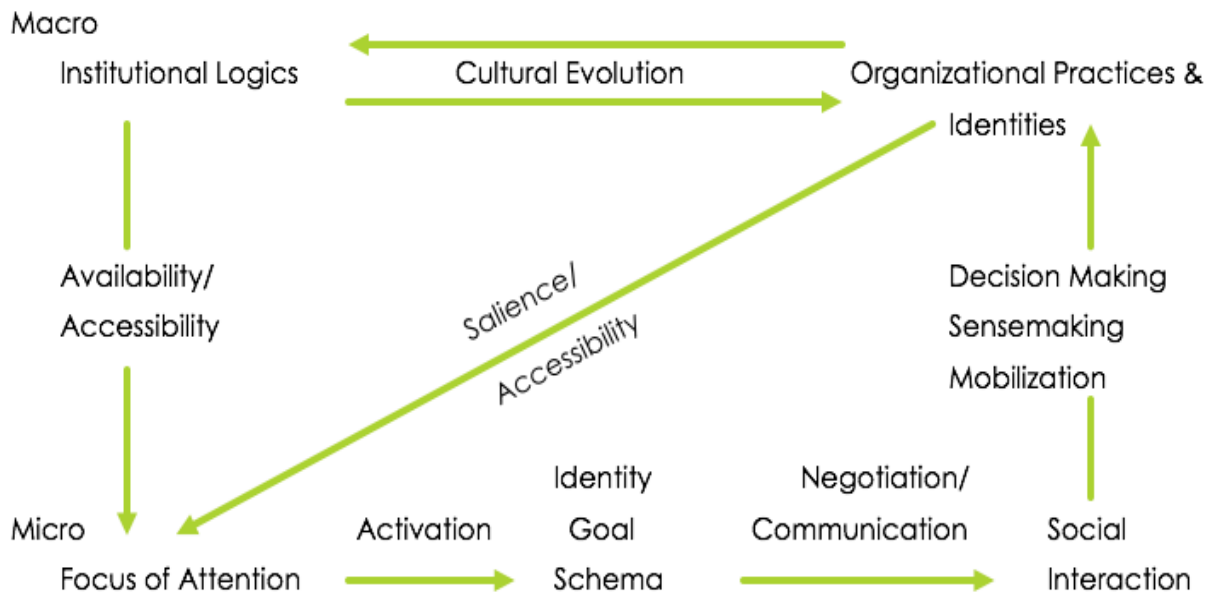

Figure 2.2. A cross-level model of institutional logics (Thornton et al., 2012)

This study will focus on how organizational practices and identities influence the micro level to understand how faculty members' focus of attention ultimately inform their social interactions with doctoral students. Thornton et al. (2012) contended that "institutional logics provide a network of accessible structures to guide the individual's focus of attention" (p. 84). Further, logics guide both the subjects or problems that receive attention and the solutions that are likely to be considered (Ocasio, 1997). The extent to which faculty use or activate these logics depends on their own agency in interpreting the situational and environmental context.

Further, characteristics of individuals – namely their various social identities (e.g., gender, racial group, nationality), role identities (e.g., parent, spouse, professional), and goals associated with these identities or the organization they are a part of – guide an individual's cognition and social interaction (Thornton et al., 2012). Beyond shaping the focus of attention, institutional logics provide a schema, or learned cognitive structure, which act as a guide for

expected behavior, inference, and problem solving (Thornton et al., 2012). Taken together, an individual's negotiation of the tensions between their identity, goals, and schemas informs their interactions with others. Given the variety of options and logics available, individuals demonstrate their agency by selecting which logics to rely upon to inform their social action and interactions (Friedland & Alford, 1991). Thus, logics have immense power to inform an individual's cognition and action.

Institutional logics have become increasingly prominent over the last 10-20 years in sociological and organizational studies (Reay & Jones, 2016). Concepts of institutional logics have been applied to studies within higher education, examining topics such as faculty evaluation in doctoral admissions (Posselt, 2015), labor market expectations of community college faculty (Gonzales & Ayers, 2018), and the disconnect between scientific and market logics that influence the socialization of doctoral students in science and engineering disciplines (Mars et al., 2014). However, to my knowledge, scholars have not explored student-faculty relationships through an institutional logics perspective, particularly in a computing disciplinary context.

The present study applies an institutional logics perspective by using the theory of microfoundations of institutional logics to understand faculty attention and behaviors as they relate to their interactions with doctoral students. This framework also allows for an examination of the ways faculty position their work with doctoral students in the broader context of all their responsibilities, and in doing so, may elucidate elements that support or threaten positive student outcomes and experiences.

Objectives

The first half of this chapter has reviewed several bodies of literature relevant to the current study, revealing that much remains to be discovered about the experiences of doctoral

students and faculty across the computing academic discipline. Literature on the current realities of graduate education and the student and institutional factors affecting persistence or attrition provide context for this study. The prevailing evidence suggests that faculty play a central role as architects of doctoral education – creating the environment and socializing students to the department, discipline, and profession. Most importantly, the faculty-student relationship has the power to support or threaten student persistence (e.g., Bair & Haworth, 1999; Girves & Wemmerus, 1988;Millett & Nettles, 2009), yet the extent to which faculty understand their role and take responsibility for student outcomes remains understudied. This study aims to fill this gap by centering the perceptions of faculty – both in how they see their role and in how they understand student experiences and thoughts of departure.

While extant research has provided invaluable insight into the supports and threats to doctoral student persistence, it is limited in several keyways. First, with the exception of a small handful of studies (e.g., Bowen & Rudenstein, 1992; CGS, 2008; Golde & Dore, 2001; Nerad & Miller, 2006,; Ostriker et al., 2011) much of the research on the doctoral experience is built upon small samples at single institutions. Further, these studies sample from a variety of academic disciplines, which limits the depth of understanding about a particular context. Next, the relevance of some data to today's current context is questionable. For example, Lovitts (2001) examined data from students who were enrolled in doctoral study in 1985, Millet and Nettles (2009) used data from students who matriculated in 1996, and the PhD Completion Project (CGS, 2008) calculated completion rates for students who began their doctoral studies in 1992. Nerad, June, and Miller (1997) noted that models of graduate student persistence are likely to differ across academic disciplines and periods of time. While the contributions and knowledge gained from the aforementioned scholars and studies are irrefutable, the changing landscape of

doctoral education – from the increasingly diverse student body to the increasing focus on STEM education – warrants an updated examination of the doctoral experience in today's educational and social context.

Further, many of these studies examine critical student outcomes, including degree completion or attrition, time-to-degree, or amount of debt, but they lack a focus on intermediate psychological outcomes that shape behavior. The present study contributes to the literature by examining what informs the decision-making process that ultimately determines student completion or departure. In doing so, this study extends prior work from Ruud et al. (2018) to elucidate the stressors internal and external to students and academia broadly and to understand their impact on students' consideration of departure. By investigating the factors that contribute to students' consideration of departure, as well as the experiences that helped them in continuing, this study will provide critical insight into the debates students weigh in their decision-making.

Given the unique ways in which disciplinary culture shapes admissions, academic environments, and interactions, it is imperative that researchers examine these issues in a disciplinary context. Though the research on environments, experiences, and outcomes in computing doctoral programs is narrow, the prevailing evidence suggests that students' experiences are shaped by the disciplinary and departmental climate, beliefs about who belongs in computing, and interactions between students, peers, and faculty. This study will examine the experiences of computing doctoral students and faculty to better understand the actual and perceived factors that contribute to students' consideration of departure. By focusing on the experiences that threaten or support students' persistence, this study will illuminate opportunities to bolster the computing pipeline.

This study relies upon a sequential exploratory mixed-methods design using student survey data and faculty interviews to illuminate the alignment or divergence of faculty perceptions and student realities of the doctoral experience that shapes students' consideration of departure. As such, the broad frameworks of doctoral degree progress from Girves and Wemmerus (1988) and microfoundations of institutional logics from Thornton et al. (2012), allow for a comprehensive inquiry into the experiences of doctoral students and faculty in computing programs. The following chapter will articulate the research design, including methodologies, sample, data collection, and analytic plan.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

The primary objective of this study is to empirically examine explanations of computing doctoral student consideration of departure from the perspectives of both students and faculty members. Secondarily, this study aims to explore how faculty members see their role in the graduate student experience and the extent to which they conceptualize their role in influencing doctoral student outcomes. To achieve these objectives, this study relies upon a sequential-explanatory mixed-methods design (Creswell, 2009) with two approaches. First, quantitative analyses of computing doctoral student survey data were used to understand the realities of students' departure considerations. Second, qualitative interviews with computing doctoral faculty were used to examine their perceptions of student departure, as well as how they conceptualize their role in graduate education and influence on student outcomes. Specifically, this study examines five key research questions:

1. What are the demographic and background characteristics (e.g., gender, race/ethnicity, citizenship) of students who have considered departure?
2. Among students who have considered departure, what explanations do they give for why they considered leaving? What supports do they attribute to helping them continue in their program? How do these explanations vary by gender and race/ethnicity?
3. What factors predict students' consideration of leaving their doctoral program prior to earning a degree? How does this vary between women and men?
4. How do computing faculty conceptualize reasons for students' consideration of departure in computing doctoral programs?
5. What role do computing faculty believe they have in shaping experiences and outcomes for computing doctoral students?

In the following sections I discuss, in greater depth, the mixed-methods design, quantitative and qualitative methods – including the data sources, samples, and analytic approach for each stream of inquiry. This chapter will end with a discussion of limitations and a summary of the study.

Mixed Methods Research Design

This study uses a sequential explanatory mixed-methods design (Creswell, 2009). The multiphase investigation begins with the collection and analysis of quantitative data followed by the collection and analysis of qualitative design (Creswell, 2009). The quantitative stream of inquiry in this study addressed research questions one, two, and three to examine the prevalence, explanations, and factors that predict students' consideration of departure. To address these questions, I relied on existing data from the Computing Research Association's Center for Evaluating the Research Pipeline (CERP) gathered on the Data Buddies Project survey which is administered to computing graduate students annually. Findings from the analysis of these data provide empirical evidence on students' perceptions of departure consideration.

In accordance with sequential explanatory methods, the qualitative stream of this research followed the analysis of the quantitative data. Specifically, this line of inquiry explored research questions four and five, which examined faculty explanations for students' consideration of departure and how faculty conceptualize their role in doctoral students' experiences and outcomes. To examine these phenomena, I conducted individual interviews with 10 faculty members in highly-ranked computer science doctoral programs. Faculty interview recruitment and sampling strategy was informed by the quantitative student survey data and will be explained in greater detail in the qualitative methods section. Faculty explanations for students' consideration departure complement the realities of students' departure consideration provided

through the quantitative survey data. In doing so, this mixed-methods design aims to uncover the extent to which faculty and student perceptions align or diverge.

Quantitative Methods

Data Source

To examine students' reported reasons for departure consideration, this study used quantitative data from the Computing Research Association's (CRA) Center for Evaluating the Research Pipeline. CERP pursues their mission to increasing diversity in computing by conducting evaluations of specific programs, such as the Grad Cohort program for women graduate students in computing, and through research on computing students through the Data Buddies Project. Funded by the National Science Foundation[3], the Data Buddies Survey (DBS) gathers data from both undergraduate and graduate computing[4] students through an annual survey[5]. As the primary source of information on collegiate computing students across the country, the survey asks questions relating to students' past experiences in computing, perceptions of the computing field and their department, professional goals and networks, affective traits (e.g., computing identity, sense of belonging, and self-efficacy), and outcomes (e.g., earning a computing degree, getting a job).

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[3] The Data Buddies Survey was made possible by National Science Foundation (NSF) grants CNS-1246649, DUE-1431112, and DUE 1821136 awarded to the Computing Research Association (CRA).

[4] CERP's definition of the computing field includes programs in: computer science, computer engineering, software engineering, electrical and computer engineering, systems engineering, computer hardware engineering, computing information systems, information systems, information science, informatics, bioinformatics, cyber security, data science, machine learning, robotics, high performance computing, human-computer interaction, computational science/social science, computational biology, computational economics, and computational mathematics.

[5] This compliments CRA's Taulbee Survey, which gathers institutional level data on computing enrollments, degree attainment, and faculty composition and compensation.

Data for this study were drawn from the 2018 administration of the Data Buddies Survey (DBS) for graduate students (see Appendix A for the instrument). In its current form, the graduate student survey has been administered annually since 2014. Surveys were administered by more than 100 computing departments that are affiliated with the Data Buddies Project. A representative from the department – usually a department chair or administrative staff member – sent the survey invitation via email to their students. Students can opt into future surveys by providing their contact information. In that case, future surveys are sent directly to the student from CERP, allowing for longitudinal analyses. The incentive for completing the graduate student survey is entry into a raffle to win a $100 gift card, however some individual departments may offer other small incentives whereas other departments (and their campus IRB offices) do not allow their students to be entered into the raffle. Response rates are estimated based on an approximate measure of how many students received the survey from their departments. For the 2018 graduate student survey, the average response rate was 17%, though it ranged from 1% to 41%, with outliers of 51% and 95% completion.

Sample

The final sample included data from 1,335 doctoral students pursuing a computing doctoral degree at 119 different research universities across the United States. Detailed information on the demographic profile of student respondents is provided in Table 3.1, with some key aspects highlighted below.

Among respondents, 43.0% were women, nearly 55.9% were men, and 1.1% identified as non-binary. This gender distribution is notable because women are overrepresented in the sample compared to their general enrollment in computing doctoral programs. While the survey instrument did not inquire to the students' subdiscipline, Zweben & Bizot (2019) reported that

women's enrollment in computing doctoral programs ranged from 19.3% in computer engineering, to 22.3% in computer science, and 42.5% in information programs.

The racial/ethnic breakdown of the sample was as follows: 0.2% Native American, 0.2% Native Hawaiian or other Pacific Islander, 3.4% Hispanic or Latina/o, 3.9% Black or African American, 7.6% Arab, Middle Eastern, or Persian[6], and 3.6% mixed minority identities. Collectively, students from the aforementioned racial/ethnic groups are those considered underrepresented racially minoritized (URM) students in computing and account for 18.9% of the sample. White and Asian students have historically been well-represented in computing disciplines and were similarly represented in this sample with 39.1% identifying as white, 37.5% as Asian[7], and 3.9% as mixed majority (white and Asian). Thus, 80.5% of the sample identified as a majority group. Compared to institutional responses to the 2018 Taulbee Survey, this sample was more diverse and has a greater representation of underrepresented and historically marginalized students than are generally enrolled in computing PhD programs. One key difference though, is that the Taulbee Survey reports international student status as a racial/ethnic identity (consistent with IPEDS reporting) whereas this instrument separates racial/ethnic identity from citizenship status. Half of the respondents in this sample were U.S. citizens or permanent residents (including dual citizens) and 47.6% were non-U.S. citizens with a temporary visa.

The age and marital status of respondents also provides context for who is pursuing a computing doctoral degree. As shown in Table 3.1, 71% of students indicated they have never been married, while nearly 26% reported being married or in a domestic partnership. Students'

[6] A large majority (83.5%) of Arab, Middle Eastern, or Persian students are non-U.S. citizens, studying with a temporary visa

[7] Asian students are primarily international students as 81.0% are studying with a temporary visa

age was calculated from the year they were born. Age ranges were calculated for descriptive analyses, and the continuous measure of students' age was used in the inferential analyses. Approximately one-quarter of respondents were in their early 20s, nearly half were in their mid to late 20s, 17.3% were in their early 30s, and the remaining 9.3% were 35 and older.

Additionally, students reported their parents' highest level of education, parents' careers, and family's socioeconomic status while they were growing up. A large majority of the sample, 76.4% collectively, reported having at least one parent with a bachelor's (27.2%), master's (28.3%), or doctoral degree (20.9%). Nearly half (43.4%) of students indicated that a parent worked in a computing or STEM field. Family socioeconomic status was normally distributed around the nearly half of students identifying as middle class.

Further, examining the academic backgrounds of students as well as the institutions where they are pursuing computing doctoral degrees provided valuable information on the college environments that shape their educational journeys and outcomes. Table 3.2 displays the academic and institutional profile of the student sample. As expected, the majority of students enrolled in computing doctoral programs earned their undergraduate degree in a computing field, with the most common discipline being computer science. More than half of students (54%) had a single major in a computing field. Approximately one-quarter of students double majored with at least one major in computing, and the most common second major was in another science, engineering, or mathematics (SEM) field. Nearly 20% of students had a single or double major in a SEM discipline, which indicated that a substantial portion of students in the sample arrived to their computing doctoral programs without having studied computing previously. The most common other SEM majors reported were mathematics and electrical or electronic engineering. More than half of the student sample, 54%, completed their undergraduate degree in 2014 or

later, and 91% had done so in 2007 or later. Also, 37.4% of students had completed a master's degree *prior* to enrolling in their doctoral program, and of those, nearly 90% were in a computing field.

Table 3.2 also highlights some institutional characteristics of the doctoral universities where students are pursuing their degree. Specifically, two-thirds of students were studying at public institutions (67.3%) while nearly one-third of students were at private, not-for-profit institutions. Students were heavily concentrated at R1 doctoral universities (92.2%) with a very high research activity, and a smaller proportion of students (7.8%) were at R2 institutions with high research activity. Given the Carnegie classification of institutions, it is not surprising that the vast majority (91.2%) of students were at more selective institutions. Nearly all students were enrolled in programs on campus and were enrolled full-time. Additionally, there was good variation in student progress in their program as approximately one-fifth of the sample in each category, which ranged from having one to five years remaining in their program. This indicated a balanced mixture of students who were in the earlier, middle, and later stages of their doctoral journeys.

Table 3.1
Demographic Profile of Doctoral Student Sample (n = 1,335)

	Percent of Students
Gender (n=1,253)	
Women	43.0
Men	55.9
Non-binary	1.1
Race/ethnicity (n=1,205)	
White	39.1
Asian or Asian American	37.5
Multiracial: White and Asian	3.9

Black, African American	3.9
Hispanic or Latina/o	3.4
Native American	0.2
Native Hawaiian or Other Pacific Islander	0.2
Arab, Middle Eastern, or Persian	7.6
Multiracial: URM Groups	3.6
Other	0.7
Citizenship status (n=1,256)	
U.S. citizen or permanent resident	50.2
Non-U.S. citizen, temporary visa	47.6
Other	2.1
Age group (n=1,227)	
18 to 24 years old	24.4
25 to 29 years old	49.0
30 to 34 years old	17.3
35 to 39 years old	5.0
40 years old and over	4.3
Disability (n=1,231)	
Yes	5.0
No	95.0
Sexual orientation (n=838)	
Homosexual	4.9
Bisexual	5.0
Other/self-identify	2.7
Heterosexual	87.4
Marital status (n=863)	
Married/domestic partnership	26.4
Widowed	0.2
Divorced/separated	2.0
Never married	71.4
Parent's education level (n=856)	
High school, GED, or less	14.5
Some college or Associate's degree	9.1
Bachelor's degree	27.2

Master's degree	28.3
Doctoral degree	20.9
Parent's career in computing/STEM (n=853)	
Yes	43.4
No	56.6
Family socioeconomic status (n=854)	
Poor	5.0
Below average/lower middle class	18.7
Average/middle class	46.7
Above average/upper middle class	27.8
Wealthy	1.8

Table 3.2

Academic and Institutional Profile of Doctoral Student Sample (n = 1,335)

	Percent of Students
Undergraduate Major(s) (n=1,297)	
One computing major	54.0
Double major: Both in computing	6.2
Double major: Computing + other SEM	14.7
Double major: Computing + non-STEM	3.5
SEM major(s): single or double with non-STEM	19.8
Only non-STEM major(s)	1.8
Had a terminal master's degree prior to doctoral study (n=1,334)	37.4
Terminal master's was in a computing field (n=493)	87.6
Time to doctoral graduation (n=1,335)	
A year or less	21.2
Two years	18.6
Three years	21.6
Four years	20.8
Five or more years	17.8
Doctoral Institutional Type (n=1,335)	
Public	67.3

Private non-profit	32.7
Doctoral Institution Carnegie Classification (n=1,335)	
R1 - Very High Research Activity	92.2
R2 - High Research Activity	7.8
Doctoral Program Institutional Selectivity (n=1,335)	
More selective	91.2
Selective	8.1
Inclusive	0.7

Measures

Dependent Measure

The outcome of interest for this study was a dichotomous measure (yes/no) of students' consideration of departure. Specifically, students were asked "During your academic career, have you ever seriously considered leaving your graduate program prior to completing your degree?". Students who replied "yes" to this question were then shown two additional questions: (1) "Why did you consider leaving?" and (2) "What helped you continue in your program when you were contemplating leaving?". For each question, respondents were able to select up to three options from a list of choices, in addition to a write-in option, though that data was not available for this study. The dichotomous measure of students' departure consideration was used in a binary logistic regression, and additional descriptive analyses were conducted on the two follow-up questions for those students who indicated that they had considered leaving.

Independent Measures

Independent variables were selected in accordance with the conceptual model of doctoral student degree progress offered by Girves and Wemmerus (1988) described in Chapter 2. While the model includes environmental variables and activities, the student characteristics focus primarily on demographic characteristics, thereby neglecting important psychosocial attributes.

Thus, I extended Girves and Wemmerus's (1988) model to include measures of students' self-efficacy, career values, and sense of belonging in computing which have been shown to influence students' persistence (e.g., Gilmore et al., 2016; Sax et al., 2018; Stout & Blaney, 2018). Below, I highlight each of the key groups of variables and measures that were included in the multivariate analyses. See Table 3.3 for a list of variables and coding, Table 3.4 for factor loadings, and Table 3.5 for descriptive statistics on variables used in the regression analyses.

Department Characteristics. Due to limited variance among some departmental characteristics (e.g., selectivity, Carnegie), the only variable included in the multivariate analysis was institutional control (public or private), which was a dichotomous measure.

Student Characteristics. Next, Girves and Wemmerus (1988) suggested several measures of student demographic characteristics. In accordance with their model, this study included the following characteristics: age, gender, race/ethnicity, and citizenship status (i.e., domestic or international student). While students' racial/ethnic identity is critical to their experiences, due to small samples sized, I aggregated underrepresented racially minoritized (URM) students for the purposes of inferential analyses and for description group comparisons. URM Groups are defined as students who identify as Black, Hispanic, Native American, Native Hawaiian or Pacific Island, Arab, Middle Eastern, or Persian, or as Multiracial with any of these groups. The remaining descriptive analyses that relied upon frequencies used the disaggregated racial/ethnic group student identities.

Moving beyond the framework offered by Girves and Wemmerus (1988), this study also included students' academic characteristics which represents elements of the prior educational trajectories and current graduate student experience. Prior studies (e.g., Engberg & Wolniak, 2013; George & Wofford, 2019) have shown that resources or experiences from one education

setting – in this case students' undergraduate experiences – can influence outcomes in later educational settings (i.e., graduate school). As such, I included a measure of whether students had an undergraduate major in a computing field.

Financial Support. Given the important role funding sources have on students' degree progress and persistence (e.g., Ampaw & Jaeger, 2012; Bowen & Rudenstein, 1992), I included measures of how students are funding their doctoral studies. I aggregated survey items into four sources of educational funding: scholarship, research assistantship, teaching assistantship, and personal fund (e.g., private or public loans, savings, credit).

Perceptions of Faculty. The next group of variables related to students' perceptions of faculty, and more broadly of the department. As relationships with faculty are the most central to students' progress and outcomes (e.g., Barnes & Austin, 2009; Lovitts, 2001), the extent to which they see faculty members as role models or mentors can shape their degree progress or consideration of departure. Girves and Wemmerus (1988) highlighted that students' perceptions of their advisor's quality, concern, and usefulness. Accordingly, this study included measures of advisor satisfaction and mentor support – both created through factor analysis. The Advisor Satisfaction factor includes measures for academic and career guidance, and well as satisfaction with frequency of meetings with the advisor. The Mentor Support factor includes six items, including the extent to which students report having a faculty member who explores career options with them, supports their research ideas, develops their tangible computing skills, demonstrates compassion and shows an interest in the student as a person, and encourages them do to their best. These measures align with empirical research from Curtin, Malley, and Stewart (2016) who identified three different types of mentoring in the faculty-graduate student relationship, including instrumental (e.g., teaches technical and research skills), psychosocial

(e.g., support and encouragement), and sponsorship (e.g., assistance building a professional network).

Grades. Similar to Girves and Wemmerus (1988), this study relied upon students' GPA to measure their academic success. Still, GPA had a high (38%) amount of missing data, though it was imputed using multiple imputation techniques with (MI=50).

Involvement. Early research on graduate education, from Girves and Wemmerus themselves (1988) and later others (e.g., Golde, 2005; Lovitts, 2001) emphasized the importance of students' academic socialization to the department and the discipline. Girves and Wemmerus (1988) operationalized this socialization through students' involvement on projects and activities with faculty and other graduate students outside the classroom. For the purposes of this study, involvement was operationalized using as authorship (first or co-author) on a publication or refereed conference paper, as well as three composite scales to measure students' involvement in professional development activities (e.g., visiting lectures, professional computing societies, training or workshops, summer institutes), teaching activities (i.e., mentored students, taught classes, and provided study support in computing), and industry activities (i.e., participation in internships, computing-related contests, and entrepreneurial projects).

Satisfaction/Alienation. Building upon students' involvement – which represents behavioral components that may shape their degree progress – Girves and Wemmerus (1988) included affective measures of satisfaction and alienation in their model – representing how students think and feel about their involvement in the graduate environment of their program. This section included measures of students' satisfaction with faculty availability outside of class as well as three factors. First, a three-item factor of Peer Support included measures of how often students receive help and support, feedback on work, and a willingness to listen to school issues

from their peers. Second, a six-item factor of Departmental Support included measures of the climate within the department, such as whether the department cared about its students, cultivated an environment that inspired students to do their best, and developed a sense of community.

Further, Girves and Wemmerus (1988) noted that feeling isolated or not fitting in – which they felt was more commonly felt by women and minority students – would compromise or threaten students' degree progress. They argued that "the degree to which faculty impart the feeling of acceptance, support, and encouragement will influence the student's sense of belonging" (Girves & Wemmerus, 1988, p. 168). Accordingly, this study included a three-item factor of students' Sense of Belonging in computing, which was created from the following item. Beyond individual faculty relationships, this study also includes perceptions of the department more broadly within this category of variables.

Psychosocial Factors. To fill gaps in Girves and Wemmerus's (1988) conceptual framework of doctoral student progress, this study included key psychosocial factors that may influence students' consideration of departure. I extended their framework by including measures of students' career value orientation and self-efficacy. Specifically, two factors of career value orientation, communal career value orientation (i.e., importance of students' future career allowing them to help others, be a role model, and have a social impact) and professional network value (i.e., importance of building a strong professional network and becoming well-known in their field) were included to represent different motivations for students' career pursuits. Also, two factors of students' self-efficacy were included: communication self-efficacy (i.e., communicating technical problems and solutions, articulating thoughtful answers to theoretical questions about your work, and discussing work with senior members of the field)

and teaching and research self-efficacy (i.e., skills related to being a capable and effective researcher and teacher). The inclusion of these psychosocial attributes may reveal opportunities to enhance graduate training.

Factor Analysis

To reduce the number of variables in the model and to enhance parsimony, I conducted exploratory factor analysis on all relevant items. Factors were created using principle axis factoring (PAF) with a promax rotation. Variables with a factor loading of 0.40 or greater were included in the factor and the reliability threshold was set to a minimum Cronbach's *alpha* of 0.65. As shown in Table 3.4, nine factors were created and were mentioned in the preceding variable sections: Advisor Satisfaction, Mentor Support, Sense of Belonging in Computing, Departmental Support, Peer Support, Communal Career Value Orientation, Professional Network Career Value Orientation, Communication Self-Efficacy, and Teaching and Research Self-Efficacy.

Missing Values

Missing data analysis was conducted on all variables of interest. I first ran frequencies to determine the proportion of data missing for each variable (see Table 3.5). While nearly all variables were missing less than 11% of data, the highest percent missing was the measure of GPA - 38%. As this variable had the least amount of missing data, compared to other measures of academic achievement, I elected to impute the missing values. I then investigated patterns of missing data using Little's MCAR test and found the test was significant ($p = .039$), indicating that the data were missing at random. In this case, multiple imputation (MI) was the most appropriate method for handling missing data concerns (Manly & Wells, 2015). Multiple imputation analyses (MI=50) were conducted for non-demographic independent variables.

Table 3.3

Variable Definitions and Coding Scheme

Variable	Definition/Coding Scheme
Dependent Variable	
Students' consideration of departure (thinking about leaving prior to completing their doctoral program)	0=Has not thought about leaving 1=Has thought about leaving
First-Stage Variables	
Department Characteristics	
Control (public or private)	1 = Public; 2 = Private not-for-profit
Student Characteristics	
Age[1]	Numerical value calculated from year born
Gender	0=Man; 1=Woman
Race/ethnicity	Individual racial/ethnic groups were used for descriptive profiles Groups were aggregated as follows for crosstabulations: White = only white students Asian = Asian or Asian American, majority groups (white and Asian) URM (underrepresented racially minoritized) = students who identify as Black, Hispanic, Native American, Native Hawaiian or Pacific Island, Arab, Middle Eastern, or Persian, or as Multiracial with any of these groups These aggregated groups were dummy coded for the regression, with Asian as the reference group.
Citizenship status	0 = US Citizen or permanent resident 1 = Non-US Citizen with temporary visa
Computing undergraduate major	0 = did not have a computing undergraduate major 1 = had at least one computing undergraduate major
Parent education level	1 = High school, GED, or less; 2 = Some college or associate's; 3 = Bachelor's degree; 4 = Master's degree; 5 = Doctoral degree
First-generation status	0 = not first gen; 1 = first gen student

Family socio-economic status	1 = Poor; 2 = Below average/lower middle class; 3 = Average/middle class; 4 = Above average/upper middle class; 5 = Wealthy
Time to graduation	1 = A year or less; 2 = 2 years; 3 = 3 years; 4 = 4 years; 5 = 5 or more years
Financial Support	
Education funded: Scholarships (e.g., merit, skill, fellowships, etc.)	0 = Unselected; 1 = Selected
Education funded: Research assistantship	0 = Unselected; 1 = Selected
Education funded: Teaching assistantship	0 = Unselected; 1 = Selected
Education funded: Personal (e.g., federal or private loans, credit, savings, parents, part- or full-time work)	0 = Unselected; 1 = Selected
Perceptions of Faculty	
Advisor satisfaction[1]	Three-item factor scale (Table 3.4)
Mentor support[1]	Six-item factor scale (Table 3.4)

Second-Stage Intervening Variables

Grades	
GPA[1]	Continuous numerical value given by student
Involvement	
Professional development activities (scale)[1]	Scale: 0 to 24 (0 = Never, 1 = Once, 2 = Two or three times; 3 = Four or more times)
How often have you been involved in each of the following groups or activities?	Rate 0 to 3 for each: visiting lectures, independent computing projects, computing student groups, professional computing societies, technical conferences related to computing, career mentoring programs or workshops, training or workshops in computing, summer institutes
Teaching activities (scale)[1]	Scale: 0 to 9 (0 = Never, 1 = Once, 2 = Two or three times; 3 = Four or more times)
How often have you been involved in each of the following groups or activities?	Rate 0 to 3 for each: mentored students, taught courses, provided study support in computing

Industry activities (scale)[1] How often have you been involved in each of the following groups or activities?	Scale: 0 to 9 (0 = Never, 1 = Once, 2 = Two or three times; 3 = Four or more times) Rate 0 to 3 for each: internships, computing-related contests, entrepreneurial projects
Authorship: has authorship experience (first or co-author on a journal publication or refereed conference paper)	0 = Unselected; 1 = Selected
Satisfaction/Alienation	
Sense of belonging in computing[1]	Three-item factor scale (Table 3.4)
Satisfaction with faculty availability outside of class (e.g., office hours, answering questions via email, etc.)[1]	1=Strongly disagree; 2=Somewhat disagree; 3=Neither agree nor disagree; 4=Somewhat agree; 5=Strongly agree
Departmental support[1]	Six-item factor scale (Table 3.4)
Peer support[1]	Three-item factor scale (Table 3.4)
Psychosocial Variables	
Communal value career orientation[1]	Three-item factor scale (Table 3.4)
Professional network value career orientation[1]	Two-item factor scale (Table 3.4)
Communication self-efficacy[1]	Three-item factor scale (Table 3.4)
Teaching and research self-efficacy[1]	Five-item factor scale (Table 3.4)

[1] Indicates variable was standardized for logistic regression.

Note. First- and second-stage variables are from Girves and Wemmerus's (1988) framework.

Table 3.4
Factor Loadings and Reliability for Composite Variables

Variable	Factor Loadings
Advisor Satisfaction *(n=1,237; Cronbach's alpha = .871)*	
How dissatisfied or satisfied are you with the following?	
How often you meet with your advisor(s)[1]	0.746
The academic guidance your advisor(s) provides[1]	0.956
The career advice your advisor(s) provides[1]	0.803
Mentor Support *(n=1,239; Cronbach's alpha = .914)*	
To what extent do you have a mentor who…	
Helps you improve your computing skills?[2]	0.733
Shows compassion for any issues you discussed with them?[2]	0.874
Shares personal experiences as an alternative perspective to your problem?[2]	0.812
Explores career options with you?[2]	0.812
Encourages you to do the best you can in your coursework?[2]	0.776
Supports your research ideas?[2]	0.816
Sense of Belonging in Computing *(n=1,314; Cronbach's alpha=.758)*	
How much do you agree or disagree with the following statements?	
I feel like I belong in computing[3]	0.860
I feel like an outsider in the computing community (reverse coded)[3]	0.669
I feel welcomed in the computing community[3]	0.645
Departmental Support *(n=1,247; Cronbach's alpha = .865)*	
Please rate how you feel about the environment of the department of your computing program	
I felt a sense of community in the computing department[3]	0.726
The department cared about its students[3]	0.882
The environment in the computing department inspired me to do the best job that I can[3]	0.748
The department is NOT very supportive of its students (reverse coded)[3]	0.802
My ideas or opinions are minimized or ignored (reverse coded)[3]	0.593
Computer science administrators and faculty care about diversity[3]	0.564
Peer Support *(n=1,253; Cronbach's alpha = .902)*	
How often to you receive the following from other students if you need it?	

Help and support[2]	0.913
Willingness to listen to issues you are having at school[2]	0.900
Feedback about your work[2]	0.797
Communal Career Value Orientation *(n=1,319; Cronbach's alpha = .765)*	
How important is it to you that your future career allows you to do each of the following?	
Have a social impact[4]	0.734
Be a role model[4]	0.654
Help others[4]	0.795
Professional Network Career Value Orientation *(n=1,319; Cronbach's alpha = .733)*	
How important is it to you that your future career allows you to do each of the following?	
Become well-known in my field[4]	0.761
Build a strong professional network[4]	0.761
Communication Self-Efficacy *(n=1,297; Cronbach's alpha = .794)*	
I am confident that I can…	
Clearly communicate technical problems and solutions to a range of audiences[3]	0.769
Articulate thoughtful answers to theoretical questions about your work during a presentation[3]	0.895
Discuss my work with senior members of my field[3]	0.602
Teaching and Research Self-Efficacy *(n=1,296; Cronbach's alpha = .811)*	
I am confident that I can…	
Be a capable researcher in my field[3]	0.808
Become an expert in my field[3]	0.845
Successfully teach a course in my field[3]	0.587
Be an effective mentor[3]	0.604
Publish in the top journals in my field[3]	0.698

[1] Five-point scale: 1 = "Very dissatisfied" to 5 = "Very satisfied"

[2] Five-point scale: 1 = "Not at all" to 5 = "Very much"

[3] Five-point scale: 1 = "Strongly disagree" to 5 = "Strongly agree"

[4] Five-point scale: 1 = "Not at all important" to 5 "Extremely important"

Table 3.5

Descriptive Statistics for Predictors of Considering Departure (n=1,335)

	Mean	SD	Min, Max	% Missing
Dependent Variable				
Consideration of departure (thinking about leaving prior to completing their doctoral program)	0.35	0.48	0, 1	0.0
Independent Variables				
Control[1]	1.22	0.47	1, 2	0.0
Age[1]	28.09	5.47	18, 66	8.1
Gender[2]	--	--	0, 1	7.2
Race/ethnicity[2]	--	--	--	10.4
Citizenship status[2]	--	--	0, 1	7.9
Computing undergraduate major[1]	0.78	0.41	0, 1	2.8
Education funding: Scholarships[1]	0.40	0.49	0, 1	0.0
Education funding: Research assistantship[1]	0.75	0.43	0, 1	0.0
Education funding: Teaching assistantship[1]	0.55	0.50	0, 1	0.0
Education funding: Personal resources[1]	0.24	0.43	0, 1	0.0
Advisor satisfaction (factor)[1]				7.3
How often you meet with your advisor(s)	4.17	1.08	1, 5	7.0
The academic guidance your advisor(s) provides	4.09	1.10	1, 5	7.1
The career advice your advisor(s) provides	3.96	1.14	1, 5	7.2
Mentor support (factor)[1]				7.2
Helps you improve your computing skills	3.28	1.37	1, 5	6.6
Shows compassion for any issues you discussed with them	3.87	1.18	1, 5	6.8
Shares personal experiences as an alternative perspective to your problem	3.63	1.29	1, 5	6.7
Explores career options with you	3.38	1.36	1, 5	6.7
Encourages you to do the best you can in your coursework	3.55	1.32	1, 5	6.7
Supports your research ideas	4.04	1.13	1, 5	6.8
GPA[1]	3.82	0.20	3.04, 4.87	38.2
Professional development activities (scale)[1]	10.14	4.76	0, 24	10.9
Visiting lectures related to computing	2.28	1.01	0, 3	8.0
Independent computing projects	1.61	1.13	0, 3	8.4
Computing student groups	1.06	1.06	0, 3	8.3
Professional computing societies	0.96	1.03	0, 3	8.8

Technical conferences related to computing	1.79	1.08	0, 3	8.9
Career mentoring programs or workshops	0.97	1.01	0, 3	9.0
Training or workshops in computing	0.91	1.01	0, 3	8.7
Summer institutes	0.53	0.87	0, 3	8.4
Teaching activities (scale)[1]	4.02	2.49	0, 9	9.5
Mentored students	1.65	1.12	0, 3	8.3
Taught courses	1.11	1.12	0, 3	8.6
Provided study support in computing	1.26	1.22	0, 3	8.4
Industry activities (scale)[1]	2.56	2.00	0, 9	8.8
Internships related to computing	1.12	1.01	0, 3	8.2
Computing-related contests	0.96	1.04	0, 3	8.3
Entrepreneurial projects	0.49	0.87	0, 3	8.3
Authorship[1]	0.66	0.47	0, 1	0.0
Sense of belonging (factor)[1]				1.6
I feel like I belong in computing	4.00	0.98	1, 5	1.3
I feel like an outsider in the computing community (reverse coded)	3.84	1.17	1, 5	1.4
I feel welcomed in the computing community	3.88	0.92	1, 5	1.4
Satisfaction with faculty availability[1]	4.10	0.92	1, 5	5.0
Departmental support (factor)[1]				6.6
I felt a sense of community in the computing department	3.60	1.14	1, 5	5.8
The department cared about its students	3.89	1.07	1, 5	5.7
The environment in the computing department inspired me to do the best job that I can	3.56	1.02	1, 5	5.8
The department is NOT very supportive of its students (reverse coded)	3.97	1.09	1, 5	5.8
My ideas or opinions are minimized or ignored (reverse coded)	3.99	1.06	1, 5	6.1
Computer science administrators and faculty care about diversity	3.90	0.98	1, 5	6.0
Peer support (factor)[1]				6.1
Help and support	3.71	1.04	1, 5	6.0
Willingness to listen to issues you are having at school	3.73	1.08	1, 5	6.1
Feedback about your work	3.61	1.09	1, 5	6.1
Communal value career orientation (factor)[1]				1.2
Have a social impact	3.77	1.04	1, 5	0.9
Be a role model	3.36	1.18	1, 5	1.1
Help others	3.90	0.99	1, 5	1.0
Professional network value career orientation (factor)[1]				1.2

Become well-known in my field	3.07	1.19	1, 5	0.9
Build a strong professional network	3.38	1.11	1, 5	1.1
Communication self-efficacy (factor)[1]				2.8
Clearly communicate technical problems and solutions to a range of audiences	4.26	0.73	1, 5	2.7
Articulate thoughtful answers to theoretical questions about your work during a presentation	4.22	0.75	1, 5	2.7
Discuss my work with senior members of my field	4.22	0.76	1, 5	2.7
Teaching and research self-efficacy (factor)[1]				2.9
Be a capable researcher in my field	4.16	0.806	1, 5	2.7
Become an expert in my field	4.11	0.837	1, 5	2.7
Successfully teach a course in my field	4.10	0.907	1, 5	2.9
Be an effective mentor	4.09	0.862	1, 5	2.7
Publish in the top journals in my field	4.07	0.859	1, 5	2.7

[1] Indicates that missing data was imputed for this variable

[2] Means and standard deviations are not provided due to the categorical nature of the data.

Data Analysis

Research question one asks about the demographic background characteristics of the students who had considered departure. To address this question, I first examined the frequency of the dependent variable (DV, consideration of departure). I then used two-way crosstabulations with Chi-square analyses and z-tests with the Bonferroni correction to examine significant differences in consideration of departure across groups for gender and racial/ethnic identities as well as citizenship status.

Research question two addressed the explanations student gave for why they considered leaving, as well as the supports they attribute to helping them continue in their program. I first filtered the sample to include only those who had considered departure, then ran frequencies on each explanation for why students had considered leaving. Students' choices were then examined with two-way crosstabulations and z-tests with the Bonferroni correction to identify any significant ($p<.05$) group differences by gender and aggregated racial/ethnic identity. I repeated

this process for the supports students identified in helping them continue in their program when they had thought about leaving.

Research question three examined the factors that predict students' consideration of departure and how they may vary for men and women. Multivariate analyses using binary logistic regression were conducted on an imputed dataset, in accordance with an adapted conceptual framework offered by Girves and Wemmerus (1988). Given the distribution of the DV, I adjusted the cut point to the mean (0.35). Specifically, I ran three cumulative models in a blocked logistic regression, with the first model including first-stage variables from Girves and Wemmerus's (1988) framework, followed by a second model with the second-stage intervening variables, and then a third model representing additional psychosocial characteristics which expands their framework. Regression findings were reported for the pooled dataset in each cumulative model. However, since goodness-of-fit analyses were not available for the pooled dataset, I inspected them for each of the 50 imputed datasets. The Chi-square was significant for all three models (p=.000 for all three models). The Hosmer and Lemeshow test for all 50 datasets for models 1 and 3 was not significant, and 48 out of 50 datasets for model 2 were not significant. Thus, I could not reject the null hypothesis that the model was a bad fit. Lastly, the classification summary improved for each model, with a range of 65.7-66.9 for model 1, 68.6 to 70.3 for model 2, and 70.3 to 72.4 for model 3. Collectively, these goodness-of-fit tests indicated a good model fit. I also inspected multicollinearity among the independent variables by using ordinary least squares (OLS) regression procedures and found that all tolerance (TOL) and variance of inflation (VIF) values were within acceptable thresholds for the third and final model.

After running the main effects model, I tested interaction effects to examine gender differences in the predictors of students' consideration of departure. As discussed in chapter two, women in computing doctoral programs experience vastly different interactions, climates, and outcomes compared to their male counterparts. Notably, women reported being put down by their male peers, experienced unwelcoming or hostile environments in the lab, felt marginalized and invisible (Anderson-Rowland et al., 2007), and have less favorable interactions and satisfaction with faculty (Cohoon, 2007). These negative, and perhaps even sexist, interactions have detrimental effects on women's educational and career trajectories (Barker et al., 2009; Eccles, 1994). Given the gender gaps in sense of belonging in computing (e.g., Lewis et al., 2017; Sax et al., 2018) and enrollment and computing degree attainment (NSB, 2018; Zweben & Bizot, 2018), along with the finding from this study that gender emerged as the most predictive variable in the main effects model, this study extends Girves and Wemmerus's (1988) empirical model by examining interaction effects to study differences in consideration of departure by gender. I ran a separate model with interaction effects to determine any differences by gender for key variables that were both supported by prior literature and were also significant in the main effects model for this study.

Qualitative Methods

Phenomenology

This study was guided by a social constructivist lens and relies upon a phenomenological approach to understand two key phenomena reflected in research questions four and five: how faculty understand reasons for students' consideration of departure, and how faculty conceptualize their role in doctoral student experiences and outcomes. Phenomenology emphasizes the importance of the individual's lived experiences and how they make meaning

from those experiences (Moustakas, 1994). Given the transitory nature of the human experience (Seidman, 2013), phenomenological approaches inquire about individual's subjective understanding by seeking their point of view (Patton, 2002). This subjective understanding, according to a social constructivist worldview, is negotiated socially and historically through interactions with others (Creswell, 2009). Accordingly, this study relied upon interviews to capture the experiences and perceptions of faculty members in doctoral computing programs. Further, interview methods were appropriate for the study of microfoundations of institutional logics as they allow for exploration into how faculty members understand and negotiate their identity and goals in a broader organizational context.

Sample

To bridge the quantitative and qualitative streams of inquiry, I used the quantitative student survey sample as a guide for selecting the institutions from which to recruit my qualitative faculty sample. Specifically, I reviewed the institutional profiles of schools with a high student respondent count of more than 18 students per institution. To narrow the scope of my inquiry and to enhance the alignment of institutional contexts among faculty participants, and with input from a computing faculty member who had piloted my interview, I selected institutions that are engaged in the FLIP (Diversifying Future Leadership in the Professoriate) Alliance. Eight of the 11 FLIP Alliance institutions were represented in my student sample and are top-10 ranked computer science doctoral programs according to U.S. News and World Report Rankings (2018). FLIP Alliance institutions are responsible for producing the majority of computing faculty across institutions of higher education, and the Alliance seeks to increase diversity in the professoriate (Center for Minorities and People with Disabilities in Information Technology, n.d.). These institutions were chosen as recruitment sites due to their commitment

to enhancing the graduate experience and doctoral outcomes and their representation among the student survey respondents.

From the eight FLIP Alliance institutions well-represented in my quantitative student survey sample, I conducted purposive, criterion recruitment of participants with the following criteria: computer science faculty, teaching in R1 programs, who are currently advising doctoral students. Participants were recruited via emails from myself and also from one of the Principal Investigator of the FLIP Alliance. I supplemented criterion sampling with snowball sampling to gather a larger participant pool to reach saturation.

As shown in Table 3.6, 10 faculty members participated in this study. All of the participants have tenured positions in computer science programs. Three participants were FLIP Advocates (institutional representatives for the FLIP Alliance), seven were men, and three were women. Nearly all faculty members were white, while one identified as white and Latino. Compared to the demographics of computing faculty, women faculty members are slightly overrepresented in this sample as they comprise 30% of the interview sample but just 15.7% of full professors in computing disciplines (Zweben & Bizot, 2020). Similarly, white professors are overrepresented in this sample given that they comprise nearly 100% of this sample, but are 57.6% of associate professors and 61.9% of full professors across computing disciplines (Zweben & Bizot, 2020).

Table 3.6
Demographic Profile of Faculty Participant Sample

Pseudonym	Institution	Gender	Race/Ethnicity	Rank
Dr. Anderson	C	Man	White	Associate Professor
Dr. Cleary	F	Man	White	Professor
Dr. Costanzo	B	Man	White	Associate Professor
Dr. Goodwin	B	Man	White	Associate Professor
Dr. Haddad	E	Woman	White	Professor

Dr. Klein	D	Woman	White	Professor
Dr. Moore	C	Woman	White	Professor
Dr. Pierce	C	Man	White	Professor
Dr. Pogo	A	Man	White & Latino	Professor
Dr. Stachowiak	C	Man	White	Professor

Data Collection

The qualitative stream of inquiry relied upon data gathered from semi-structured interviews with 10 computer science doctoral faculty. The interview protocol was pilot tested with two computing faculty members in the fall 2019 term. I incorporated their feedback and refined the protocol with input from committee members.

Interviews were conducted with Zoom video conferencing software in winter 2020 and lasted for approximately 60-90 minutes. Participants received a study information sheet in advance of the interview, along with a brief background questionnaire to gather demographic data for each participant. This questionnaire (see Appendix B) inquired about the participants' faculty position (e.g., rank, years at institution, total years as a faculty member) and their demographic characteristics (e.g., gender identity, race/ethnicity). At the beginning of each interview, participants were asked for verbal consent to participate in the study and have their interview recorded. To protect the faculty members' anonymity, pseudonyms were assigned, and any identifiable information shared during the interview that might reveal the identity of the participant, their students, department, or institution is not reported in the results of this study.

Interview Protocol

The interviews followed a semi-structured format that allowed the conversation to develop organically and provides space for faculty participants to discuss what is important and meaningful to them (Patton, 2002). The protocol was informed by a social constructivist lens and phenomenological approach. By inquiring about participants' past educational trajectories,

experiences in their own doctoral programs, as well as their motivations for pursuing a faculty role, I gained insight into how they developed subjective meanings of their lived experiences. Further, in accordance with Thornton et al.'s (2012) microfoundations of institutional logics, the protocol also included questions about the faculty member's role and how they juggle potentially competing responsibilities, their perceptions of doctoral attrition, and the ways organizational practices shape their work. I conclude with an exploratory question that asks the participant to think more broadly about the entire computing discipline. The full protocol is available in Appendix C.

Data Analysis

Data analysis occurred in several stages and was guided by phenomenology, which typically, to capture the lived experiences and meaning making of participants, relies upon an inductive approach to data analysis (Moustakas, 1994). The goal of qualitative data analysis is to fracture the data and rearrange or relate categories of codes to generate themes or patterns in the data (Saldaña, 2016). In this way, coding generates the critical link between gathering data from participants and providing explanations of their meaning (Charmaz, 2006).

Following each interview, I wrote a reflective summary of how the interview went to note the ideas, comments, and experiences that stood out to me most. Then, putting that aside, I listened to all the interview recordings while reviewing the transcripts. As I read the transcripts, I conducted pre-coding by identifying significant passages or quotes that stood out to me (Saldaña, 2016) and I later compared those notes to my post-interview notes to look for similarities and differences in what I noticed. I took preliminary jottings and then conducted a thorough reading of the transcript where I noted similarities and differences among faculty perceptions and views. I created a participant summary table from these patterns and wrote an analytic memo in my

research journal about my observations. Writing memos throughout the data analysis phase served as an intellectual workspace for me (Thornberg & Charmaz, 2014), allowing me to reflect, develop codes, identify emergent patterns, and make connections to theory and the overarching phenomena (Saldaña, 2016).

Qualitative methodologists (e.g., Creswell, 2009; Saldaña, 2016) recommend at least two cycles of coding as the qualitative analytic process is cyclical in nature. In the first cycle of coding, where I split the data into individual coding segments to attune to the participants' perspectives (Saldaña, 2016), I employed in vivo, open, and process coding. In the second round of coding analysis, I used pattern, focused, and axial coding to explore how categories and subcategories of codes relate to one another, to theory, and to the broader phenomena. In this stage, I searched for patterns of similarities, differences, and connection between the codes. I created code maps and trees to visualize connections and relationships between the codes and identified how many participants' accounts touched on each of the broader themes. I conducted my first and second cycle coding using Dedoose software.

These rounds of coding elucidated the participants' subjective understanding of why students consider leaving their doctoral program and the faculty members' role in doctoral student experiences and outcomes. I then relied on Thornton et al.'s (2012) microfoundations of institutional logic to critically examine the vocabularies of practice and faculty interactions with students to see how these were embedded in other systems of institutional logics. In doing so, I was keenly aware of the tension between understanding my participants' views and experiences with the two phenomena of inquiry and the questions their stories raised for me.

Trustworthiness

An important component in qualitative research is ensuring trustworthiness – in the design, collection, and analysis of data as well as the interpretation of the findings. Validity threats appear in two ways, through research bias wherein a researcher's values and expectations may influence the design and conclusions of the study and through reactivity where the researcher's presence may influence those being studied (Maxwell, 2013). I employed multiple strategies to mitigate validity threats and to ensure the trustworthiness of the data and conclusions. First, I wrote a summary following each interview and processed my thoughts through reflexive memos during data analyses. I reflected on the circumstances of the interview (e.g., where it occurred, time constraints, relevant current events), how I conducted the interview and built rapport, how the participant reacted to the questions, and what interviewing strategies I could improve upon. This practice of reflexivity (Patton, 2002) enhanced the trustworthiness of my data collection by strengthening my practices to avoid leading questions, practice an ethic of care, use a non-judgmental tone, and focus my questions on the participants' lived experience. I also discussed my interview skills and progress with peers and committee member to make adjustments and improvements in my role as the interviewer.

I also conducted member checks with study participants by sharing my interpretations of particular passages from their transcripts via email or over Zoom conferencing software to ensure I was understanding and representing their thoughts appropriately. Due to the Covid-19 restrictions and changes to workplace expectations, I elected not to pursue more thorough member checks of themes and findings so as not to add pressure or responsibility to my participants who were navigating working and teaching from home while juggling other personal responsibilities. Prior to publishing from this study, I plan to reach out to my participants again

to discuss the thematic findings and elicit their feedback for additional clarification. In doing so I will avoid misinterpretation and enhance the trustworthiness of my conclusions (Maxwell, 2013).

During the analysis phase, I looked for disconfirming evidence or negative cases that may challenge my conclusions. This enabled me to check my biases and assumptions, and to expose flaws in my methods and data organization. To further ensure the trustworthiness of my analysis and findings, I engaged in peer debriefing (Creswell, 2009) to solicit feedback from my student peers and members of my committee. This included a review of my codes, themes, and/or conclusions.

Positionality

My approach to this study, which shapes its design and my interpretations, is informed by my own experiences, perspectives, and interests. Understanding my own positionality allows for a critical awareness of the ways in which my own biases may impact this study. First and foremost, I am a doctoral student studying why other doctoral students may consider leaving their programs prior to earning their degree. Next, my interest in the subject of doctoral attrition through a disciplinary lens in computing is motivated by two critical experiences. I have served as a graduate student researcher and senior data manager on the Building, Recruiting, and Inclusion for Diversity (BRAID) Project which focuses on effort to diversify computing at the undergraduate level. Also, prior to pursuing my PhD, I worked in a tech job where I saw some of the impact of the lack of diversity in the field. These experiences have allowed me to develop an understanding and a language to use in connecting with members of the computing community. Thus, my personal interest in broadening participation within computing generally, and in graduate education specifically, has shaped the design and my preparedness to approach this subject.

Limitations

This study contributes to the literature on doctoral student departure as well as the role of faculty in students' experiences and outcomes, however it is important to acknowledge its limitations. First, the quantitative portion of this study relied upon existing data that were designed and collected by CERP. Accordingly, the analysis does not include other measures that might be useful in studying doctoral student considerations of departure (e.g., well-being concerns, program characteristics, specifics on timing and amount of funding, stage of doctoral progress – in coursework, advanced to candidacy, etc.). Thus, this study may not account for all of the possible variables that influence students' departure considerations. Additionally, the data was limited by low response rates with a median institutional response rate of 14% and an average of 17%. There may also be a selectivity bias in the sample as institutions choose to participate in the Data Buddies Survey. Their incentive to participate is a departmental report comparing their students to others at similar institutional types. It is likely that only departments who are truly interested in their students' experiences in computing would participate, so the generalizability of the survey is limited.

Further the dependent variable is a single item with a dichotomous response choice. The language of the question, "have you seriously considered leaving", is open for students to interpret what "seriously" means. Some students might interpret it to mean that they have thought about it a lot, whereas others might view serious consideration to be that they have investigated the administrative requirements for leaving their program. Additionally, the question does not ask when or for how long students have considered leaving. This limits the possible conclusions as I cannot know when students' departure considerations arose, how long-lasting they were, or if different experiences or interactions in graduate school lead to consideration at

different points in the program.

Additionally, the qualitative stream of inquiry will focus on the perspectives of a limited number of computing faculty and the sample may be biased based on recruitment and self-selection. First, there may be a bias toward larger programs because they may be more likely to have a higher number of student survey respondents, which would have put them in a possible institutional recruitment pool. Next, faculty from highly-ranked programs likely have a more privileged institutional context than faculty at other institutions. Lastly, there is a notable self-selection bias among participants. Many faculty members, either now or in the past, hold leadership positions in their department that are involved in various aspects of the graduate experience. As a result, they may have participated in this study because they are perhaps more aware of or committed to addressing challenges in doctoral computing education.

Summary

This chapter provided an overview of the sequential explanatory mixed-methods design (Creswell, 2009) that guides this inquiry into doctoral computing attrition. The primary objective of this study was to empirically examine explanations of computing doctoral student consideration of departure from the perspectives of both students and faculty members. It also explored the role faculty have in shaping doctoral experiences and outcomes. The quantitative stream of inquiry, which utilized graduate student survey data from CERP's Data Buddies Survey, provided a current and discipline-specific view into the prevalence of students' consideration of departure and the factors that support or threaten students' thoughts on completing their degree. I also explored gender differences in how women and men experience their graduate program and whether that influences their consideration of departure. The realities of the student experience were complemented with qualitative interviews with 10 computer

science faculty members from highly-ranked doctoral programs. Using a social constructivist lens and a phenomenological approach, I explored faculty members' perceptions of students' departure considerations, as well as their own role in doctoral student experiences and outcomes.

CHAPTER 4: QUANTITATIVE FINDINGS

This chapter presents findings from the quantitative portion of this study which examined students' consideration of departure using student responses to the 2018 CERP Graduate Student Data Buddies Survey. This chapter begins with a presentation of descriptive findings, first addressing research question one which aims to identify the demographic and background characteristics of students who have seriously considered leaving their program prior to completion. Then, findings from the second research question explore students' explanations for why they considered leaving and what supports have helped them continue in their program. Lastly, findings from the third research question are shared to illuminate the factors that predict students' consideration of departure. I conclude the chapter with a summary of the quantitative results and a preview of Chapters 5.

Research Question One: Who Considers Departure?

The first research question focuses descriptively on students' consideration of departure to examine both the prevalence of considering departure as well as any group differences in this consideration among students across gender and racial/ethnic identities. Students responded to the question of whether they had seriously considered leaving their program prior to earning a degree. More than one-third of doctoral students in this sample, 34.6% (n=462), reported seriously considering departure.

I then used two-way crosstabulations with Chi-square analyses and z-tests with the Bonferroni correction to examine significant differences in consideration of departure across groups. Table 4.1 highlights key group differences in terms of the proportion of students among different gender and racial/ethnic identity groups, as well as citizenship status, who have considered departure. Additional information regarding the demographic profile of students and

significant differences in the distribution of students who have and have not considered departure is given in Table 4.2.

When comparing differences across groups of students who have considered leaving their program prior to departure, I found that women were significantly more likely to think about leaving than men – a finding which is consistent with trends in doctoral attrition (CGS, 2008). Specifically, 38% of women had considered departure compared to 31% of men.

Additionally, interesting differences emerged among students with different racial/ethnic identities. Notably, the proportion of white students who had thought about leaving, 44.4%, was significantly higher and nearly double the proportion of Asian, Asian American, or mixed majority students who had considered departure (23.2%). Further, 38.1% of students from underrepresented, racially minoritized groups had thought about leaving their doctoral program, which was also significantly higher than the proportion of Asian students who considered departure. There were no significant differences in the proportions of URM students and white students who had considered departure. Group differences for individual racial/ethnic groups that comprise the URM aggregated group were also examined, though no significant differences emerged between individual groups. Thus, aggregated findings are reported in Table 4.1. That white students were significantly more likely than Asian students and no more or less likely than URM students to consider departure is interesting since limited research (CGS, 2008; Denecke et al., 2007) on doctoral attrition has found that URM students are more likely than white and Asian students to actually leave their degree program. Additionally, existing research has often aggregated white and Asian students together given that they are well-represented within STEM fields, so findings from this study and the significant disparities in departure consideration between white and Asian students reinforce the need to examine group differences.

Lastly, significant differences were examined by citizenship status. This is particularly relevant for computing disciplines as the majority (62.6%) of students enrolled in doctoral computing programs are international students (Zweben & Bizot, 2019) and rising international student enrollment accounts for much of the substantial growth in computing graduate programs (NSB, 2018). As shown in Table 4.1, domestic students reported considering departure at twice the rates of international students. Forty-six percent of U.S. citizens or permanent residents reported that they had seriously thought about leaving their doctoral program prior to earning their degree, compared to just 23.4% of international students. The fact that fewer international students consider departure is also consistent with existing research on doctoral completion across disciplines which finds that international students ultimately complete their doctoral degrees at higher rates than domestic students (CGS, 2008).

Table 4.1
Group Differences Among Students Who Have Considered Departure

	n	Percent among group	Significantly different from
Gender			
(1) Women	539	38.0	2
(2) Men	700	31.1	1
Aggregated racial/ethnic groups			
(3) White	471	44.4	4
(4) Asian, Asian American, or mixed majority	499	23.2	3, 5
(5) URM Groups[1]	226	38.1	4
Citizenship			
(6) U.S. citizens or permanent residents	631	46.0	7
(7) Non-U.S. citizens, with temporary visa	598	23.4	6

[1] No differences were found among individual URM identities
Note. Differences were significant at $p<.05$ level

Table 4.2

Demographic Profile of Doctoral Students, by Consideration of Departure

	Percent Among			
	Have Considered Departure	Have Not Considered Departure	χ^2	Sig.
Gender	*n = 431*	*n = 822*	9.7	**
Women	47.6	40.6		
Men	50.6	58.6		
Non-binary	1.9	0.7		
Race/ethnicity	*n = 414*	*n = 791*	57.1	***
White	50.5	33.1		
Asian or Asian American	23.9	44.6		
Multiracial: White and Asian	4.1	3.8		
Black, African American	4.8	3.4		
Hispanic or Latina/o	3.9	3.2		
Native American	0.2	0.1		
Native Hawaiian or Other Pacific Islander	0.0	0.3		
Arab, Middle Eastern, or Persian	7.2	7.7		
Multiracial: URM Groups	4.6	3.0		
Other	0.7	0.8		
Citizenship status	*n = 434*	*n = 822*	73.8	***
U.S. Citizen or Permanent Resident	66.8	41.5		
Non-U.S. Citizen, temporary visa	32.3	55.7		
Other	0.9	2.8		
Age group	*n = 426*	*n = 801*	20.9	***
18 to 24 years old	17.6	28.1		
25 to 29 years old	53.8	46.4		
30 to 34 years old	18.1	16.9		
35 to 39 years old	4.5	5.2		
40 years old and over	6.1	3.4		
Disability	*n = 429*	*n = 802*	23.9	***
Yes	9.1	2.7		
No	90.9	97.3		
Sexual orientation	*n = 273*	*n = 565*	7.7	

Heterosexual	84.2	88.8		
Homosexual	4.4	5.1		
Bisexual	7.0	4.1		
Other/self-identify	4.4	1.9		
Marital status	*n* =277	*n* = 586	1.7	
Married/Domestic Partnership	28.2	25.6		
Widowed	0.0	0.3		
Divorced/Separated	2.2	1.9		
Never Married	69.7	72.2		
Parent's Education Level	*n* = 273	*n* = 583	12.2	*
High School, GED, or Less	11.7	15.8		
Some College or Associate's Degree	12.5	7.5		
Bachelor's Degree	26.4	27.6		
Master's Degree	24.5	30.0		
Doctoral Degree	24.9	19.0		
First Generation Status	*n* = 273	*n* = 583	2.5	
Yes	11.7	15.8		
No	88.3	84.2		
Parent's Career in Computing/STEM	*n* = 275	*n* = 578	0.2	
Yes	44.4	42.9		
No	55.6	57.1		
Family Socioeconomic Status	*n* = 273	*n* = 581	8.9	
Poor	5.9	4.6		
Below Average/Lower Middle Class	21.2	17.6		
Average/Middle Class	42.5	48.7		
Above Average/Upper Middle Class	27.1	28.1		
Wealthy	3.3	1.0		

Note. *p<.05, **p<.01, ***p<.001

Research Question Two: Explanations of Threats and Supports

The second research question examined students' explanations of what threatened or supported their progress in their doctoral program. On the survey, students who reported that

they had seriously considered leaving their program received two follow-up questions probing their explanations for why they considered leaving, as well as what helped them continue in their program when they were contemplating leaving. For each question students were able to select up to three responses from a list of choices. In the sections below I describe findings from the frequency analysis of reasons to stay and reasons to leave. Additionally, students' choices were examined with two-way crosstabulations and z-tests with the Bonferroni correction to identify any significant ($p<.05$) group differences by gender and aggregated racial/ethnic identity.

Factors that Contributed to Students' Thoughts of Departure

Students who replied "yes" to the question of whether they had seriously considered departure were then asked, "why did you consider leaving?" They were given ten choices as well as a write-in text response. Due to data privacy issues, text responses were not available for analysis. The remaining ten response choices were analyzed using frequencies and crosstabulations. Results are shown in Table 4.3.

Among the most commonly selected explanations for why students considered leaving their program prior to completion were choices related to students' sense of inclusion and support. Specifically, nearly half (49.1%) of students indicated that they felt isolated in their program. The next most commonly selected explanation, chosen by 25.7% of students, was that the professors were not supportive. Additionally, 13.7% of students indicated that they considered leaving because their department did not make them feel welcome. The high percentages of students who selected these explanations, along with the less commonly selected explanation of not having any friends in the major – chosen by 7.1% of students – indicates how a perceived lack of connection and support from faculty and students in the department can lead students to consider leaving their program.

Additionally, one-fifth of students reported that they considered leaving their program due to health issues that inhibited their ability to feel or be successful. While the type of health issues experienced by students, whether mental or physical, is unclear, this finding does align with current conversations (e.g., Flaherty, 2018b; Walker, 2015) and emerging research (e.g., Barreira et al., 2018; Evans et al., 2018) around the mental health crisis in graduate school.

Less common explanations of why students considered leaving were related to academic performance. Few students reported that they considered leaving due to finding the courses difficult (8.5%), having trouble passing courses (4.6%), challenging math requirements (4.3%), or not enjoying the course material (6.1%). The stark contrast in the lower proportions of students who identified academic challenges as key factors in their consideration of departure compared to the prevalence of challenges related to lack of community and support indicates that students' environments and their interactions with others heavily shape their potential progress or departure from their doctoral program. Lastly, 56.3% of students reported that they considered leaving for "other issues not listed above." This indicates that there are potentially many other explanations for what contributes to thoughts of departure beyond the common academic, socioemotional, and health choices.

Differences by Gender

Differences in students' explanations for why they considered leaving were examined by gender using z-tests with the Bonferroni correction. As shown in Table 4.3, significant gender differences were found on only one item. Notably, women were significantly more likely than men to report that health issues which inhibited their ability to feel or be successful contributed to their consideration of departure. More than a quarter of women identified health issues as a contributor their thoughts of leaving, compared to less than 16% of men.

Differences by Racial/Ethnic Identity

Students' explanations for why they wanted to leave were similarly explored to identify any significant differences by racial/ethnic identity. Z-tests with the Bonferroni correction were conducted to compare proportions of white, Asian, and underrepresented racially minoritized students. A unique pattern (shown in Table 4.3) emerged across nearly all of the explanations students selected, including those with significant racial/ethnic differences. Significant differences in proportions were observed on three explanations with significantly larger proportions of URM students choosing those three explanations than did Asian or Asian American students. No significant differences were observed between white students and students from other racial/ethnic identities.

First, a majority of URM students (58.1%) reported that they considered leaving because they felt isolated in their program, compared to 38.6% of Asian or Asian American students. Feeling isolated was the most commonly selected explanation for consideration of departure among URM students. Additionally, more than one-fifth of URM students reported that the department did not make them feel welcome in the program while significantly fewer Asian students, less than ten percent in fact, attributed their consideration of departure to this. Lastly, four times as many URM students (14.0%) indicated that they considered leaving due to difficult courses compared to their Asian (3.5%) counterparts. No significant differences emerged between white students and Asian or URM students.

Table 4.3

Among Students Who Have Considered Departure, Explanations for Why they Considered Leaving, by Gender and by Racial/Ethnic Identity

		Percent Among Gender		Percent Among Racial/Ethnic Group		
	Percent Selected (n=460)	Women (n=204) a	Men (n=217) b	White (n=209) c	Asian or Asian American (n=114) d	URM[a] Groups (n=86) e
I felt isolated in my program	49.1	52.0	44.2	50.7	38.6 [e]	58.1 [d]
The professors were not supportive	25.7	21.6	28.1	23.9	23.7	27.9
I experienced health issues that inhibited my ability to feel/be successful	20.0	26.0 [b]	15.7 [a]	19.6	22.8	18.6
The department did not make me feel welcome	13.7	9.8	17.5	12.9	8.8 [e]	22.1 [d]
The courses were difficult	8.5	10.3	6.5	8.6	3.5 [e]	14.0 [d]
I did not have any friends in the major	7.2	8.3	6.0	6.7	7.9	8.1
I did not like the course material	6.1	7.4	5.1	4.3	7.0	9.3
I was having trouble passing my courses	4.6	5.4	4.1	4.8	2.6	7.0
The math requirements were too hard	4.3	4.9	3.7	5.3	3.5	4.7
I had other issues not listed above	56.3	54.4	59.9	59.8	58.8	46.5

[a] URM Groups are defined as students who identify as Black, Hispanic, Native American, Native Hawaiian or Pacific Island, Arab, Middle Eastern, or Persian, or as Multiracial with any of these groups.

Note. Superscripts indicate significant differences between groups at $p<.05$.

Factors that Supported Students to Continue in Their Program

Students who reported that they had seriously considered departure were also asked, "What helped you continue in your program when you were contemplating leaving?" They were given seven choices as well as a write-in text response. Similar to the explanations for leaving, text responses were not available for analysis because of data privacy issues. The remaining response choices were analyzed using frequencies and crosstabulations. Results are shown in Table 4.4

The leading reason students reported for continuing in their program, selected by a majority of students (52.7%), was that they had already invested too much time and resources. Intellectual engagement and social support were also popular reasons why students continued in their program. The second most common explanation for staying, selected by 44.6% of students, is that they liked their field of study. Next, students also reported that support or encouragement from others including family (43.1%), friends (38.7%), and professors (36.3%) helped them continue when they were contemplating leaving.

Interestingly, only 15.6% of students indicated that they stayed because the job market is promising. Computing is unique in that students have an abundance of job opportunities both within and outside the academy so job prospects could be both a reason to leave and a reason to stay depending on what position students are most interested in.

Differences by Gender

A few key differences emerged between women's and men's explanations of what helped them continue. First, men were significantly more likely than women to attribute their decision to stay with liking their field of study. Nearly half (49.8%) of men selected this reason while less than 40% of women did. Additionally, women, more so than men, relied on their networks of

support. Specifically, women were significantly more likely than men to attribute meaningful support from friends (44.8% to 31.9%) and faculty (43.8% to 30.5%) as influential in helping them continue in their program.

Differences by Racial/Ethnic Identity

When examining differences in explanations for what supported students to continue by racial/ethnic identity, only one reason emerged as significantly different. Underrepresented racially minoritized students were significantly more likely than their white peers (55.3% to 36.9%, respectively) to report that family support is what helped them stay in the program.

Table 4.4

Among Students Who Have Considered Departure, Students' Explanations for What Helped Them Continue in Their Program, by Gender and by Racial/Ethnic Identity

		Percent Among Gender		Percent Among Racial/Ethnic Group		
	Percent Selected (n=455)	Women (n=203) a	Men (n=213) b	White (n=206) c	Asian or Asian American (n=113) d	URM[a] Groups (n=85) e
I had already invested too much time and resources	52.7	49.3	58.2	54.9	50.4	54.1
I liked the field of study	44.6	39.4 b	49.8 a	46.6	41.6	41.2
My family encouraged/supported me	43.1	45.3	41.3	36.9 e	44.2	55.3 c
My friends encouraged/supported me	38.7	44.8 b	31.9 a	35.9	42.5	42.4
Professors/faculty encouraged/supported me	36.3	43.8 b	30.5 a	33.0	42.5	38.8
The job market is promising	15.6	12.3	17.4	16.0	15.0	11.8
I had other reasons not listed above	18.2	20.7	16.0	23.3	13.3	11.8

[a] URM Groups are defined as students who identify as Black, Hispanic, Native American, Native Hawaiian or Pacific Island, Arab, Middle Eastern, or Persian, or as Multiracial with any of these groups.

Note. Superscripts indicate significant differences between groups at $p<.05$

Research Question Three: Factors Predicting Consideration of Departure

The third research question for this study examined the factors that predict students' consideration of departure, that is whether they had thought about leaving their program prior to completion, and how that may vary by gender. Multivariate analyses using binary logistic regression were conducted in accordance with an adapted conceptual framework offered by Girves and Wemmerus (1988). Specifically, I ran three cumulative models in a blocked logistic regression, with the first model including first-stage variables from Girves and Wemmerus's (1988) framework, followed by a second model with the second-stage intervening variables, and then a third model representing additional psychosocial characteristics which expands their framework. Main effects findings are discussed below for the final, third model, though results from all regressions are shown in Table 4.5. Variables with odds ratio greater than one indicate an increased likelihood that students had thought about leaving their program, whereas odds ratios less than one indicate variables that reduce the likelihood that a student had thought about leaving. Findings are discussed based on the stages of the conceptual framework. Lastly, based on significant main effects, I explored gender differences using two-way interaction terms.

First-Stage Variables

Girves and Wemmerus's (1988) conceptual framework posited that two stages of variables intervened to influence students' doctoral degree progress. Findings from the first-stage variables, including student and departmental characteristics, financial support, and perceptions of faculty, are discussed below.

Department Characteristics

The use of secondary data for this study limited the possible departmental variables, though a measure of institutional control (i.e., whether the institution is public or private) was

used. I found no significant effect on students' consideration of departure based on the institutional control.

Student Characteristics

Several demographic characteristics emerged as significant predictors of students' consideration of departure. Notably, gender was the strongest predictor, across all three models, and in the final model. Women were 50% more likely than men to seriously think about leaving their doctoral program prior to earning a degree. That women think more than men about leaving is not surprising given that literature on doctoral attrition (e.g., CGS, 2008; Nerad & Cerny, 1993) has found that women actually leave their programs at higher rates than men do. However, what is surprising is that controlling for all other variables in the model, gender still remained the strongest predictor.

Additionally, students' age and citizenship status were also significant predictors. Older students were more likely to think about leaving than younger students, such that for every one standard deviation increase in age, students were 20% more likely to think about leaving their program. Next and in line with descriptive findings, international students were 46% less likely to think about leaving compared to their domestic counterparts.

Further, two key student characteristics were not significant in predicting students' consideration of leaving. None of the racial/ethnic identity variables were significant contributors to students thinking about leaving their computing graduate program. This is notable given the significant group differences reported in research question one – namely that white and underrepresented, racially minoritized students were significantly more likely than Asian students to think about leaving – though it indicates that when controlling for other experiences and perceptions, students' racial/ethnic identity is not as integral to their thoughts of leaving.

Lastly, having an undergraduate computing major did not significantly predict students' consideration of departure.

Financial Support

Four dichotomous measures of whether students relied on certain funding sources were included in the inferential analyses: scholarships, research assistantships, teaching assistantships, and personal resources (e.g., loans, credit, savings, part- or full-time work). While funding their doctoral studies with personal resources was a significant predictor of considering departure in the first model, once accounting for the intervening variables in model two, personal funding was no longer significant. In fact, none of the financial support variables were significant in the final model, which suggests that *how* students fund their program is less salient to their thoughts of leaving. However, given the important role of funding sources on students' degree progress and persistence (e.g., Ampaw & Jaeger, 2012; Bowen & Rudenstein, 1992), it may be that funding resources are critical in the later decision-making process to stay or leave.

Perceptions of Faculty

Girves and Wemmerus' (1988) model highlighted the critical role of faculty in students' progress, particularly the importance of students' perceptions of their advisor's quality, concern, and usefulness. A factor representing mentor support was not significant in the final model, though it was significant in models one and two. This suggests some covariance between mentor support and the psychosocial variables pertaining to students' career orientation values and self-efficacy that entered in model three.

While mentor support was not ultimately predictive of students thinking about leaving, satisfaction with the advisor relationship, in accordance with an abundance of literature (e.g., Barnes & Austin, 2009; Lovitts, 2001), was significant. For each standard deviation increase in

students' satisfaction with their advisor, they were 23% less likely to think about leaving their program. The individual items in the advisor satisfaction factor – frequency of meetings, academic guidance, and career advice – serve as tangible elements of the relationship and are indicative of what students may be looking for from their advisor relationships.

Second-Stage Intervening Variables

The second block of variables representing the intervening variables offered in Girves and Wemmerus's (1988) framework, which includes measures related to students' academic performance, involvement in activities outside the classroom that socialize them to the department and discipline, and affective measures of students' satisfaction or alienation in their department or program are discussed in this section. Nearly half of the significant predictors in the final model are included this block, revealing the importance of these intervening variables.

Grades

Students' academic performance, as measured through their grade point average (GPA), emerged as a significant predictor. For every one standard deviation increase in GPA, students' likelihood of thinking about leaving decreased by 23%.

Involvement

Girves and Wemmerus (1988) posited that activities and experiences outside the classroom that help to socialize students to the department and to the discipline would influence students' progress in their program. Several composite measures and aggregated variables were computed to reflect student involvement in various activities (see Table A2 for variable coding). Notably, students' involvement in professional development (e.g., conferences, lectures, and student groups) and teaching (e.g., mentoring students, teaching courses, and providing study support) activities were not significant predictors in their consideration of departure. Also, a

measure of students' authorship experiences, as measured by first or co-authorship on a journal article or refereed conference paper, was not significant. Attending lectures or conferences, teaching courses, and writing papers are typical activities many doctoral students engage in, which serve to acclimate them to life as an independent researcher, but findings from this study revealed that these experiences are not predictive of students' thinking about leaving their programs.

However, what did emerge as a significant predictor was the level of involvement students had with industry activities such as internships, computing contests, and entrepreneurial activities. For each standard deviation increase in the time students spent on activities related to the tech industry, they were nearly 35% more likely to think about leaving before finishing their degree. The pull of employment in industry is quite strong, as evidenced by nearly 60% of doctoral degree earners being employed in industry positions after graduation (Zweben & Bizot, 2019), so it is not surprising that exposure to other, non-academic career paths might encourage students to think about leaving their program.

Satisfaction/Alienation

Three of the four variables representing affective measures of students' satisfaction or alienation in their department emerged as significant predictors of students' consideration of departure. First, with each standard deviation increase in sense of belonging in computing, students were 25% less likely to think about leaving their doctoral program. Similarly, for each standard deviation increase in students' perceived departmental support (e.g., that they had a sense of community, cared about their students, inspired students to do their best, and cared about diversity) students were almost 30% less likely to consider departure. These findings indicate that the climate within the department, and the extent to which it is welcoming and

supportive, play a critical role in reducing the odds of students thinking about leaving their program prior to earning a degree.

Surprisingly, and in contrast to the supportive role of departments, peer support was shown to actually increase the likelihood of students' consideration of departure. While it was not significant in the second model, once psychosocial variables were added to the third regression model, peer support emerged as significant. With each standard deviation increase in peer support, students were 20% more likely to think about leaving their doctoral program. I will elaborate on these findings and other possible explanations in Chapter 6.

Psychosocial Variables

This study expands and addresses gaps in Girves and Wemmerus's (1988) conceptual framework by incorporating a third block of variables that represent psychosocial characteristics which may also shape students' consideration of departure. While some psychosocial variables were included in measures of satisfaction and alienation, I explored the influence of other measures of students' values and self-efficacy in different domains, and the role they may play in students' consideration of departure. The inclusion of this block of variables both improved goodness of fit measures and two of the four composite factor measures in this block were significant predictors of students' consideration of departure.

First, though students' communal career value orientation (i.e., placing a high value on helping other sand having a social impact) was not significant, each standard deviation increase placing importance or value on a professional network (i.e., becoming well-known in their field and building a strong network) significantly reduced the likelihood of students thinking about leaving by 30%. It is possible that if striving to build a professional network is a priority, students may be less likely to think about leaving since those thoughts might potentially

compromise the network or hinder their ability to become well-known in their field. Alternatively, it is also likely that students who are not thinking of leaving, or are more certain of their commitment to finishing, may already be building a stronger professional network.

Additionally, measures of students' self-efficacy (i.e., the belief in their ability to succeed at specific tasks or achieving certain outcomes) across different domains were shown to have different relationships with the outcome of thinking about leaving. Self-efficacy related to students' skills in communicating about their work was not a significant predictor of students thinking about leaving. However, students' self-efficacy regarding their teaching and research skills did emerge as a significant predictor. Specifically, for each standard deviation increase in students' confidence in their ability to be an effective teacher, mentor, and researcher they were 31.4% less likely to think about leaving their doctoral program. Again, this finding makes sense as the components of this factor represent common markers of success and skill in a doctoral program. This finding suggests that students are less likely to think about leaving a path where they are more confident in their ability to succeed. Thus, what students value and what they are good at may affirm their certainty of the path to the PhD and therefore reduce the odds of them questioning or thinking of leaving it.

Collectively, the importance of psychosocial variables measured in this block as well in the satisfaction/alienation component indicates that the interactions students have within their program and departments and how they perceive those interactions contribute to certainty or doubt about staying in or leaving their doctoral program.

Table 4.5

Summary of Logistic Regression Predicting Students' Consideration of Departure (n =1,160)

	Model 1				Model 2				Model 3			
Variable	b	SE	Sig.	Exp(B)	b	SE	Sig.	Exp(B)	b	SE	Sig.	Exp(B)
Stage 1 Variables												
Department Characteristics												
Control (public or private)	-0.17	0.15		0.85	-0.21	0.16		0.81	-0.27	0.16		0.766
Student Characteristics												
Age	0.11	0.07		1.12	0.16	0.08	*	1.17	0.19	0.08	*	1.203
Gender: Woman	0.42	0.14	**	1.52	0.39	0.15	**	1.48	0.41	0.15	**	1.5
Race/ethnicity: White (ref: Asian)	0.27	0.18		1.31	0.37	0.19		1.44	0.29	0.19		1.335
Race/ethnicity: URM Groups (ref: Asian)	0.28	0.19		1.33	0.21	0.20		1.23	0.24	0.21		1.267
Citizenship status: International	-0.91	0.16	***	0.40	-0.82	0.17	***	0.44	-0.61	0.18	**	0.55
Computing undergraduate major: yes	-0.02	0.17		0.98	0.12	0.18		1.13	0.03	0.19		1.04
Financial Support												
Education funded: Scholarships	-0.02	0.14		0.98	-0.02	0.15		0.98	-0.01	0.15		0.99
Education funded: Research assistantship	0.31	0.17		1.37	0.30	0.18		1.35	0.25	0.18		1.28
Education funded: Teaching assistantship	-0.11	0.14		0.90	-0.14	0.14		0.87	-0.15	0.15		0.87
Education funded: Personal	0.33	0.16	*	1.39	0.25	0.17		1.29	0.19	0.17		1.21
Perceptions of Faculty												
Advisor satisfaction (factor)	-0.34	0.08	***	0.71	-0.28	0.09	**	0.76	-0.26	0.09	**	0.77
Mentor support (factor)	-0.24	0.08	**	0.79	-0.19	0.09	*	0.83	-0.15	0.09		0.86
Stage 2 Variables												
Grades												
GPA					-0.22	0.09	*	0.80	-0.26	0.10	**	0.77
Involvement												
Professional development activities (scale)					-0.07	0.10		0.93	0.02	0.10		1.02
Teaching activities (scale)					0.08	0.08		1.08	0.08	0.09		1.08
Industry activities (scale)					0.31	0.09		1.37	0.30	0.10	**	1.35
Authorship: has authorship experience					0.26	0.17		1.29	0.29	0.17		1.34
Satisfaction/Alienation												
Sense of belonging (factor)					-0.39	0.08		0.68	-0.29	0.08	**	0.75
Satisfaction with faculty availability					0.08	0.08		1.08	0.10	0.08		1.10
Departmental support (factor)					-0.31	0.09		0.73	-0.34	0.09	***	0.72
Peer support (factor)					0.14	0.08		1.14	0.18	0.09	*	1.19
Psychosocial Variables												

Communal value career orientation (factor)	0.12	0.09		1.12
Professional network value career orientation (factor)	-0.33	0.10	**	0.72
Communication self-efficacy (factor)	0.06	0.09		1.06
Teaching and research self-efficacy (factor)	-0.38	0.09	***	0.69

Note: * = p < .05; ** = p < .01, *** = p < .001

Differences by Gender

The fact that women in computing disciplines experience vastly different interactions, environments, and outcomes compared to men, along with the finding from this study that gender emerged as the most predictive variable in the main effects model, I extended Girves and Wemmerus's (1988) empirical model by examining interaction effects to study differences in consideration of departure by gender. Specifically, I ran a separate model with interaction effects to determine any differences by gender for key variables that were both supported by prior literature and were also significant in the main effects model for this study. Interaction effects (shown in Table 4.6) were examined for advisor satisfaction, mentor support, departmental support, and peer support were all tested by gender, though only one, satisfaction with advisor, emerged as significant.

Table 4.6
Summary of Interaction Effects by Gender (n=1,160)

	b	SE	Sig.	Exp(B)
Gender X Advisor satisfaction	0.42	0.16	**	1.52
Gender X Sense of belonging	-0.13	0.16		0.88
Gender X Departmental support	-0.24	0.18		0.78
Gender X Peer support	-0.08	0.17		0.93

Note: ** = $p < .01$

In the main effects model, students' satisfaction with their advisor actually reduced the odds that a student would think about leaving their program by 23%. Plotting the interaction effect revealed how advisor satisfaction differentially predicts students' consideration of departure for women and men. As show in Figure 4.1 below, satisfaction with advisor is associated with fewer thoughts of leaving for both men and women, but the slope is steeper for men. This indicates that men who are more satisfied with their advisor are even less likely than women who are similarly satisfied with their advisor to consider leaving their doctoral program

prior to completion. The findings from both the main effects model and the interaction effects further supports existing research (e.g., Barnes & Austin, 2009; Girves & Wemmerus, 1988; O'Meara et al., 2013) that emphasizes the critical role of the advisor in doctoral student experiences and outcomes, though the present findings indicate that, controlling for all of the other variables in the model, the role of the advisor is especially impactful for men.

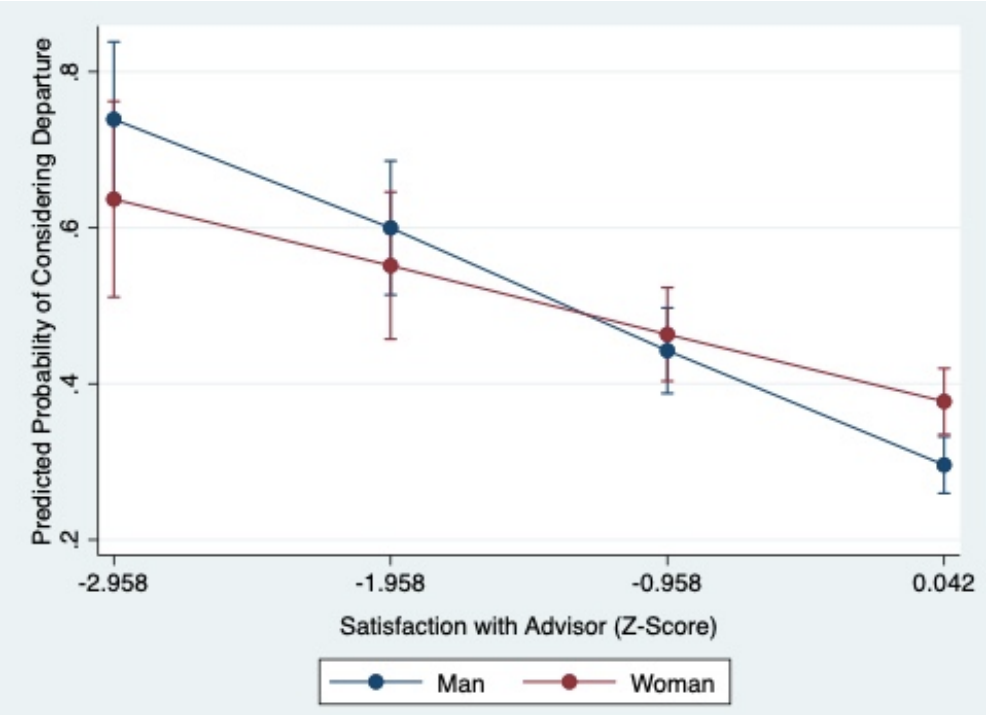

Figure 4.1 Interaction between gender and advisor satisfaction

Summary of Quantitative Findings

The quantitative stream of inquiry sought to examine students' consideration of departure and what influenced their thoughts of leaving, as well as what supports encouraged them to stay. Nearly 35% of doctoral students surveyed in 2018 indicated that they had seriously thought about leaving their program prior to completion. Descriptive analyses revealed that a preponderance of students who considered departure were women, identified as white or from an underrepresented racially minoritized group, and were U.S. citizens or permanent residents.

Students' explanations of why they wanted to leave revealed that nearly half of students felt isolated in their programs. Not feeling supported by professors and not being welcomed by the department were also commonly cited reasons for students wanting to leave. Conversely, when asked what encouraged students to stay, intellectual engagement and social support were given as some of the leading reasons. These findings indicate the critical influence of the departmental environment and support system, and how a lack of support or a harmful climate may push some students toward leaving while a good support system may help retain students. Interestingly, a majority of students reported that they stayed in their program because they had already invested too much time and too many resources, which suggests that students may be weighing many factors in their cost/benefit analysis about whether to stay or leave.

Lastly, findings from the inferential analyses revealed many significant predictors of students' consideration of departure. Student characteristics, satisfaction/alienation, and psychosocial characteristics were the most predictive elements of the adapted conceptual framework that guided this study. Students were less likely to think about leaving when they had greater satisfaction with their advisor, felt a stronger sense of belonging in computing, and experienced a more supportive departmental climate. Additionally, students who placed more importance on their professional networks, were more confident in their teaching and research skills, had higher GPAs, and were international students were less likely to think about leaving. Conversely, students were more likely to think about leaving program if they identified as a woman, if they were older, had more engagement in activities related to industry, and if they received more support from their peers. Collectively, these results highlight that, beyond their demographic characteristics, students' consideration of departure is heavily influenced by their experiences and relationships with others in their department. Notably, students' satisfaction

with their advisor reduced the likelihood of students' thinking about leaving, though the effect was stronger for men.

The next chapter will discuss findings from the qualitative stream of inquiry that examined faculty perceptions of students' consideration of departure as well as how faculty conceptualize their role in doctoral student experiences and outcomes. Finally, Chapter 6 will provide a discussion of how the quantitative and qualitative lines of inquiry complement one another to reveal partial alignment of student and faculty explanations of departure, as well as a few critical ways in which they diverge.

CHAPTER 5: QUALITATIVE FINDINGS

In this chapter I review findings from the qualitative portion of the study which examined faculty members' explanations of why students might consider leaving their program, as well as perceptions of their role in doctoral students' experience and outcomes. As discussed in Chapter 3, data for the qualitative stream of inquiry comes from interviews with 10 computer science faculty members at highly ranked institutions (to see a participant list in Chapter 3, refer to Table 3.4). I used an inductive phenomenological approach to analyze data from faculty narratives and their explanations for students' consideration of departure, which addresses research question four, then I positioned the findings in the microfoundations of institutional logics framework to explain how the faculty members' focus of attention on what they perceive to affect students' consideration of departure shapes their interactions with students. In doing so, I discuss research question five regarding how faculty understand their role in the doctoral student experiences and outcomes, based on the areas of that experiences they deem as most threatening to student persistence. While these qualitative findings are organized by research question, there is considerable connection between how faculty see their role and the reasons students may consider leaving; namely, that faculty play a prominent and indispensable role in how students navigate their doctoral journeys and whether they complete or leave. I conclude the chapter with a summary of the qualitative results and a preview of Chapter 6.

Research Question Four: Faculty Explanations for Students' Consideration of Departure

As a parallel inquiry to students' explanations for their consideration of departure – discussed in Chapter 4 – I examined what faculty perceived to contribute to students' thoughts of leaving their doctoral program. Faculty members identified several contributing factors for students' consideration of departure which, when considered in relation to Thornton et al.'s

(2012) model, reflect their individual cognition and focus of attention: research is not for everyone, the pull of industry, intellectual and psychosocial challenges, and advisor fit. Faculty attention was shown through the issues they identified, the language used to describe them, and how prevalent they are in shaping interactions with students.

Research Is Not For Everyone

First, one of the most common explanations faculty members gave for why students considered leaving their doctoral program was that students came to the realization that research was not a good fit for them. Seven faculty pointed to this reason early on in their response, revealing that it is a fairly common perception among faculty.

Several participants noted that students' lack of understanding about what research entails is a notable factor in their consideration of departure. Students may be unfamiliar with the research process, may not understand the various responsibilities on a research project, or may not fully comprehend the rigor of the work. Dr. Pogo stated that for some students, their decision to pursue a PhD was "the next default step after undergrad" and that it "seemed like a good idea at the time." Students may, then, begin their program without a clear understanding of the work involved in doing independent research. Similarly, Dr. Anderson, who is a mid-career faculty member not that far removed from graduate school, shared this about his own doctoral journey:

> Even if you look on my own experience, at 21 I had no idea what grad school was. What was research? And many of the students are making that same choice. They're ill-informed. They're not to blame; it is because you don't know something until you do it.

Here, Dr. Anderson revealed his understanding of what students today may be going through; that they may pursue graduate school without fully knowing what it will be like. In doing so, he revealed that students' doctoral degree pursuits, in his opinion and experience, are in part an

experiential venture allowing students to learn more about research. Students, he noted, are not to blame for their lack of prior knowledge about this, and that the act of pursuing a graduate degree may be a bit of exploration itself as students attempt it to learn more about it. By matriculating, students are able to explore what research is and after getting some exposure they may decide that research is just not a good fit for them.

According to faculty participants, even for students with prior research experience from their undergraduate education, they may still find that doctoral level research and the journey to becoming an independent researcher is much different than they expected. For example, Dr. Anderson shared the following,

> Now there is what I would call 'research inflation'; that is research is occurring in younger and younger ages. So, some of the students know more about what they're getting into. But I'll tell you, there is a significant difference between being a third author on a paper helping with some data analysis and getting your name on that paper, from leading research. And that is a difficult, difficult job.

This comment illuminated the substantive difference in research responsibilities. Whereas helping with data analysis may be more straightforward, Dr. Anderson perceived that leading a project requires much greater intellectual leadership, coordination, and decision-making. The elevated level of autonomy and ownership required to lead a research project may make some students doubt whether research is a good fit for them or not. Given the selective nature of the computing programs where faculty were recruited from, it is quite typical that admitted students have at least one publication and some prior research experience. Still, these students may encounter difficulties and may consider leaving as a result.

Additionally, the length of time it takes for student to realize that research is not for them varies. Dr. Pogo commented that students learn that research is "not really what [they] wanted to do to begin with, and that takes a couple years to figure that out." Some faculty members have had students think about and actually leave after the first semester, while for others it may take longer to decide if independent research is a good match for their intellectual and professional goals.

Alternatively, faculty suggested that students may undertake and complete a few years of the program but then may consider how much additional time they want to invest in it. Completing the first few years of a PhD program allows students to take courses and engage in independent or collaborative research with their peers or advisor. This process and engagement (assuming good teaching and mentoring) shows them the research process from beginning to end, from ideation to publication. These experiences then allow students to make more informed choices about whether or not to continue in the program after engaging with the process of doing research. Dr. Clearly noted:

> Some come to a realization that research life is not what they thought it was and it's not appropriate for them; it's not something that they want to spend the rest of their life doing or even the next two or three years doing.

This comment highlighted the fact that after gaining research experience, students may decide that a life-long career as researcher is not desirable, and that they might not want to even spend the next few years doing it just to complete their PhD. Thus, faculty perceived that students may be weighing the costs of the additional time investment needed to finish, as well as their enjoyment (or lack thereof) of the work it would take to finish, and consequently may consider leaving if those costs are too high.

The nature of how faculty discussed students' consideration of departure relative to this explanation revealed their perception that figuring out that research is not for you is actually an acceptable reason to think about and actually leave a doctoral program. Faculty noted that it is good for students to discover their interests and use it to inform their future paths, as evidenced by Dr. Moore's comment:

> I actually emphasize this point that this is not for everyone and you know, it's got to be the right match for you. Now maybe that sounds negative, but I do want people to, I mean not feel like, "Oh they're failing if they discover that it's not the right match for them." Yeah. But then we're there to help them…make sure they get what they need.

In this passage, Dr. Moore signaled that it is not a negative thing for students to discover that research life is not for them. She emphasized that students are not failing. In conjunction with the previous comment from Dr. Anderson about the experiential nature of doctoral studies, it is evident that identifying lack of fit with a research career is an understandable and acceptable reason for students' consideration of departure. Dr. Moore's comment also signaled that faculty do indeed have a role to play in supporting students if they decide to leave the program.

The Pull of Industry

Faculty also identified the pull of industry positions in the tech sector as a contributing factor to students' consideration of departure, and often to their actual departure. As discussed in Chapter 1, computing disciplines are unique in that there are plentiful job opportunities in both academic positions as well as industry. In the following sections, I describe two explanations faculty perceived to contribute to students' consideration of departure as it relates to opportunities in industry: financial incentives and the desire to escape the grind of the PhD. I

conclude this section with a discussion of the extent to which faculty are understanding, and in some cases even supportive, of students' consideration of departure.

Financial Incentives

The robust job market and high salaries at tech companies provide an alluring draw for graduate students according to faculty interviewed for this study. Dr. Stachowiak said it most simply, that "in computer science there are tons of great, exciting jobs that pay an enormous amount of money and don't require a PhD." Several faculty members explained that upon doing an internship, which is fairly common in computing doctoral programs, students sometimes receive a job offer. With or without an explicit offer, students learn that they do not *need* a PhD to get a job, and that their advanced education from some amount of graduate coursework makes them a more competitive and sought-after prospective employee. Dr. Goodwin offered one example of this, where a student of his had done an internship and received a job offer from Google. The student told him, "I'm going to go make some money." To help contextualize what students are considering, Dr. Costanzo stated:

> One thing that makes them think about leaving is sometimes the salaries that they see in industry. The salaries when you see that somebody at Facebook can make $250, $260, $280K [per year], when students are making $24K, and that's fully funded.

The difference in magnitude of what a fully-funded graduate student makes compared to a potential industry salary is remarkable. Several faculty members commented on the attractive salaries which they observe students weighing in their consideration of departure. Faculty stated that in many cases, students will complete their coursework and leave with a master's degree, though some do leave upon receiving the offer, and some decide to stay to finish their degree.

Escape the Grind of the PhD

In addition to the monetary incentives, only two faculty members discussed how students also weigh the difficulty of the journey ahead if they were to continue pursuing their doctorate. While other faculty discussed the challenges inherent in doctoral study – which will be discussed in greater detail later in this chapter – Dr. Costanzo was the only one to explicitly connect the pull of industry. Dr. Costanzo observed that some of the debate students have when thinking about whether to continue in their PhD program relates to the arduous work of actually earning the PhD:

> For some people it gives them pause, because they're like, "Why do I have to put with all of this abuse?", even though the group is, hopefully living well, and we are like a friendly bunch, it's still very difficult. I'm mean it's tough, and so "why do I go through this grind?"

Here, Dr. Costanzo emphasized how the grind of graduate school may introduce some hesitancy and consideration of departure. He also contended that, even if the research group gets along well, students still have a tough time. When asked about what he meant by "abuse", he clarified:

> Well, when I say abuse, I mean it was kind of… I shouldn't say abuse because that's a loaded word, but no, the grind, I mean the fact that this is intellectually demanding, there's no guarantee of success. I mean, you can always have a snag, you can get scooped.

The intellectual demands, the lack of certainty about future success, as well as the risks of encountering research problems is a lot for students to grapple with. The high demand for publications adds to the "intense" and "not friendly" experience of doctoral study. The use of this language reflects the awareness faculty have for the onerous journey to a doctoral degree. A student simply explained to Dr. Goodwin that, "This is not fun; I'd rather be in industry." Thus, faculty understand that students may contemplate leaving their graduate program for industry

opportunities that would allow them to escape the grind and not endure the hardships of the doctoral workload.

Faculty Reactions to the Pull of Industry

While half of the faculty interviewed for this study explicitly named attraction to industry opportunities as an explanation for why students consider leaving their doctoral program, there were mixed reactions to this depending on who it benefits. First, there was a high level of faculty understanding for students' consideration of departure, and even their actual departure, for industry jobs. Specifically, taking into account what is good for the student and that students make decisions in their best interest, most faculty members viewed consideration of departure for an industry opportunity as acceptable. Dr. Costanzo reflected that everybody will factor in financial incentives to their decisions at some point. Others spoke supportively about students deciding to take industry opportunities. Dr. Anderson viewed opportunities in industry as a good thing students should consider and perhaps take if that makes them happy. Dr. Pierce was also encouraging:

> I've had students leave and be very early employees at very successful startups… they'd be crazy not to. They went and did a summer internship. They were working on this exciting thing. They're like, "I gotta do this, right?" And I'm like, "yeah, you gotta do that."

In this example, Dr. Pierce was exceptionally supportive and understanding that students may have rare opportunities to get in with a company that is on the way up. According to him, these can be great career opportunities that students are smart to consider. These examples demonstrate that some faculty perceive industry opportunities as a justified reason for students to consider leaving their doctoral program.

While some faculty were understanding of the pull of industry, student departure to industry jobs can sometimes leave faculty advisors in a bind. For faculty advisors of students who considered and decided to leave for an industry job, these departures may disrupt planned research projects. Dr. Klein commented,

> I got burned on several of these occasions. These are outstanding students, they are technically very capable doing research, but basically their families, …basically they are pressured to start working. So, they get this first degree – a master's degree – and then they'll leave and that's really a problem for the faculty because I put them on grants. I accept grants understanding…they will actually do a longer term [of study]. I actually started, myself, hiring master's students; they [already] have a master's degree so then I know that when they come here, they really are interested and dedicated to [pursuing] the PhD.

Dr. Klein expressed frustration with losing students to industry. She observed a pattern among some students, particularly international students, who may see the PhD as a path toward getting a master's degree and then a job. This led her to change her admissions practices, prioritizing students who already had a master's degree in order to try to ensure that students were really interested in the PhD and could reliably work on research projects for the projected amount of time. So, while the industry opportunities may be attractive opportunities for students, it may also represent a threat to faculty research plans.

A final notable observation – half of the faculty interviewed for this study had prior industry experience of their own, either before or after earning their doctoral degrees. Faculty mentioned that faculty research lab and industry partnerships are reasonably common, that some faculty work part-time or take their sabbatical to work in industry positions, and that 60% of

doctoral graduates pursue industry positions (Zweben & Bizot, 2019), a students' interest in leaving school for industry is well-understood. The consideration of industry opportunities is not stigmatized, but rather seems to be normalized as a good path for students to pursue right away or after they graduate.

Intellectual and Psychosocial Challenges

Computing faculty members elaborated most on a variety of issues that collectively represent intellectual and psychosocial challenges which, they observed, contribute to students' consideration of departure. Below, I describe how faculty commented on issues related to the intellectual grind of doctoral study, competition and comparison, and mental health concerns. The preponderance of their comments revealed that these issues are the most prominent and receive the most faculty attention.

The Grad School Grind

Dr. Haddad, in paraphrasing Einstein said, "If you knew what you were doing, it wouldn't be called research." Research, according to several faculty members, is inherently hard. As previously described, Dr. Costanzo referred to the doctoral journey as a "grind", which is intellectually demanding with no guarantee of success. Dr. Haddad also stated that "research comes with some failures," while Dr. Moore remarked that,

> Research is inherently an *insecur*e proposition. I mean, you're constantly feeling like you're trying to do something that's very difficult. Theoretically it's something nobody's ever done…so it's always going to be very hard and people are always going to feel like they're not doing it well enough.

The intellectual rigor, demands, and uncertainty of research make the task of doctoral pursuit an arduous one. There are successes and failures along the way as students and faculty both

undertake the creation of new knowledge through their research. Further, Dr. Moore's comment elucidated the doubt and insecurity that often emanates from doing something difficult. Learning how to navigate and cope with the ups and downs of doing research is, in itself, challenging and for students, can contribute to their consideration of departure.

Coursework and Milestones. Additionally, the transition from undergraduate study to doctoral coursework and research can introduce new challenges which may contribute to students' consideration of departure. Dr. Anderson conveyed that graduate study introduces more ambiguity that students did not have to contend with during their undergraduate education. In graduate school, he perceived that students have more ownership of their path and are responsible for executing their research and writing their papers. He expressed that owning all of the responsibility is "challenging for a lot of us." Faculty perceived that the ambiguity and responsibility may be too much or may be too uncomfortable for some students who can then doubt if they should continue.

Next, faculty discussed how coursework itself can present intellectual challenges and amplify the pressure on students. Dr. Stachowiak explained that students in his program are high academic achievers, noting that "no graduate student here has ever gotten more than one B in their undergrad career." He explained that some of them struggle with being in the bottom half of the class for the first time in their educational journey. On the other hand, Dr. Goodwin observed that students may seek refuge in coursework, using it as a "distraction, especially if research is viewed as difficult." He articulated that while students know how to study and how to get A's, students "don't know how to read the literature and be inspired." Thus, students who have been very successful in their undergraduate education may be more comfortable sticking to graduate coursework instead of engaging in the difficult work of independent research. The new learning

tasks of reading literature and developing new ideas can be daunting and can lead students to distract themselves by focusing on classes. The common thread through both of these examples is that faculty perceive that students, perhaps for the first time, are confronted with challenging intellectual work that takes them outside of their learning comfort zone. Given that faculty participants were recruited from top tier programs with high admissions standards, their students were likely at the top of their class in undergrad, knew how to study, and how to perform well academically. Now, faculty suggested that amidst the doctoral journey, students may encounter intellectual difficulties, experience a decline in their academic performance, or retreat to the safety of coursework to avoid the potentially steep learning curve of research.

Further, departmental policies can also intensify the pressure students experience, which consequently may cause them to consider whether they want to continue pursuing their PhD. At one institution, the computing department requires doctoral students to maintain at least a B+ average. A faculty member at this institution asserted that, "It creates tremendous pressure especially for the PhD students, because they have to do research and do well in the classes, and the classes are tremendous to manage." This faculty member suggested that expectations for independent research progress and requisite academic performance in classes collectively heighten the pressure students feel. They remarked further that they encourage their students to take only a class or two at a time, then fill the rest with an independent study to allow them space to focus on their research. Doing so may relieve some of the pressure and provide support for the students conducting research.

However, depending on the advisor, additional work in research assistantships can intensify the pressure students experience. A faculty participant revealed that they have heard of some advisors telling students "I pay you 50%, you do this and this by a particular deadline. I

don't care if you don't do well in machine problems or your class!" They explained that this can put the student in an untenable predicament where the departmental policy requires a standard of academic performance, but their direct advisor demands more time and attention on research work. In this anecdote, it also appeared that the referenced advisor was prioritizing their own research deadlines over departmental policy. While it is unclear how common this type of behavior is, the faculty member who shared this anecdote postulated that they tend to hear more of this behavior on projects with research partnerships or contracts, for instance with the Department of Defense, which can require regular demonstrations and progress updates on a particular time-table. I include this anecdote, not to generalize that all students endure this additional pressure, but rather to illustrate that even faculty perceive that some computing doctoral students are truly contending with an abundance of pressure and expectation, some of which may be exacerbated by contradictory messages from departments and faculty members.

Beyond expected coursework and research work, significant milestones in the doctoral journey may elevate the struggle that students experience. Dr. Cleary stated that “the amount of stress that’s induced by certain milestones, some of which you could argue might not be essential,” is another explanation for students’ consideration of departure. He described the qualifying process in his department as “a pretty intense written and oral examination” that many of their peer institutions do not have. While he acknowledged the intensity and resulting stress that arises from the qualifying exam, he also articulated that this milestone requirement is not shared across programs, or that it looks very different. This is understandable given the autonomy of each department and institution, though he acknowledged that his department sometimes loses potential students to peer institutions who do not have this added requirement. Also, faculty from other institutions discussed past changes their departments have made to the

qualifying process to both reduce stress and also align the milestones with work that supports research development. They acknowledged that extraneous and stressful exams were not critical to the development of students' research skills and were subsequently adapted or eliminated.

The final milestone of completing the dissertation, and students' perceived expectations for it can, according to one faculty member, intensify the pressure students feel. Dr. Stachowiak asserted that "students have a fundamental misunderstanding of what a PhD represents." He stated that students may think about leaving their graduate program prior to completion because they have,

> An overly inflated view of what a PhD dissertation is supposed to be. And that is, it is not your magnum opus. It's your training wheels for learning how to do independent research. And if three years down the road you don't look back at your thesis and say for god's sake I spent two years on that turd, then your career is going the wrong direction.

He observed that students have amplified expectations that their dissertation research should be a defining work of immense significance. He clarified that it is meant to continue students' training and to further help them develop as independent researchers. In fact, his comment signaled that students, if their careers are progressing well, should be able to look back and see how their dissertations could have been better. While Dr. Stachowiak suggested that students' expectations are "inflated," he did not discuss where these expectations came from or what they were informed by. This faculty member's critique of students' exaggerated expectations fails to consider the role of faculty advisors in explaining or framing the standards for the dissertation, which they will approve in their capacity as committee members.

Lack of Progress. Faculty discussed how the stress of juggling so many highly demanding responsibilities – from coursework, to exam milestones, and research assistantships –

as well as the inherent intellectual demands of research can cause students tremendous strain and hardship that they consider leaving their doctoral program. These hardships can be amplified by further challenges in conducting research which can slow students' progress, creating struggle and feeding thoughts of leaving their program. Specifically, faculty discussed how students' selection of a dissertation topic and the slow or sometimes stalled process of executing their research can diminish or impede their perceived and actual progress toward the doctoral degree.

Faculty members reported that students can sometimes languish in the middle years of their program, where it is not clear if they are making progress. They identified the selection and defense of a dissertation study as a tripping point for some students, which can frustrate students. At several of the faculty members' institutions, students' qualifying exam processes require their written and oral defense of their proposed dissertation research. Taking too long to get to the point where they are ready to take the qualifying exam can occur because, according to Dr. Pogo, they either "haven't really crystallized their topic" or do have a topic but have not made tangible progress to prepare for their qualifying exam. While some students struggle to develop their dissertation idea, Dr. Stachowiak commented that a common occurrence among some advisors who run multi-student projects is that one person gets a great thesis topic while other students play a more supporting role with the topics they get. It is conceivable that the interpersonal dynamics at play in the research team could impact students' satisfaction or motivation to make progress on their dissertation research.

Additionally, faculty observed that students' struggle to make progress is partially related to the difficulty of research. Dr. Moore pointed out an interesting sub-disciplinary difference, that "Theory is just really, really hard. It's math basically. You're going to create new math. It's actually very difficult." She added that "I do think that students do feel bad when they can't

solve the problems they're trying to solve." She, and a few other faculty, observed that the lack of progress is both perceived and actualized. At times, it is just slow while other times, non-existent. This, of course, can happen in other computing sub-disciplines as well.

Dr. Moore articulated that "If you're not able to handle long stretches of these dry periods…then it's going to be more difficult." Feeling bad, experiencing difficulty, and having a "dry spell" can be tough for students to handle. She noted, however, that faculty can also experience these challenges, though an advantage faculty have is that during dry spells, they still have teaching and service responsibilities so they "don't feel like a totally useless person." When asked if she thought students might also feel like a "useless person," she replied, "I think that sometimes they do." Thus, faculty suggested that students, who are developing as independent researchers and who are being introduced to and enduring the highs and lows of research, sometimes for the first time, may be frustrated and struggle with not doing well or not making progress. Dr. Moore's comment revealed that, unlike faculty who have other responsibilities for teaching and service that still give them purpose or meaning, students may not have any other work that gives rise to positive self-worth.

Similarly, Drs. Pogo and Stachowiak are quite familiar with the struggle of not making progress. They shared that in their own doctoral journeys, they struggled with selecting a topic and making progress. Dr. Pogo expressed how he spent a "year and a half having no idea what [he] was going to do [his] dissertation about." He articulated that he was not clear on what a viable dissertation topic was, and only after getting some clarity from his advisor was he able to run with a topic. On the other hand, Dr. Stachowiak avoided his advisor out of embarrassment that he was not making progress on his dissertation. He confessed that this lack of progress, along with the feeling that "it's never going to end" made him question if the PhD was right for

him. Thus, faculty who have also experienced the challenges of not making progress related to students going through this and are able to provide support and encouragement; which will be discussed later in this chapter.

Inflation of Research Productivity. The expectations of doctoral study have evolved over the years and one consequence of this is an inflation of research productivity. Associate Professor Dr. Anderson, who has served as a faculty member for less than 10 years, commented that, "There's a difference in expectation that has occurred between the time I was a grad student and then now, in terms of … your immediate research productivity." He has seen a tremendous shift in expectations in a matter of a few years, and he attributed this to general inflation across the entire graduate school pipeline. Graduating seniors in their applicant pool are quite competitive, sometimes with four publications on their resume already. He also disclosed that it is now rare that his program accepts a student who does not have at least one publication.

Dr. Goodwin noted a similar issue where "the record in CS is pretty intense, unfortunately." He remarked that the disciplinary expectations of research productivity, which he saw as four conference publications and two journal papers, is "a consequence of the highest productivity students." Those students who are churning out conference papers, presentations, and journal publications are raising the bar and changing what it means to be productive. "The rate of publication is very high" according to Dr. Costanzo who has seen students graduate with six to eight publications. He exclaimed that "It's intense, you need to churn these things out, and it's like running a marathon at a sprint pace. It's really not friendly." This simile served to emphasize the absurd demands on research productivity. To contextualize even further, Dr. Stachowiak exclaimed that "people are now graduating with CVs that would've got them tenured 10 years ago." Faculty members were in agreement that the expectations of research productivity

are quite difficult and that striving to reach these expectations, particularly to be competitive on the faculty job market, is an exceptionally challenging feat. The language used by faculty, "unfortunate," "intense," and "not friendly," to describe the experience for students signaled their understanding of the difficulty, as well as their judgment of it as burdensome. However, faculty members did not discuss ways to challenge this systemic research inflation even though they admit it can cultivate harmful environments and expectations for students.

Faculty observed that students have internalized these expectations and are eager to get to work on research. Dr. Anderson shared that students limit their coursework so they can get started on research projects immediately. Students have said to him, "we want to get the fellowships" or "we want to get those competitive internships and we've got to show this track record." Faculty suggested that these student behaviors and choices are in response to the expectations and competitive standards they want to meet. In response, computing programs either already have reduced the coursework requirement or have discussed doing so to help provide more space for research productivity. Dr. Anderson stated that these conversations and decisions "parallel where the culture is moving for students." He added that "it's just mentally draining" for students to juggle so much, and that mental load might make them think about leaving their program. Thus, beyond the inherent difficulties of research, faculty observe that students are striving to meet rising expectations. Dr. Costanzo described that it is tough because the work "is always in the back of [their] mind." The cumulative pressure adds to the intellectual grind and mental drain students experience.

Competition and Comparison

While all this pressure and expectation permeates the environment, it is magnified by the competition and subsequent comparison among students. Dr. Costanzo described "this constant

sense of competition" which occurs because "academia is competitive…I think that makes students feel a lot more stressed out when they start." He commented that students begin with an understanding of the competition of research and then learn there is quite a lot more that goes into building a career, which he said is not "particularly nice." The pressure to get into top conferences, which in computing are more prestigious than most journals, with acceptances rates of only 10-20%, drives the competition between students who are striving to build robust CVs. Several faculty members divulged that they likely would not have made it into their institution's program by the competitive standards today. Dr. Haddad remarked that she "had less pressure in my life than what typical graduate students go through." Faculty have observed a number of contributors that add to the mounting pressure students today experience that can cause them to consider leaving their doctoral program prior to completion such as the constant comparison, the visibility of others' successes, and social media.

Nearly half of the faculty interviewed for this study explicitly vocalized how comparison to others and visibility of others' success can cause students to question themselves. Dr. Stachowiak expressed that seeing the success of people around you "can be *daunting* in some ways." Dr. Pogo added that "you only hear about the successes." Students, and oftentimes faculty, announce when they put out a publication, get accepted to a conference, or receive a grant.

Several faculty members explicitly named social media as a factor in the comparisons students make. They commented that students are only seeing the very best things on social media since so few people share their rejections or disappointments publicly. Faculty observed how this can skew students' views of others and can deflate students' views of themselves or their work. Dr. Anderson stressed that these comparisons are,

> Oftentimes negative, because…it's like the social media…you only share the best of, and so it's really hard…You look over here and you see this person; they've got three pubs this year, or whatever you're trying to do. That comparison is oftentimes *deflating* I think, but unfortunately we all do it, I think.

The negative influence of social media is that it can present only one side, typically the best side, of a persons' experience. Further, Dr. Klein conveyed that "If you are in a competitive department like ours, the students are not dumb. They see that one is doing better than the other, has better ideas than others, and then they do get depressed." Her comment illustrated the real impact comparison and competition can have on doctoral students. While Dr. Anderson acknowledged that comparison to others is an aspect of behavior that we all do, the effect on students who are striving to compete in a rigorous and demanding culture is deflating and, according to Dr. Klein, can detrimentally impact their mental health.

According to Dr. Costanzo, students' comparison of themselves to their peers partially explains why students consider leaving their program. He portrayed students' reactions as "Oh. This person published three top security conference papers last year. What am I doing? I'm not doing anything. I don't have anything." This highlighted how students may see or hear of another person's accomplishments and then subsequently question their own, further illustrating the point about students' awareness of each other's success made by Dr. Anderson.

Dr. Haddad pointed out that this comparison can have a real effect on students' consideration of departure. She shared her observations that some women specifically in her program may see the publication records of others – some of whom had already written five papers despite barely starting graduate school – and start to wonder "Oh my, I might never be good at this. Why don't I think of other ways to make something good out of my life?" In

thinking about students' comparisons to others, Dr. Haddad specifically noted that women sometimes think about or actually leave their doctoral program because they (like many other students) may make comparisons and begin to have doubts about themselves or feel they are behind and may start looking for alternative career paths.

The visibility into how others are doing, particularly when students only see the successes, can give students the perception that they are the only ones struggling, which can exacerbate their doubts. Dr. Costanzo illustrated this well when he said,

> I think that people won't necessarily realize how much other people are struggling. If you're struggling by yourself, you're isolated and everybody, you look at Twitter, or God forbid, you look at Facebook and all you see is successes, "I got a grant. I got a paper accepted." Yeah, guess what? People don't post when they get a paper rejected for the tenth time, right?

He also depicted the negative influence of social media and pointed out that it is difficult for students, particularly if they are more isolated, to see beyond the blatant wins that are announced on social media and to understand the rejections or obstacles that went into that success. He likened it to professional athletes – that the public generally sees the big race and potential win, they do not see the weeks, months, or years of training, struggle, injury, and setbacks the athlete had to endure to get to their best day and biggest success. In academic spaces, visibility into the success of others may make it seem that it was easy, thereby obscuring the effort it took to publish a paper or receive a grant.

Another professor attended a National Science Foundation workshop as a graduate student where he heard more advanced students discuss their doctoral journey. He stated that he was "so surprised to hear them say that they felt they were struggling because [he] was like,

'What? You guys are rock stars." His perception of other students, who were seemingly quite successful – enough for him to review them as "rock stars" – was challenged when he learned that even the rock stars struggle. He also shared that some of those rock stars did not end up finishing their doctoral programs, demonstrating that everyone can have doubts and think about leaving.

Thus, faculty perceived that the natural tendency of people, and graduate students in particular, to compare themselves to others can fuel the conditions that ultimately lead student to doubt themselves or their ability, and therefore, think about leaving. Without speaking to students, it is impossible to truly know the causal relationship between competition, comparison, and doubt, but these faculty perceptions are useful in illustrating a link between these elements of academic culture and the psychosocial impact faculty observe in students. One pattern that emerged from nearly all faculty interviews, is that these competitive dynamics and perceptions of others seem to have a strong and oftentimes detrimental impact on students' mental health.

Mental Health Challenges

The prevalent explanation faculty gave for students' consideration of departure was the mental health challenges many graduate students experience. Dr. Cleary commented that "there's at least increased awareness of mental health and the role it plays, particularly with graduate students" and that "mental wellness is an increasingly urgent matter on campuses." Beyond the faculty members' recognition and the campus attention graduate student mental health is receiving, Dr. Anderson shared that "it definitely feels more common for students to talk about mental health." Many of the issues previously highlighted in this chapter do indeed relate to students' mental health – from the toll of the intellectual grind, to the increasing pressure of research productivity expectations, the culture of competition and comparison that exacerbates

self-doubt, and the stress of managing coursework and independent research, as well as challenges in the advisor relationship – indicating the connection between what students experience in their environment and how it shapes their mental health. Below, I describe two additional explanations faculty discussed for why students may consider leaving their doctoral programs, imposter syndrome and isolation.

Imposter Syndrome. Many faculty members broadly indicated that "imposter syndrome" was a contributing factor in students' consideration of departure, though their language and descriptions of what this is and how it affected students varied. For example, Dr. Goodwin explained his view:

> I think a lot of it is probably mental health related, and I mean there's a lot of ways to describe that. I think some of it is perhaps imposter syndrome, right? You come in and you think people made a mistake and you're not comfortable with having to be in this position and so doubt can accumulate and then that can lead to other things like maybe depression. I think some high performing individuals also come with other more complex mental health situations, and there's really no support for that.

Dr. Goodwin's characterization of imposter syndrome was defined by a few key "symptoms". First, that students may not belong in the program or that there was a mistake in their being admitted. Second, students may not be comfortable in their position as a doctoral student. Third, that these doubts can be additive, potentially culminating in or contributing to more serious mental health conditions such as depression, for which there exist little support.

Other faculty members discussed imposter syndrome in terms of self-doubt and feelings of inadequacy. Dr. Costanzo reflected that students wonder "Is this for me? Why am I here? I don't belong here." He added that students may feel they are not good enough in general, or that

maybe they are but they are not competing at a high enough level. These doubts, he said, "make people want to leave." In other instances, doubts can arise from interactions with others. According to Dr. Cleary,

> Some wish they could do it but have lost confidence. So maybe a bad experience with an advisor or a research group and, you know, for various emotional or psychological reasons, they put themselves in a bad position and start to doubt their ability.

He suggested that while students may still be motivated to pursue their PhD, their confidence may be shaken or diminished due to bad experiences with peers and/or their advisor. The language "they put themselves" reflects an attribution these circumstances to the student, seemingly placing the responsibility for this situation at their feet – a point that will be discussed in Chapter 6. This doubt is troubling, and perhaps more so for students who may be more susceptible to imposter syndrome. Dr. Haddad pointed out that "women and minorities feel it even more," and are in fact more inclined to leave their PhD program (Anderson-Rowland et al., 2007).

Alternatively, while some faculty members characterized imposter syndrome as a mental health issue, self-doubt was normalized by other faculty participants. Dr. Pogo stated that every student he has ever had has gone through a period of self-doubt where they question whether their topic is good or if their contributions will be valuable. To him, this period of self-doubt and questioning the intellectual and disciplinary value of a students' work is part of the process of pursuing a PhD. In fact, he stated that "I don't think you can avoid imposter syndrome at places like this," and confessed that even though he is a tenured full professor, he still experiences imposter syndrome and self-doubt. He admitted that it is difficult not to feel that way when surrounded by brilliant people in his department. His comments revealed a key difference in how

faculty may be conceptualizing different elements of imposter syndrome – some that view intellectual self-doubt as a mechanism to push students to really find the value and contribution of their work, and some that give rise to detrimental thoughts on students' belonging and capability in their doctoral program. The differences in these views signal that some faculty members may hold deficit perspectives that pathologize the students' mental health, while others view these issues as part of a learning process.

Imposter syndrome, self-doubt, not belonging, insecurities, lost confidence, inadequacy – these are all real psychological struggles all too common among graduate students, which may be further exacerbated when students are isolated.

Isolation. Substantially fewer faculty discussed isolation, either physical or social, as a contributing factor to students' mental health challenges, and subsequently, their thoughts of departure. Dr. Klein simply stated that "loneliness is a big issue." The perspectives shared by two faculty members revealed distinct insights into *why* students may be experiencing isolation and *how* it can affect them.

First, Dr. Stachowiak acknowledged how growth in funding and expansion of research labs can actually make students *more* isolated. He stated that because his computing department has received more funding in recent years, they have been able to expand to two academic buildings with more lab space for students. In the past, students shared offices with students from other research areas. This heterogeneous mixture of doctoral students provided them exposure to a variety of research projects. However, with the additional lab space, students are now housed with their own research team in their respective areas. Dr. Stachowiak commented,

> Now, all the systems people are in one lab and all the computer vision people are in another lab and all the machine learning people are in a third lab. So, you can be

> increasingly isolated within your research area, which I think is ultimately not good for your career as a researcher. So, I tried to sort of push back against that.

He expressed that the laboratory structures resulted in siloed subdisciplines that can limit students' exposure to one another, which he argued is not good for their overall career. He noted that this hindered students' growth and awareness of a broader set of computing knowledge. While Dr. Stachowiak's comment related more to students' intellectual development, given what he and other faculty members shared earlier –that it is common for advisors to prioritize more "productive" students over others, that students' seeing others successes, and the competition between students – it is plausible that being isolated siloed within a research group, and the interpersonal dynamics therein, may exacerbate mental health challenges for students.

However, isolation may occur even when students from different research teams do occupy the same space. Dr. Costanzo observed,

> That's one of the threats in very interdisciplinary environments, you just have a very broad range of interests, and sometimes what you're missing is the fact that people that are sitting in cubicles next to each other, they don't necessarily talk to each other, because they're working on so different things, that communication is not necessarily always easy.

He stressed that the disciplinary differences or specializations can be a barrier for interaction, despite the fact that students may be sitting in adjacent cubicles. For example, he stated that he perceived students from "very different fields" such as information and applied cryptography would have a hard time communicating, in part because "brilliant people are not necessarily very good at being extroverts…it's not by hostility or anything, it's just that people are like, 'well you know we don't really have anything to talk about.'" He noted that the perception of students is that if they are not discussing or working in the same research area, they will not have much to

talk about. So, then it seems that despite physical proximity, he perceived that there may still be a substantial social barrier that deters conversations. These barriers, whether literal walls or not, may prevent students from engaging and talking about the similar processes, experiences, or milestone they are going through and can exacerbate feelings of isolation. Thus, having students communally located in a disciplinarily diverse environment is necessary but not sufficient to address the isolation faculty observed.

In addition to physical barriers of separate lab spaces, and perceived social communication barriers, faculty also suggested that students' anxieties and doubts can hinder connection. Dr. Goodwin stated that intense anxiety "creates a sense of isolation that the students have, and I think for some of them it leads them to leave."

Faculty Responses to Mental Health Challenges. The prevalence of student struggles and the tension or uncertainty in how they should respond was apparent in faculty members' comments. Dr. Costanzo stated that these challenges "hit close to home," while Dr. Cleary commented that "I think every one of my colleagues has had a student who's had mental health challenges, had to go on leave for some period of time. It's much more prevalent now than it would have been maybe 20 years ago." The faculty were in agreement that the growing mental health concerns are a challenge they are not necessarily equipped to handle. Dr. Costanzo acknowledged that sometimes "there's a related pathology or something that really requires perhaps medication or more effective treatment, we're not equipped to deal with that." While Dr. Cleary stated that if he cannot effectively help students with their struggles, he will sometimes demand that students meet with the campus health services and then follow-up with them. They noted the distinction between pre-existing and severe mental health issues, and those that perhaps are not as serious but can still be difficult to deal with during the graduate program. Dr. Klein

remarked that "different professors deal with these kind of depressions better than others… We as faculty don't get very much psychological training." While Dr. Klein attested to some faculty being able to handle students' depression better than others, she lamented the lack of training and preparation faculty receive. She added that some mental health issues may be so private that they are not her business to know. However, when she starts to see the work suffering, she will ask how she can help and will rely on what the student is willing to share. These comments elucidated the precarious situation faculty may find themselves in while trying to support students.

Dr. Costanzo expressed that students face a lot of struggles, many of which could be avoided. He added that there is a risk that some graduate students will "take extreme" measures, including self-harm. In most cases though, he stated that "if we cannot prevent that from happening, it's criminal. It's not a matter of being incompetent, it's criminal." While Dr. Costanzo's language was stronger than what others used, there was a common sentiment among many participants that suicide and serious catastrophes should be prevented. Dr. Cleary noted the nationwide and institutional efforts to "train people in how to recognize and what you can do proactively for suicide prevention." Though this training is certainly useful, the focus on "avoiding catastrophes" revealed the dearth of attention for mental health issues that are not quite as catastrophic. Dr. Cleary stated that,

> I think it becomes more challenging to figure out when it's not that urgent an issue, so people aren't gonna do harm to themselves, but they still are struggling with being successful. That's where you kind of separate out faculty who say, well, this is really not my concern so, you know, deal with it versus ones who say, it is my concern, let me try to do something. And, you know, either way is difficult.

These comments revealed that faculty perceive there are differences among their colleagues – some of whom see a student struggling to be successful and want to get involved, and others that do not view the students or their struggles as their responsibility. Dr. Costanzo stated that faculty can often tell when things are going poorly for a student. He declared that "faculty who deliberately ignore these signs are awfully negligent…ignoring these signs is at the very least an utterly rotten thing to do." These perspectives raise the question of what faculty are capable of or should be expected to do to support students through their doctoral journey. The answer to this question may lie in how departments approach the graduate school journey and the expectations of their students. A few faculty members discussed a shift in the mentality about the graduate journey, from an "only the strong survive" or a "sink or swim" mentality to a more compassionate and balanced mentality today. Dr. Costanzo observed:

> I think there is a much better understanding that graduate school can exacerbate pre-existing psychological issues. We used to ignore those, back in the late 1990s when I was a student myself; that is what I referred to as the "only the strong survive" mentality. I actually heard this in graduate school -- from other students, and more than once.

The messages Dr. Costanzo heard about repeatedly during his own time in graduate school normalized the mentality that "only the strong survive." More recently, he observed,

> Nowadays, I think that a growing number of faculty acknowledge that psychological well-being is essential to a productive research environment, and that, even though we are not mental health professionals, we should at least be able to be compassionate and understanding -- and redirect students to the right resources if we feel something is going astray.

He defined a minimum level of engagement – being compassionate and understanding – and that faculty should be able to connect students to the appropriate resources if they are struggling. The acknowledgement of the importance of psychological well-being to good research is a substantive shift in the approach to graduate study, though one that is still building momentum. The ability or willingness for faculty to support students through various psychosocial challenges may affect the students' journey and their consideration of departure. The role and influence of faculty will be discussed at length in the response to research question five.

Advisor Fit

The previous explanations faculty gave for students' consideration of departure centered the student – their interests, career opportunities, and challenges in pursuing the doctoral degree. However, consistent with an abundance of literature that points to the advisor relationship as most critical to graduate student success (e.g., Barnes & Austin, 2009; Sverdlik et al., 2018), nearly all faculty participants identified advisor fit as another explanation for students' consideration of departure. However, the brevity of comments regarding advisor fit signaled that issues of advisor fit did not receive much of their attention.

One element of advisor fit which Dr. Anderson spoke of is how well the advisor and student work together intellectually. He commented that sometimes it just takes time and experience to see if it is a good fit, "You really don't know until you start working with someone. I mean, for me, I really don't know until I go end to end, which means ideation all the way to publication. I get signals and signs, and that's about a year." According to Dr. Anderson, seeing how the student and faculty member work through the entire research process is a good indicator of how well they will work together on future projects.

Additionally, faculty suggested that students may consider leaving if their area of research is no longer able to be supported for a variety of reasons. Explanations for students' consideration of departure offered by Dr. Pierce include that, "their advisor's a jerk, their advisor left for industry and doesn't have time for them anymore. And we're happy to find other advisors, but sometimes the student is just like, 'that's not what I came here to do." Not only does this comment signal a personality or interpersonal conflict, but it also identified a shift in faculty priorities when they leave for industry. Several participants discussed how, in some instances, faculty work in both academia and industry which may reduce the time faculty spend with their students, and in other instances, faculty may leave academia completely to pursue industry opportunities. This can leave students in a bind if their area of research focus cannot be supported by any of the remaining faculty members. Dr. Pierce's comment signaled that departments may try to help the student find another faculty member who can support them, but if a student has a narrow research focus, they may decide that they do not want to pursue another area and may then consider leaving.

Relatedly, faculty suggested diminishing attention from advisors may contribute to students' consideration of departure. This can happen because of the aforementioned role conflict or draw to industry, but it can also happen as a result of faculty prioritization. Dr. Stachowiak noted that aspects of academic culture motivate faculty to devote their time to only the "most productive students", leaving others behind:

> I think a third factor is that — let's be serious – faculty are selfish, and they spend their time with the most productive students. And so, you can find yourself getting less faculty attention and that's a downward spiral. You're not being as productive as the two people across the room and therefore, your advisor is giving them more time than your advisor is

> giving you and therefore, you get discouraged and make even less progress. So, I think that it's not quite abandonment by advisors, but it is diminishing attention from advisors; because the advisors are going to spend their time where the work is getting done, where the papers are coming out.

Dr. Stachowiak acknowledged that faculty may be focused on short-term gains – building their research agendas – and are looking out for their interests by investing more in students who help build their own CV. As a result, students who are not as productive in terms of producing or contributing to papers and publications that will help build the faculty member's CV do not receive as much attention. Dr. Stachowiak also acknowledged the psychological consequences of students feeling discouraged and falling even further behind, thereby exacerbating the problem. He later added that among faculty, "this is an extremely common behavior." Thus, the advisor's goals and priorities for their own work ultimately drive attention to some students, leading to fewer or potentially worse interactions with other students perceived as "less productive", which may result in them thinking about leaving their doctoral program.

Dr. Klein reported similar issues of advisor fit, and also revealed an additional and concerning explanation for students' consideration of departure – feeling abused by their advisor. She stated:

> I've also seen that sometimes advising styles do not quite match and some of the students feel they are not getting attention from their advisor or they feel abused, basically [the advisor says] "demo and stay here 24/7 and work on this otherwise I will not let you graduate or I will not let you do this or that."

Her comment revealed that faculty advisors hold substantial power and influence over student experiences and outcomes and also how they may abuse that power by making egregious

demands on the students' work schedule and serious threats to their future. She reported this as an example of how students "feel abused" and may consider leaving as a result, which seems reasonable given that this mistreatment is in fact abusive.

Another faculty member, who also serves in an administrative position leading the doctoral program at their institution, echoed that the advisor relationship is the most critical to success in grad school. Though, they noted they've had very few conversations with students who actually want to leave. Instead, students typically go to them with concerns about their advisor. For example, "they're complaining about whether they're getting enough attention, whether their advisor's helping them to publish, … it's usually issues of fit with the advisor." Students may not be forthcoming about any desire to leave, but they have expressed how their advisor's behavior and engagement (or lack thereof) with them was causing problems and was detrimentally affecting their progress. It is noteworthy that in all of these examples, faculty members did not discuss the advisors' poor behavior, but rather mentioned that the student did not fit with their advisor, which seems to imply that students are the ones who need to change.

Indeed, in situations where the advising relationship is causing problems for the student, the common response was to help the student switch to another advisor. One faculty member explained that in situations like this,

> We'll brainstorm about other possible advisors that they might try to approach. So, I think that, what else can we do? I mean, there's obviously some faculty members who are not, you know, as dedicated to the students as they should be, but it's not clear how much we can change that.

While there is an awareness that some faculty members are not as student-focused as this particular department expects, the faculty member suggested that there is little that can be done,

despite the fact that they may be negatively impacting students' experiences and progress. According to one faculty member, the difficulty or inability to address problematic advisor behavior is, in part, due to tenure limitations. Another contributing factor to the challenge of addressing problematic behavior, according to Dr. Stachowiak is that, "I think all of us are reluctant to have difficult conversations with our friends." This "passive" behavior is common among faculty according to Dr. Pierce, which makes it challenging to have direct communication to address issues or have hard conversations, either with faculty colleagues or students. Due to the challenges of addressing faculty behavior, which revealed a lack of effective feedback mechanisms for faculty improvement, students are encouraged to switch advisors. While there is some support to help students find a new advisor, the lack of attention given to addressing faculty colleagues' behavior revealed that the onus remained on individual students to take action.

Expectations for Consideration of Departure

Notably, approximately half of the faculty members interviewed disclosed that they too had considered leaving their doctoral programs, sometimes on many occasions. Faculty perspectives shared in reflection on their own journey and in what they observe in their students revealed an additional emergent theme, namely that thinking about leaving is a normal part of the developmental process and something that students *should* think about.

First, the doctoral journey is long and often comes at a very transitional and transformative stage in students' lives where they are defining what their future looks like. Dr. Pierce, who pursued his PhD immediately after his undergraduate degree, meaning he was in his early 20s when he started, indicated that in those years he was trying to figure out who he was going to be when he grew up. He commented, "if you're not asking yourself those questions over

the five or six years that you're in a PhD program, I'm not sure that's healthy… are you so heads down and so sure of what you want to do?" He raised questions of whether it was healthy to go through a long and difficult journey without considering, and perhaps that being too assured of future plans might not be good for students.

Dr. Haddad felt similarly, even stating that for students who are very assured and have a one-track mind for their career, particularly if they are so focused on getting a top-tier faculty position, then that is "a literal avenue to a nervous breakdown." She recommended that students take a more moderate approach wherein they view the PhD journey as spending a few years cultivating new skills, solving problems, examining new paths, and seeing what interests them. Doing so, she argued, relieves pressure on students and allows them to meaningfully question what is right for them. Dr. Anderson also recommended that students consider various questions while pursuing their doctoral degree. They include,

> Generally, do you feel supported by all faculty? Do you think that the teaching is good? Are you educationally getting what you want out of the program? Do you enjoy living in [redacted location]? Do you have a support network here?

These questions, he stated, are important for students to build a good life and to make the decisions that will allow them to pursue what makes them happy.

Additionally, faculty members also expressed that students should be evaluating whether research is a good fit for them and if the career they want requires a PhD. This primarily was discussed in relation to students who decide to leave their program after many years. Faculty argued that it is better to raise these questions earlier so students can make the right decision for themselves. In fact, several faculty members across multiple institutions discussed their efforts to encourage these thoughts and conversations earlier so that students do not linger.

Lastly, Dr. Pierce emphasized that the difficulty of earning a PhD would naturally lead to thoughts of quitting. He exclaimed, “I can't believe anyone would go through the entirety of a PhD program and not seriously think about leaving along the way; and this is from the survivor, right?” Despite the fact that he survived his doctoral journey and has had a successful career, he expressed doubt that anyone would endure the whole program and not think about leaving. He used an analogy to describe the difficulty: that when kids are doing something challenging, they think about quitting often. He stated that “we get better [about not quitting] as we get older.” He commented that “when you're doing really hard stuff, when you've been stuck on a problem for a week or a month - and no, it's not a survival of the fittest, we shouldn't provide support - but it's hard.” The intellectual challenges inherent in doctoral study and the delays in progress are really hard. He also rejected the survival of the fittest mentality. Instead, he stated about students’ thinking about leaving, “It's natural, but that doesn't mean that we shouldn't have all the best supports for helping students sort of navigate those challenges or times of questioning.” He argued that although it is a difficult journey, thinking about leaving is natural, and faculty should help students navigate the challenges of the journey and provide support for students as they work through those questions.

Research Question Five: The Faculty Role in Shaping Students’ Experiences and Outcomes

The first half of this chapter discussed faculty members’ explanations for students’ consideration of departure, revealing the issues they are most attuned to. Now, in the second half of this chapter, I discuss findings that address research question five which examined the role faculty believe they have in shaping the experiences and outcomes for students. In doing so, I suggest that the issues faculty think are most important and central to students’ consideration of departure are the ones that most meaningfully shape how they engage and interact with students.

Consistent with prior literature (e.g., Barnes & Austin, 2009; O'Meara et al., 2013; Sverdlik et al., 2018), the computing faculty interviewed for this study were aligned in their view that they have great influence on students' experiences and outcomes in the doctoral journey. Dr. Moore stated that "the advisor-advisee relationship is the most important relationship in grad school…it can really make or break your success." Put most simply, faculty members described their role as helping students to be successful and happy in life and in their chosen careers. Dr. Costanzo expressed, "I try to help them figure out who they are and what they're good at." He does this by helping students identify their strengths and supporting them in doing work they are good at, which in his opinion allows them to "get happy." Faculty described being heavily involved in shaping and guiding students' paths through the doctoral journey and beyond. While some characterized their role in more concrete terms such as teacher, mentor, and coach, others were more general in their descriptions, saying that they do "quite a bit to help them [students] be as successful as possible."

Since the purpose of this study is to examine students' consideration of departure, I focus on how faculty see their role with respect to the experiences and outcomes for doctoral students. Below, I describe the dimensions of faculty influence on the doctoral experience – academic guidance, career guidance, and psychosocial support.

Academic Guidance

One of the most foundational roles faculty discussed is the how they provide academic guidance for doctoral students. From helping students select topics, to teaching technical skills and concepts, recommending readings, and participating in the research process, faculty noted an assortment of ways in which they guided students' scholarly development.

Eight of the ten faculty members interviewed explicitly described their involvement in cultivating students' research and writing skills. Dr. Stachowiak stated that "A lot of what I do is sit in on student presentations and help them understand how to make their work accessible and compelling." The skills for communicating research methods and findings effectively is not only honed in presentations, but also in writing, which Dr. Costanzo said nearly all students struggle with. His description provided clarity on the challenges of technical writing:

> The world doesn't care that you really struggled long and hard to get the results. The world cares about the results and wants to understand why the result matters and why it's sound, and why it's a scientific advancement. So, getting students to shift from, "this is what I've done" to "these are the results, and this is how science is advanced by what we've done," it is really challenging, and I think that's one of the main… well, one of the main impacts that we as faculty have when we are training those students.

While students may spend considerable time going through detailed methodological steps, faculty argued that it is more compelling for them to communicate not what they did, but what their findings mean for science and for the problems they study.

Faculty also spoke of the various approaches they use to help students cultivate these skills. Dr. Goodwin described his process of co-writing with students – giving them line edits, helping them learn from his own writing, and closely collaborating on projects. This, he argued, was critical in teaching students "how to present what they've accomplished and how to frame it." Additionally, other strategies for intellectual development included reading work aloud, forming reading groups for exam preparation and feedback, and presenting talks to fellow students and faculty for feedback. On reading work aloud, Dr. Goodwin acknowledged that

> This style of learning, it's a little more labor intensive, it requires a lot of vulnerability because you're in among your peers and people are critiquing you and so you'd have to be able to not be defensive. I think there's a lot of just good skill building in general that comes from that experience.

Even though it may take more time and effort, Dr. Goodwin suggested that reading work aloud and soliciting feedback from others would allow students to not only hear and identify issues in their own writing, but provide them with an opportunity to correct it, and to receive feedback from others, ideally in a constructive way. Admittedly, sharing work publicly can be difficult for students, which is why Dr. Costanzo's approach of inviting criticism on his own work can be empowering for students. He voiced that, "I tell students, 'give me your best shot, and destroy my talks when I give a talk' because that also gives them the opportunity to see that we are colleagues." He described downplaying his status to treat them like junior colleagues, and in doing so he creates a more open space for students to offer critiques and build their confidence.

In other instances, faculty conveyed different approaches to supporting students' intellectual development, which may, in part, be explained by sub-disciplinary differences. A faculty member in theoretical computer science remarked that they spend several hours each week in one-on-one meetings with students to work through the mathematical challenges of research. Another faculty member in the more applied subdiscipline of human-computer interaction, where it is common to have larger research teams, noted that they delegate more lab responsibilities to support students in becoming independent researchers. Thus, the mentoring provided by the faculty member, along with the additional responsibility, allows more advanced students to supervise junior team members and drive the research forward. In both cases, faculty noted that they provided mentorship and guidance on the research, though the process varied.

One final example worth noting, although only shared by one participant, was supporting students in cultivating their own scholarly voice by encouraging conference attendance. Specifically, this faculty member shared that they sometimes give more responsibility to an advanced student, sending them to a conference to represent him as the principal investigator. He communicated that,

> It's that kind of crossover experience where a student finds himself having to think about, "What am I going to say as a professional?" As opposed to, "I'm always working for this guy." I find that really important to do when that comes up.

The faculty member who suggested this practice extends his network to students who are then able to cultivate relationships with other faculty at the conference and offers opportunities for students to develop their scholarly voice.

A variety of strategies and approaches are used by faculty in their role as teachers and mentors. Beyond the content knowledge expertise, they also focused on developing students' ability to effectively communicate research to others.

Career Guidance

Faculty members also stated that a significant portion of their role is to provide career guidance to doctoral students. Conversations with students about their career interests and path begin early in the doctoral journey according to faculty members. Dr. Cleary described that the conversation he has about students' career interests is:

> A continued conversation because those things can change over time, and the decisions about what someone should do should be based on giving them the greatest likelihood of being successful at what they want in their next step and the years beyond that…making that an explicit part of the conversation I think is important.

The intentionality and timing for these conversations varied among the faculty members interviewed. For some, such as Dr. Cleary, the conversation begins during the admissions process. For others such as Dr. Klein, the conversation is intentional and usually occurs in the students' second year after they have had a chance to acclimate to doctoral life. On the other hand, Dr. Haddad discussed that she does talk to her students but that she recommends they should be open to different career paths and not be so narrow in their desired career path.

According to participants, the common motivator for these conversations is for faculty to know how to better tailor the doctoral journey and work to what the student is interested in. Dr. Costanzo pointed out that the feedback loop of understanding what the student wants and "how we can try to feed those needs" shapes both the kind of work students do, as well as the rigor and outlets for that work. In other words, because different career paths (e.g., faculty, industry, or government positions) have different requirements and qualifications, faculty interviewed for this study reported wanting to be able to adjust the students' doctoral experience as well as the products of students' work to align with the qualifications necessary to help them be successful in their chosen path. One example of this was offered by Dr. Klein, who stated:

> If they think they want a faculty position, then I will drive them very hard [toward] publishing in the third and fourth year and towards the fifth year. I will tell them they have to have at least two or three top conferences and then journal papers and so on. I'll show them and analyze what some of the resumes look like at basically all the top places.

> I will also advise them that, basically if it doesn't materialize in the fourth year, they should be looking at industrial labs or maybe stay one more year as a postdoc.

In this example, the students' interest for a faculty position drives Dr. Klein's mentoring interactions and rigorous standards to push the student to be more competitive with top-tier conferences and journals in order to have the requisite CV to get a job in a top program. However, she commented that she may also redirect students from this path if their publication record by the fourth year is not sufficient. In that case, she will recommend industry positions, or even a postdoc to allow the student more time to build their CV.

The relaxing of publication requirements based on students' individual goals was the most commonly cited adaptation to faculty expectations for students' work. This reduces the pressure to "build a record" and instead allows faculty to refocus the students' efforts on what work prepares them most effectively for their career interests. Dr. Anderson described how he advises students interested in industry positions:

> When I try to have a lot of those conversations, like, "Okay, so you want to go into industry, you've been clear with me about that in the past. Let's get you into some internships where you're building that professional network, and you have a variety of understandings, on-the-ground understanding of what that's going to be like, what your life is going to be like." And also, we all know that unfortunately we don't live in a perfect meritocracy. It's [about] connections and is somewhat nepotistic. So, you're building those connections to allow you to have that job that you want when you graduate.

In this comment, Dr. Anderson described providing support and encouragement for the student to pursue outside opportunities via internships so that they can truly understand what a life in that

career path looks like, and how they may be successful in that by building a strong network. Notably, Dr. Anderson expressed that he made a personal commitment to himself upon becoming a faculty member that he would not push students into academia. He stated,

> I've tried very hard to counteract, I think, the academic stereotype of "every student wants to be an academic." That means they're going to have different kinds of dissertations, and maybe the rigor of the work is going to be slightly different.

He described going against the common assumption that PhD students want to be faculty members. This stereotype lingers, despite the fact that a majority of PhD graduates do not in fact pursue academic positions (Zweben & Bizot, 2019). Thus, student experiences can look very different depending on whether and how much they communicate their career interests to their advisors and also how the advisor responds. This raises questions of the extent to which faculty who are more reliant on student labor to meet funding and project demonstration deadlines would be similarly supportive. The faculty in this sample seemed responsive and open to any path students were interested in, though this may not be the case for all faculty.

In addition to career guidance and variations in the student experience, dissertations may also be tailored to students' interests and performance. Dr. Anderson stated that dissertation projects and rigor may be different based on the students' career interests. For example, students interested in faculty positions may need a dissertation focused more on advancing science, whereas students interested in industry may be able to complete their dissertation requirements with a project focused more on applications and execution of research activities. In another instance, Dr. Goodwin described that for a student who was struggling:

> We restructured the program to lower the bar basically so that this person could succeed in the way that they were best received. They had some skills, they weren't the right

> skills for a PhD program, but they were skills that would help them get out and get a job, and so it's a matter of changing the kind of work that they were going to do.

According to him, lowering the bar could mean fewer publications and presentations, lowering the quality of work, or doing other work (e.g., programming or building infrastructure to analyze data) that does not emphasize abstract thinking or experimentation in the same way. Dr. Goodwin stated that these activities are "still evidence of research productivity, but it's just better aligned for other types of advisors and projects." This comment pointed to the variance in the work required to earn a doctoral degree based on different advisor's standards. In fact, Dr. Goodwin stated:

> I think in general, whether they complete or not, I have a lot of control over that because I can always, I have my standard, but I can always lower my standards, right? I don't think that has huge consequences actually. I think it's more about what I expect…I don't think anybody else knows what my standard is.

These examples point to the high amount of control and autonomy faculty members have in determining the rigor of work necessary to complete the doctoral degree. Thus, it is evident that faculty have immense power and influence in shaping students' experiences and outcomes, from whether students engage in internships, get exposure to and support for other career paths, focus on research productivity and publications, and even if students complete their degree. Further, Dr. Goodwin's comment above implies a lack of accountability in that he has full discretion in implementing his standards and does not have to share or reconcile them with any departmental or institutional standards.

The aforementioned examples of the role faculty have in adapting doctoral work and experiences to align with career interests focused primarily on individual students, namely their

direct advisees. However, three faculty members also described their role in regard to organizing or participating in workshops or panels to support career development for the broader community of doctoral students. These workshops may be part a practicum series or may be stand-alone events organized by students or faculty. Topics include preparation for interviewing and negotiation, as well as broader opportunities at research universities, teaching institutions, or industry positions. In one instance, a lecture series was established because many advanced graduate students indicated "they are not getting help, either from advisors or from the department on how to be a good faculty member." This indicated that some advisors do this work individually with their students and others do not. Further, this comment revealed a potential gap in the professional development for students in that department, which stands in contrast to another department with substantial development opportunities for students. Dr. Pierce illustrated his involvement in these efforts:

> I've helped put together some panel series on the different approaches or outcomes. Like, "here's the industry research panel, here's the research university panel, here's the teaching focus panel"...and then the sort of natural stuff around how to decide if that's the right path for you, making connections to other people who've been on that path….It's a little bit more than exposure…[it's] "here's the next three steps to take." It's the surrounding mentoring.

Dr. Pierce's work went beyond merely serving on the panels, but also encompassed other mentoring such as helping students understand the questions to ask to decide what path is best for them, encouraging networking to explore options, and what to do next. For these three faculty members, engaging in programmatic or structured development opportunities was not required of their positions, but they engaged in this service work, nonetheless.

Two additional faculty members from different institutions referred to programs that prepare graduates for their careers and the competition on the job market as "enlightened." This departmental engagement to develop and support students' career growth and transitions was not viewed as common place, and they noted clear differences in how programs that are "enlightened" treat their students compared to their presumably non-enlightened counterparts. One faculty member recalled a visit from a computing organization consultant who had told him, "It is surprising how few computer science graduate programs take collective responsibility for graduate students as opposed to them being the chattel of some faculty member." When asked if he agreed with the consultant's assessment, he shared his observation from his many years as a faculty member that,

> In most universities and programs, undergraduates are viewed as a broad responsibility, and graduate students are viewed as an individual faculty responsibility. This is wrong, but it's common…Enlightened programs take collective responsibility for the success of students.

This comment pointed out a critical difference in how undergraduate students are often viewed differently than graduate students. Though this faculty member did not agree with the practice or view graduate students are the "chattel" of faculty members, he has seen that this philosophy is common.

Across the board, faculty members interviewed for this study took great interest in both learning about and supporting their doctoral students' career interests on an individual level, and in some instances, on a more systematic or departmental level. This seems to reveal that the orientation these faculty participants have in being student-focused is uncommon, but as this was

not a study of computing programs or departments, it is unclear if the dedication and support offered by these faculty is equally shared by colleagues across their programs.

This collective responsibility for student success was illustrated by multiple participants from the same institution who described their department's practice of elevating and marketing students. These faculty advisors shared their practice of writing letters of recommendation and nominating students for awards to help recognize and elevate them. Even more, this department has integrated opportunities for student support into their organizational practices. One faculty member revealed:

> We, every year, sit there and discuss in detail every student who thinks he or she is going to graduate that year. And the goal of that is to make sure everybody understands at the level of at least a few sentences what their research is and what sorts of jobs they desire and what sorts of jobs they might be well suited for. So, this person you ought to market to your friends at top 10 departments for example, this person at the other extreme is best suited for the development organization at a tech company.

The fact that all faculty members in this department are involved and give their attention to the career paths of all graduating students, including promoting them to their professional networks, revealed the salience of the broader departmental culture and priorities to ensuring the success of students.

Faculty participants offered a multitude of examples for how they provide career guidance to doctoral students. The nature of their support for students, particularly in tailoring the experiences and expectations for students based on their career interests, illustrated that the doctoral journey is "a slightly different path for every student" as Dr. Anderson stated. A central tenet of the faculty role among the faculty in this sample, then, is to set students up for success.

Collectively, these efforts to develop students intellectually, to prepare them to be competitive in their chosen path, and to promote them through awards or networking may "add up to having a pretty big impact in their life" according to Dr. Moore.

Psychosocial Support

Providing psychosocial support was the most widely and deeply discussed characteristic of the faculty role in the doctoral student experience and outcomes. The importance and attention faculty gave to intellectual and psychosocial issues as explanations for students' consideration of departure, combined with their identity as an advisor, motivated their communication and priorities for student interactions.

Participants' comments regarding their role revealed that faculty members can indeed shape students' ability to handle the highs and lows of the doctoral journey. Dr. Cleary noted the importance of advisor support, which he learned from not having a very supportive or involved advisor in his own doctoral training:

> I recognize the importance of having a supportive advisor. I didn't know at the time, but most of the PhD students who worked with my supervisor…never completed their doctoral studies, and I understand why – because they didn't get much attention or mentoring. So, I realized the importance of a faculty advisor in at least initially helping individuals gain the confidence they need to then be able to complete what is a difficult journey.

Not only does Dr. Cleary's comment speak to themes shared earlier in this chapter—that diminished attention and lack of mentoring may contribute to students' thoughts of and actual departure—it also clearly articulated his understanding of the faculty advisor's role in providing psychosocial support to students as they pursue the demanding doctoral journey. Faculty

members interviewed stressed two critical ways in which they provide psychosocial support to students: by encouraging students through setbacks and by normalizing failure.

Encouraging Through Setbacks

As previously discussed, research is inherently difficult, and as Dr. Moore said, it is "an inherently insecure proposition." Because the faculty in this sample observed and understood that many students experience self-doubt, rejection, imposter syndrome, or do not feel that they belong, they see it as their role to help counteract these thoughts and feelings by providing encouragement and support. Dr. Stachowiak described it as "a lot of cheerleading," while Dr. Cleary emphasized that much of his role is "helping them deal with crises of confidence." Dr. Moore described her role as "a combination of encouragement and keeping them going." Faculty expressed that this direct and often verbal encouragement can help build students back up when the grind of the PhD is wearing on them. Dr. Haddad described how she also engaged in actionable encouragement, such as "telling other people about them, get them to give talks in places where they will be appreciated. That's all part of helping them along in this journey." She went beyond verbal affirmation to help put students in a position to see that she as their advisor is not the only one who thinks their research is interesting.

Faculty also described instances of how they interrupted students' self-doubt and provided validation by leveraging their own standing as a professor. Dr. Pogo spoke at length about how he related to students' doubts and insecurities, downplaying his status to demonstrate by saying "I want to tell you about times in my career when I felt the same way." He described feeling similar doubts throughout different times in his career, and that he had to work to overcome it. Dr. Pogo emphasized how prevalent these doubts are:

> I can tell you that it's not that unusual. And most of my colleagues at some point have felt exactly what you're feeling, and it doesn't make you a bad person or a sub-par researcher. It's part of the difficult growth process that research is.

These comments demonstrate how he reframed doubt as part of the learning process that everyone goes through, which may help the student see they are not the only ones struggling. He actively counteracted some of the mental hurdles prevalent among graduate students. He also told his students,

> I know you're going to think about those things. Have some faith. I wouldn't be working with you if I didn't think this was a good project with a good contribution and that you have the ability to be the person to make that contribution.

Through these comments, Dr. Pogo aimed to provide reassurance and understanding, while also validating students' work, their ability to conduct valuable research, their potential, and his belief in them.

Dr. Costanzo employed a similar strategy of leveraging his position as a respected professor and authority figure to reframe students' perspective. I include the lengthy quote below to portray the full exchange he had with his students:

> So, I had some interactions with some students that in so many words told me, "I don't belong here," and I actually look at them, and I say, "Do you think I'm incompetent?" They're like, "What? No. We're not talking about you right now." I'm like, "Oh, you're totally talking about me, because I'm part of the admissions committee. You think we're so incompetent, that we're going to admit somebody who doesn't have the intellectual potential to finish, and no, we expect you to finish. If we admitted you it's because we know that you can complete this. So, maybe you don't believe in yourself, and that's fine,

> that's completely fine. Hopefully, you'll solve that problem, but this is not an objective metric. We have a much more objective metric; we are completely dispassionate about this thing. I mean, there's a hundred people who applied, there's five or six that get in for a given program, believe me. You're costing us a lot of money also."…Usually when I say that, I'm saying it like I try to put some humor into it, but every single thing I say is actually true...We wouldn't invest in people that we think have no chance of finishing. So, I notice that having this kind of discussion with students, helps them realize that, "Okay, yes, maybe there's something in myself that I don't see."

In this exchange, Dr. Costanzo turned the focus from the students' doubts of whether they belong in the doctoral program to their trust in his own competency as a faculty member. He argued that given his role on the admissions committee, which he explained is far more objective, he knows that the students have the intellectual potential to complete their doctoral degree and that the department expects that they will fulfill this potential. He also infused humor into the situation to emphasize that the he and the department invested in each student. Essentially, he provided these reassurances by interrupting their self-doubt, validating their potential, and communicating his belief in their ability to finish. Dr. Costanzo also stated that, "if we can do anything to fend off some of those bad thoughts, we should do it, and if we're not, we are not really doing our jobs as advisors and protecting people from themselves, to some extent." From his perspective, intervening to disrupt negative thoughts or doubts is part of the faculty advisor role.

Normalizing Failure

Faculty members also described how they strive to thwart doubts, insecurities, and other negative thoughts and feelings students may experience by normalizing struggle, rejection, and failure. As previously discussed, challenges students face with comparison, competition,

conference or journal rejections, and a lack of progress can contribute to doubts, insecurities, and suffering in the grind of the PhD journey. Dr. Haddad emphasized that "research invariably comes with some failures, sometimes you try to prove something or try to develop something, and you realize it's not true or not possible." This, she argued was the very nature of research. This perspective, along with the encouragement she offered through setbacks, helps support students and keep them going through the ups and downs of the doctoral journey.

Further, two faculty members discussed normalizing failure for students by sharing their own failures openly. Dr. Pogo advocated for the use of failure bios:

> They don't put posters in the lobby advertising that someone's paper didn't get in or that someone didn't get this huge competitive grant they applied for. You only hear about the successes. So, unless students also are regularly reminded that by the way, for every success, there's like 10 failures, they might start to believe that unless they succeed in everything they do, they really don't belong here. And it seems like it'd be healthy to counteract that, and I am doing it in the most radical possible way.

His comment illustrated both a deep awareness of how students are affected by the successes they hear of and how they form beliefs about belonging as a result. By regularly sharing failures, and normalizing how common they are, Dr. Pogo attempts to counteract the detrimental view students may have – that they must succeed in everything.

Similarly, Dr. Costanzo discussed that he talks about his hit rate – the rate of success in his conference papers, publications, or grants – to put things in context for his students. This, he attested, allows them to see that even esteemed and advanced faculty have plenty of failures. He expressed that "the key message is that we should all embrace rejection/failure as 'the cost of doing business; in our field, as opposed to something that makes us feel bad." With this framing,

Dr. Costanzo hoped to model for students that rejections or failures are not personal, they are a part of the research process should not detract from students' self-worth or belonging.

Additionally, one faculty member discussed how providing transparency into the research process can help normalize the struggle and effort common in research. As part of a practicum on research skills, faculty break down the journey of a paper. The faculty member likened this to the "*VH1 Behind the Music*" series, where students have an opportunity to read the paper and then,

> We tell them everything that went into the genesis of the paper, and all of the dirty laundry, the rejections, the fact that oh, the initial paper had nothing to do with that, this was born of a mistake in the original paper that by the way never got published because it was terrible.

According to the faculty member, first-year students in this practicum have reported that "this is so helpful" and indicate that they understand a bit more of the process. The fact that it is given by a faculty member is "a big win" that normalizes the long journey of a paper, how it evolves over time, how the struggle is part of the learning process, and shows students that indeed, everyone has failures.

Part of the value of the practicum's behind-the-scenes view of academic papers is that there is an opportunity for faculty to proactively discuss their failures with students. Dr. Pogo verbalized that students, without a dedicated space, may find it difficult to learn about the struggles or failures experienced by others:

> If a student asked a typical faculty member here to talk frankly about their failures, I think most of them would, but I'm actually going the other way and I'm pushing it. I'm finding opportunities to make myself visible to talk about this because I realized that as a

> student, it's probably pretty hard to go to office hours and say, “hey, I'm not here for a class question. I want you to tell me about your failures.” I could see how students might be a little intimidated to just do that.

In challenging normal faculty behavior by openly sharing his failure bio and looking for opportunities to talk with students, Dr. Pogo expressed his aim to bring these lessons to the students. He emphasized that students may be reluctant to express self-doubts to faculty and may in fact be too intimidated to approach faculty. He alleviates these issues by being open with students. Dr. Pogo has received a positive response from students who told him,

> ‘I can't believe how much I appreciated hearing that. That's exactly what I needed to hear because I'm at a low point in my dissertation and I'm not really sure if this is the right thing for me to be doing’.

As evidenced by this comment and others shared previously, faculty demonstrated that the ways in which they interact with students and the messages they share can have a tremendous impact on students’ thoughts and perceptions. The most prevailing characterization of the faculty role focused on how faculty provided psychosocial support to their students, which allowed them to influence the students’ experience, perceptions of research, setbacks, and success. This section provided a number of examples for how faculty demonstrate this support to effectively reframe students’ thoughts, which may influence their persistence in the program.

Summary of Qualitative Findings

The qualitative stream of inquiry sought first to examine faculty perceptions of students’ reasons for consideration of departure. Faculty participants explained that students may think about leaving their doctoral program because they realize a research career is not for them and that attractive industry positions provide great financial opportunity and an escape from the grind

of the doctoral journey. Further, faculty suggested that issues of fit with advisors and various intellectual and psychosocial challenges may make the journey of doctoral pursuit quite demanding and problematic for students. Specifically, the highs and lows of the doctoral journey, they reported, can cause a great deal of self-doubt, imposter syndrome, or depression which can contribute to students' thoughts of leaving. A few faculty members also remarked that students should evaluate and may think about leaving as they reflect on their career goals and interests. In other words, faculty perceived that thinking about leaving is both expected and a normal part of the developmental process.

Next, I reviewed findings from the inquiry into the role faculty believe they have in shaping the experiences and outcomes for computing doctoral students. Faculty agreed that they have a great influence on students and they overwhelmingly framed their role as supportive and encouraging, striving to set students up for success in their chosen careers. Three dimensions of faculty influence on students emerged: academic guidance, career guidance, and psychosocial support. Faculty members commonly viewed their role as helping to counteract doubting and insecure thoughts and feelings students experience by providing encouragement and support.

In the next chapter I will discuss how the results of this chapter square with those from Chapter 4 and will specifically address the extent to which student realities and faculty perceptions for consideration of departure align or diverge. I will also review how the findings of this study contribute to the literature on doctoral student experiences and outcomes, as well as implication for theory, research, and practice.

CHAPTER 6: DISCUSSION AND IMPLICATIONS

This concluding chapter summarizes findings from this study and focuses on how the quantitative and qualitative streams of inquiry align or diverge. I begin with a summary of the study, including its aims, theoretical frameworks, and methodological designs. Then I synthesize key findings and contributions of the study. I conclude with a discussion of implications for theory, research, and practice.

Overview of the Study

Despite growing enrollments in computing programs at all levels of higher education (Zweben & Bizot, 2018), high rates of doctoral attrition (Zhou & Okahana, 2019) compromise efforts to expand and diversify both the computing and technology workforce as well as the faculty pipeline, which is currently facing a severe shortage (Flaherty, 2018a). To understand the mechanisms that threaten and support doctoral student persistence, this study focuses on students' consideration of departure – an important psychological precursor to their decisions about whether to stay or leave their doctoral program. This study first explores explanations of student departure from both the student and faculty perspectives. Then, I examine how computing faculty members conceptualize their role in doctoral student experiences and outcomes. As discussed below, findings from this study may inform areas of alignment or divergence between student realities and faculty perceptions, which are important given the critical role faculty have in doctoral student progress and completion (e.g., Lovitts, 2001; O'Meara et al., 2013). This study explored the following research questions:

1. What are the demographic and background characteristics (e.g., gender, race/ethnicity, citizenship) of students who have considered departure?

2. Among students who have considered departure, what explanations do they give for why they considered leaving? What supports do they attribute to helping them continue in their program? How do these explanations vary by gender and race/ethnicity?
3. What factors predict students' consideration of leaving their doctoral program prior to earning a degree? How does this vary between women and men?
4. How do computing faculty conceptualize reasons for students' consideration of departure in computing doctoral programs?
5. What role do computing faculty believe they have in shaping experiences and outcomes for computing doctoral students?

This study used a sequential mixed-methods design (Creswell, 2009) wherein the quantitative data collection and analysis preceded and informed the qualitative data collection and analysis. Research questions one, two, and three rely on quantitative student survey data from the 2018 graduate student Data Buddies Survey administered by the Center for Evaluating the Research Pipeline (CERP) to investigate the dependent variable – students' consideration of departure. Descriptive analyses (i.e., frequencies and crosstabulations) were used to answer research questions one and two. Inferential analyses (i.e., logistic regression) were guided by an adapted model of Girves and Wemmerus's (1988) conceptual framework of doctoral student degree progress. Research questions four and five relied upon semi-structured interviews with 10 faculty members at highly-ranked computer science doctoral programs. Qualitative data collection and analysis were guided by a social constructivist lens and a phenomenological approach to emphasize and center participants' voices. In this chapter, I also discuss findings from faculty interviews in relation to the microfoundations of institutional logics framework to

advance interpretation and understanding of the role faculty believe they have in shaping the experiences and outcomes for doctoral students in computing.

While Chapters 4 and 5 reviewed the quantitative student findings and the qualitative faculty findings separately, in this chapter I integrate the findings across research questions to provide a more comprehensive interpretation across both streams of inquiry. In doing so, I discuss the extent to which student realities and faculty perceptions for consideration of departure align or diverge. Additionally, because the sequential research design enabled me to share the quantitative findings from the student survey with faculty during their interviews, I include some of their reactions and interpretations to provide additional context.

Importance of Supportive Environments

This study, in alignment with previous research (e.g., Gardner, 2009b; Gilmore et al., 2016; Girves & Wemmerus, 1988; Lovitts; 2001), provides evidence to suggest that the social structure, relationships, and culture in computing doctoral programs meaningfully shape students' thoughts and behaviors, including their thoughts of departure. Student explanations reveal both a self-awareness of the thoughts and feelings (e.g., confidence, satisfaction, isolation) that contributed to or diminished their thoughts of leaving, as well as the sources of interaction from the environment (e.g., peers, faculty, department) to which they attributed those thoughts and feelings. In contrast, faculty explanations largely omit environmental explanations, focusing instead on the ways that individual students may struggle (e.g., crisis of confidence, doubts, coping with rejection) in their doctoral journey.

From these findings, it is evident that the extent to which students experience supportive environments is most salient to their consideration of departure. Collectively, three elements seemed to shape students' consideration of departure and informed the extent to which students

and faculty perceived doctoral environments to be supportive: peer relationships, isolation, and relationships with faculty.

Peer Relationships

Examining student and faculty explanations in tandem reveals that relationships with peers can either be supportive or detrimental to students' doctoral journeys. One of the more remarkable findings from this study is that peer support positively predicts students' consideration of departure; that is, students who reported greater peer support were significantly more likely to think about leaving their doctoral program. This finding suggests that having a supportive peer group plays a complicated role in students' psychological consideration of departure. In this study, peer support was measured by a factor of students' responses to three items indicating the frequency that they received help, support, and frequent feedback from peers on their work, and had peers who are willing to listen to school-related issues. This support may allow students to consider a variety of educational and life paths—including the possibility of leaving their doctoral program. Alternatively, it may be that students who contemplate leaving their program are more likely to seek out peers for support in navigating this decision.

Further, the presence or absence of personal peer relationships (beyond the academic relationships described above) can support or threaten students' persistence. This finding from research question two is illustrated by the fact that 7.1% of students indicated that not having friend in the major was an explanation for their consideration of departure. These students then may be more isolated and, without a peer support system, more likely to think about leaving. On the other hand, receiving support and encouragement from friends was shown to be a contributor in students' decision to stay in the program. In fact, women were significantly more likely than men to attribute support from friends as influential to their persistence.

Faculty perceptions of students' consideration of departure also indirectly pointed to the impact of peer interactions on students. Specifically, half of the faculty interviewed observed that students experience more self-doubt when they compare themselves to their fellow students. They characterized this comparison as daunting and deflating to students' views of themselves and their skills, which consequently may explain why students think about leaving their doctoral program. In context of the quantitative findings, this may indicate that students who receive more help and feedback on their work may also have more opportunities to see other students' work, which could fuel comparisons and force them to examine how they measure up to their competition in other students.

While many faculty members were surprised by the findings that experiencing more peer support significantly increases students' consideration of departure, two faculty members remarked that they strive to cultivate a healthy peer dynamic in their research labs. Dr. Costanzo voiced that he tries to discourage internal competition and emphasize that all of his students can succeed. Meanwhile, Dr. Anderson remarked that peer relationships were essential in his own doctoral journey, characterized by "taking classes and working together, and succeeding together, and failing together, and commiserating together." Recognizing the importance to his own path, he now intentionally organizes quarterly lab retreats to cultivate peer bonds among both graduate and undergraduate students in his lab. Thus, even in their brief comments in response to the quantitative findings, Drs. Costanzo and Anderson revealed that faculty members *can* and sometimes do shape peer culture.

Isolation

Students' feelings of isolation, as they contribute to their consideration of departure, reveal a disconnect between student realities and faculty perceptions. Approximately half of

students indicated that they considered leaving because they feel isolated in their program. Given that Lovitts (2001) found that a lack of community is one of the four primary reasons for doctoral attrition, it is concerning that, even 20 years after Lovitts's foundational research on doctoral student attrition, students' feelings of isolation could still serve as a primary reason for leaving their program.

When integrating faculty perspectives, however, it is noteworthy that very few faculty members identify isolation as a factor in students' consideration of departure. Drs. Stachowiak and Costanzo provided seemingly contradictory observations on isolation, with one indicating that siloed research labs contribute to isolation while the other observed that even in shared spaces, students may not be interacting or making meaningful connections that combat isolation. Although not explicitly named by faculty in connection to isolation, two participants did comment on how visibility into others' success may lead students to believe they are the only ones struggling. It is possible that students who feel they are the only ones struggling may feel isolated, though this study was not able to investigate that potential connection.

The fact that so few faculty members attributed students' consideration of departure to feeling isolated may signal a lack of awareness as to the extent of how isolation affects students' trajectories. Yet, when I shared that feeling isolated was a leading reason for students' consideration of departure, Dr. Goodwin remarked that he was not surprised because "the training that goes into becoming a PhD is isolating." Dr. Costanzo also replied that "admittedly it rings alarm bells, because I know it's a recipe for disaster…it's really something that we need to fend off." Drs. Klein and Costanzo commented that student socials may be useful to bring students together. Further, Dr. Klein went on to describe the positive effects she has seen after initiating a regular social program for students a few years ago. Thus, it seems that these faculty

are indeed aware that isolation may be a threat to students' experiences and that community building is likely to be beneficial. However, in light of the finding that students in the same physical space may still struggle with connection, physical proximity is necessary but not sufficient to create community and ward off feelings of isolation.

While feeling isolated, specifically, was not included in the logistic regression model as it was only asked of students who indicated they had considered departure, related significant findings point to the positive effects of community connections. Particularly, increased sense of belonging in computing and greater departmental support reduced students' odds of thinking about leaving, which has clear implications for departments that seek to cultivate community within doctoral programs.

Relationships with Faculty

Findings from this study add to the abundance of literature (e.g., Bair & Haworth, 1999; Barnes & Austin, 2009; Lovitts, 2001; Millett & Nettles, 2009; Sverdlik et al., 2018) that identifies the advisor relationship as most critical to doctoral student experiences and outcomes, including their persistence or attrition. The quality and nature of the relationship heavily impacts students' experiences throughout the program, in both positive and negative ways. As evidenced in this study, both students and faculty perceive the student-faculty relationship to be influential in students' experiences, though they differ in their views on how this relationship affects students' consideration of departure.

Students and faculty partially align in their attribution of students' consideration of departure to unsupportive faculty advisors. More than one-quarter of students who indicated that they had thought about leaving their program attributed this to professors in their computing programs who were not supportive. This finding reveals how prevalent of a problem

unsupportive faculty are, particularly in that some portion of students who haven't thought about leaving could also view faculty as unsupportive. Surprisingly, faculty members also indicated that poor advisor fit contributes to students' consideration of departure. The fact that faculty did indeed name advisors at all is particularly noteworthy as it signals a departure from prior literature that indicated faculty rarely consider the faculty-student relationship as a contributing factor to doctoral attrition (e.g., Gardner, 2009b; Gilmore et al., 2016).

Consistent with Lovitts' (2001) finding that unsatisfactory advisor relationships are a primary reason for doctoral student attrition, faculty participants observed that the behavior of diminishing attention from faculty can detrimentally impact students' progress and motivations, which may contribute to their consideration of departure. Although faculty did acknowledge advisor fit as an explanation for students' thoughts of leaving, several participants had only brief comments and seemingly accepted that issues of advisor fit are normal in doctoral education. This is partially true to the extent that fit issues may arise from intellectual or research alignment (e.g., students or advisors' research interests may not align or may change), though the diminishing attention that results from faculty prioritizing the most productive students is a choice and, according to participants, a common behavior among faculty. This may be explained by the logics that frame individual values, priorities, and action which will be discussed in greater length later in this chapter. Recognizing the harmful effects of poor faculty relationships, the common response to issues of unsupportive faculty or diminished attention from advisors was to have the students change advisors, as opposed to addressing advisor behavior or the structural arrangements that incentivize such behaviors.

Alternatively, evidence from students and faculty indicates that when faculty are involved and supportive, they can have clear and life-changing impacts on students' lives, educational

trajectories, and persistence. Approximately 36% of students reported that support and encouragement from faculty helped them continue in their program when they had thought about leaving. This support was significantly more instrumental in the persistence of women compared to men, which indicates that supportive faculty relationships could be instrumental in helping to narrow the gender gap in computing (Zweben & Bizot, 2018). Further, students' satisfaction with their advisor was shown to significantly and substantially reduce the likelihood of their consideration of departure, consistent with findings from previous research (Ruud et al., 2018). Evidence from this study reveals that greater advisor satisfaction was on par with higher levels of perceived departmental support and a stronger sense of belonging in computing in reducing students' odds of thinking of leaving. Notably, satisfaction with one's advisor was particularly impactful for reducing men's consideration of departure compared to their peers who were women. In other words, among men and women who are similarly satisfied with their advisors, men are even less likely than women to think about leaving. Thus, advisor satisfaction is more influential in reducing the likelihood of men's consideration of departure, though for students who have thought about leaving, faculty support and encouragement is significantly more important to women's persistence.

Similar to the evidence from students, faculty expressed their role in supporting students' persistence. By examining faculty perspectives – specifically the role they believe they have in doctoral student experiences and outcomes – this study makes an important contribution and builds upon the work of prior scholars (Barnes & Austin, 2009; Lechuga, 2011). Faculty explanations of students' consideration of departure heavily relied upon the intellectual and psychosocial challenges students experience (i.e. intellectual grind, competition and comparison, mental health challenges). Perhaps due to this focus on students, faculty highlighted that the

psychosocial support they provide to students is most salient to their role and influence on students. Their emphasis on providing psychosocial support that serves to normalize students' setbacks and the difficulties of the doctoral journey is, at least in part, due to their recognition that students who struggle may do so because they are less confident and therefore more vulnerable to thinking about leaving.

In addition to psychosocial support, faculty also highlighted their role in providing academic and career guidance, which collectively can shape students' educational and career trajectories. These findings are consistent with two dimensions of holistic faculty support identified by Posselt (2018); namely, academic and psychosocial supports that, respectively, served to reframe and normalize struggle and validate competence and potential. While Posselt (2018) relied upon phenomenological interviews with STEM doctoral students, these findings advance what is known about the *faculty* perspective by illustrating how holistic faculty support emerges in a computing disciplinary context and how faculty members' intentional application of these supports is a key element of supporting student persistence.

The Computing Context

Given that this study centered the perspectives of students and faculty in computing disciplines, findings from this study are particularly critical to advancing knowledge about doctoral student persistence in computing fields specifically. As previously noted, doctoral programs in computing disciplines have persistent retention problems, and this is likely due in part to close ties and applications to industry. In fact, Dr. Anderson provided some valuable context on how pervasive industry connections are in computing doctoral programs, particularly those subdisciplines that are more applied (e.g., artificial intelligence, machine learning, human computer interaction). He stated that many students have internships in their first two years of

the doctoral programs and that big companies may in fact sponsor students in getting their PhD, provide datasets, or collaborate directly with research labs. Yet, evidence from both student and faculty perspectives highlighted how opportunities in industry may attract students and contribute to their consideration of departure. Faculty suggested that the lucrative salaries offered to those in tech positions, as well as the ability to escape the grind and workload of a doctoral program may provoke students' thoughts of leaving. Findings from the logistic regression also signaled how strong the pull of industry is for students: students who spent more time on activities related to the tech industry (e.g., internships, computing-related contests, entrepreneurial projects) were significantly more likely to think about leaving before finishing their degree. Faculty members were not at all surprised by this finding.

Interestingly, the industry connections and collaborations are attractive not only to students, but also to faculty, and such collaborations impact students' educational and career trajectories in a variety of ways. On the one hand, faculty in this study described how industry connections to faculty research labs may provide students with more research opportunities and a strong professional network. However, some faculty members may prioritize these industry pursuits by serving in a joint appointment, spending their sabbatical, or even spending their free time working in tech companies, and thus have substantially less time for their students. In some cases, faculty suggested that students may lose their advisor entirely when faculty leave academia to pursue industry positions themselves. Thus, as computing faculty are drawn to collaborations with tech companies, their students' academic progress may suffer as this study found diminishing attention from faculty can have negative consequences on students' experiences and may threaten their persistence. To address this, one faculty member revealed that their department created a policy specifically for faculty who are heavily involved in

industry activities, requiring them to develop a written plan for how they will continue to support their students. Additionally, the department arranges a co-advisor for the student to ensure they receive the mentoring they need to advance in their studies.

Faculty Perceptions that Reinforce and Challenge Institutional Logics

Institutional logics guide the allocation of attention by shaping what problems and issues get attended to and, consequently, what solutions are considered in decision making (Ocasio, 1997; Thornton & Ocasio, 1999). Interpreting the findings from this study through the microfoundations of institutional logics framework (Thornton et al., 2012) enables our further understanding of the practices and norms that guide faculty members' individual and organizational behavior. Doing so reveals that when faculty explanations for students' consideration of departure are focused on the students themselves, faculty will primarily take action that addresses student issues instead of broader systemic and environmental challenges in doctoral education. Additionally, faculty behavior and their interactions with students, especially, is guided by faculty members' identities, roles, and goals (Thornton et al., 2012), meaning that there is considerable variation in how faculty act when considering threats to student departure.

Through in-depth interviews, faculty members discussed their explanations of what contributes to students' consideration of departure. In doing so, they revealed the logics or interpretive frames that shape their understanding of threats to student persistence. As previously discussed in Chapter 5, faculty explanations for students' consideration of departure were primarily attributed to individual student career interests (i.e., deciding that research was not a good fit for them, or pursuing industry opportunities) and intellectual or psychosocial struggles rather than the larger environment or culture in their program or in doctoral education. Thus,

faculty look to students and how they experience or cope with the doctoral process to understand threats to student persistence.

This student-focused logic is reflected in the vocabularies of practice and the language used, which reveals how faculty members view students' consideration of departure, often from a deficit perspective. For example, Dr. Cleary's comment that "maybe a bad experience with an advisor or a research group and, you know, for various emotional or psychological reasons, *they put themselves* in a bad position and start to doubt their ability" seems to signal that students are responsible for those circumstances, as opposed placing responsibility on the advisor. Additionally, unlike how faculty had multiple ways of describing imposter syndrome – from doubts, to insecurities, or lost confidence – the repeated use of the word depression signaled that faculty may actually characterize a variety of struggles as depression, thereby not distinguishing between specific psychosocial challenges. For example, Dr. Klein repeatedly used the phrase "they go get depressed" when discussing the results of students' experiences with competition and peer comparison, not performing well in classes, and conference rejections. This language pathologizes students and overshadows circumstances or experiences, such as imposter syndrome and rejection, that faculty admit are a normal part of the research process.

Indeed, faculty participants highlighted that struggle, discomfort, failure, and other challenges are all expected, accepted, and often normalized in doctoral study. Participants acknowledged that the pressures and expectations students face today are far greater than when they were students themselves. In fact, faculty described responding to the apparent need for students to generate research and publications in order to be successful on the job market by reviewing and potentially reducing the required course load. Faculty perceived that these escalating productivity demands and competitive job market are forces contribute to doubts and

insecurities among students. Faculty members suggested that these lofty standards and expectations compromise student well-being, sometimes in extreme manners. Dr. Costanzo characterized the intensity of these research demands: "it's like running a marathon at a sprint pace. It's really not friendly." Beyond being unfriendly, common sense and running expertise would seem to indicate that trying to do a marathon at a sprint pace would easily lead to burn out, fatigue, or worse. Still, Dr. Moore argued that a students' ability to persist through the struggle is necessary for their success. So, then what does it say about students who struggle with the escalating, and perhaps unreasonable, challenges of doctoral study?

Despite their acknowledgement that the doctoral education process is increasingly demanding, the heavy focus on mental health concerns may amplify faculty members' pathologizing of students. While there seems to be an accepted or understandable level of struggle or challenge during doctoral study, it can easily escalate and compromise student well-being. In fact, awareness of and responses to the mental health crisis in graduate school more broadly (Evans et al., 2018) are building momentum. Nearly all faculty members discussed that mental health challenges may contribute to students' thoughts of departure. Dr. Clearly even noted that every faculty member he knows has had a student take time off or even leave the doctoral program due to mental health concerns. His anecdote is consistent with Geraniou's (2010) finding that disruptions in students' psychological well-being can detrimentally impact their motivation and degree attainment. Faculty members' ability to reconcile, understand, and enact their role in supporting students who have different goals, coping mechanisms, and systems of support may be increasingly challenging. Although Dr. Costanzo contends that momentum is building to recognize that "psychological well-being is essential to a productive research environment," (as opposed to the common "sink or swim" mentality) faculty members

still pathologized students who experienced the struggles commonly accepted as normal in the doctoral process. These deficit views, combined with the faculty members' acceptance of the heightening stakes and environment in doctoral programs, reinforce the student-focused logics that compel solutions related to individual students.

These logics guide faculty behavior and interactions based on what they see "is legitimate, reasonable, and effective in a given context" (Guillén, 2001, P. 14). Given this logic and interpretative frame of what threatens student persistence, faculty members described how their role and interactions with others (e.g., students, administrators, other faculty) were focused on the importance of bolstering students' ability to cope with the challenges. As discussed in Chapter 5, faculty conceptualized their role and their interactions with students in three ways, providing academic, career, and psychosocial support that promotes students' success. They described several mechanisms to deliver these supports, from one-on-one mentoring, to research team discussions and group work, and departmental programming. These efforts all reflect student-level supports that focus primarily on how faculty as individuals can enhance students' understanding of the process and skills needed to be successful in their PhD.

Despite focusing on the support faculty do offer students, faculty explanations for students' consideration of departure also imply a passiveness to their own role in affecting student outcomes. For example, faculty participants mentioned students sometimes lack an awareness of what research entails, they may have inflated expectations about what the dissertation represents, and they may feel discouraged by receiving less attention from their advisors. These explanations and the student-focused logic ignore several key questions and points of influence faculty have in the students' experience, including: what role do faculty have in teaching and mentoring students to socialize them into research? Who should set the

expectations for the dissertation? How and when are those communicated to the student? How can departments and faculty peers hold one another accountable for equitably give time to all of their advisees, instead of prioritizing more productive students? Maintaining the focus on the students' challenges reinforces the prevailing logic that students are responsible for their struggles and hinders individual accountability among faculty to address some of these issues that contribute to students' consideration of departure.

Further, these logics also inform faculty inaction that could address threats to student persistence. Specifically, faculty members indicated that there is not much they could do question or intervene when their faculty colleagues are engaging in behaviors that create challenging or negative interactions and environments for students. Faculty members discussed that respecting faculty autonomy, lacking transparency into how other faculty members advise their students, and giving the benefit of the doubt that "everyone wants to be a good advisor" despite evidence to the contrary (e.g., diminishing attention from advisors, overworking, or abusive behavior), are all explanations for why they largely do not consider talking to problematic advisors as a viable solution for student issues. Instead, the student is supported in finding another advisor. Thus, by focusing action only on solutions directed at the student, this logic can perpetuate and shield problematic faculty behavior. The faculty norm of not addressing colleague behavior may exist because addressing individual concerns with students, and moving them to another advisor, is more feasible and timelier than addressing departmental change or cultural issues in academia.

Faculty in this study were very motivated to support students' persistence and completion, however they expressed that not all faculty are driven to do so. How faculty conceptualize their role, and what they are motivated to do in that role, shapes the extent to

which they reinforce or challenge institutional logics. The tensions of the faculty role, namely the competing responsibilities for research, teaching, and service, as well as individual faculty members' identities and goals in their position may explain variations in how faculty interact with students and respond to student struggles.

On one hand, participants described other faculty who are more focused on developing their research agenda. These faculty members they argued, may not be as focused on supporting students, and as a result, some focus their attention on the most productive students. As shown in this study, these patterns of diminished attention may be a threat to student persistence and in fact may contribute to students' consideration of departure. While all of the faculty in this study were tenured, they expressed that other faculty who place emphasis on research productivity and the developing their CV and research program in pursuit of tenure and promotion may not see it as their role to support struggling students. These tensions between the research and teaching or mentoring roles of faculty is consistent with existing research on faculty responsibilities (Martin, 2011; Schuster & Finkelstein, 2006). Thus, these faculty behaviors are motivated by research goals that can conflict with the priorities for bolstering student success and persistence.

Alternatively, the majority of faculty interviewed described practices that centered their role as an advisor and supported their goal of having a "multiplicative factor" that amplifies their impact on students. In pursuit of this goal, several faculty expressed that "student interests should trump all other interests," as Dr. Stachowiak described. The additional leadership and service positions held by nearly all faculty participants provided a different lens for observing patterns among students and also informed faculty members' understanding of threats to student persistence. Motivated by a desire to have a broader impact on the student experience, along with the funding allocation and agenda setting responsibilities afforded in their leadership positions,

faculty members were able to harness their agency and challenge existing logics (i.e., to focus on individual student struggles and supports) to pursue structural or organizational solutions to address threats to student persistence. For example, faculty members discussed past and current efforts to alter the qualifying exam process, reduce required coursework, and provide additional programming and seminars to illuminate the research process.

While additional positional responsibilities altered the faculty members' point of focus and enabled them to engage in more systemic efforts to support doctoral students, it raises the question of how other faculty, who do not have the benefit of these perspectives, are equipped to prevent or respond to challenges that threaten student persistence. Given their interpretative frame of what threatens student persistence, faculty members were primarily focused on the importance of bolstering students' ability to cope with the challenges instead of scaling back the stressors of the environment. As long as faculty members and departments maintain a deficit perspective and view doctoral student attrition as the result of student issues, systemic issues in doctoral education and in computing will remain unchecked.

Implications

This study has implications for scholars, practitioners, and faculty in doctoral education broadly and in computing. Throughout this chapter I have discussed how this study builds on existing literature on doctoral students and faculty, particularly in a computing context. Below I describe key implications for theory, research, and practice.

Theoretical Implications

Findings from this study reveal both the utility of the frameworks used and also offer insights for advancing these frameworks. First, I used an adapted model of Girves and Wemmerus's (1988) conceptual framework for doctoral student degree progress wherein I

extend the scope to include additional psychosocial characteristics (e.g., self-efficacy, career values) beyond students' satisfaction or alienation. The significance of these attributes and characteristics in the logistic regression results offers evidence for how the model can be adapted to the current context to address how student thoughts and motivations shape their behaviors and outcomes. Also, applying this adapted framework to a national, multi-institutional sample of doctoral students provides further validation of the utility and relevance of the framework. While measures for some components of the framework were limited in the dataset, the non-significance of departmental characteristics and financial support may signal these factors are less salient to computing students, or that institutions with very high research activity (R1) provide adequate funding for students. Findings from this study emphasize that perceptions of faculty, students' satisfaction or alienation, and other psychosocial attributes are most predictive of their consideration of departure.

Further, by applying the microfoundations of institutional logics framework to understand how macro-level forces shape micro-level interactions, I elucidate clear connections between how the salience of organizational practices shapes faculty attention and interactions with students. Despite some challenges to the prevailing logic, findings from this study affirm the theoretical understanding that faculty members' focus of attention – what they deem as the problem to address – ultimately informs their social interactions with other actors (e.g., students, faculty, and administrators). If their focus is on individual problems and student deficits, the long-standing schemas that guide how they interact with students and the solutions they entertain or pursue will continue to inform organizational practices that reinforce structural problems. Findings from this paper illuminate some of the problematic logics and behaviors that influence students' consideration of departure. Future research should delve into the particular

organizational practices that faculty use and examine whether those practices actually impact their focus of attention. Lastly, the relevance of this framework for understanding what guides faculty behavior and their interactions with students presents an opportunity for using this theory to guide change efforts at the departmental level.

Limitations and Implications for Future Research

While this study makes several important contributions, it is also limited in a few keys ways that future research may address. First, all faculty participants were from highly-ranked computer science doctoral programs at R1 institutions. Further, all participants had already earned tenure, and many have spent decades in the field. Also, I must again acknowledge the self-selection bias of the faculty sample. Nearly all participants have or currently hold administrative or service positions relevant to leading their departments or institutional processes that affect doctoral students. As a result, they may have participated in this study because they are perhaps more aware of or committed to addressing challenges in doctoral computing education. Collectively, this sample may represent a narrower conceptualization of the faculty role and faculty priorities given their institutional context and administrative positions. Thus, an important next step in this inquiry is to incorporate perspectives of faculty from other institutions, as well as a broader representation of faculty rank to understand how program selectivity and tenure status shape faculty logics, perceptions, and interactions with students. Research might also explore how faculty perspectives and roles differ across sub-disciplinary cultures (e.g., computer engineering, information sciences).

Next, while this study generated remarkable and relevant insights from students currently enrolled in doctoral computing programs, the use of secondary data limits the scope of data and our interpretations of the student experience. Future research may explore how student mental

health challenges, computing sub-disciplinary culture, and stage in the program influence the timing and likelihood of their consideration of departure.

Further, findings from this study reveal several emergent research areas to better understand doctoral student persistence and well-being. An important contribution of the present work is the focus on faculty perceptions of the student experience. Examining the language faculty used to describe the student experience, specifically the psychosocial challenges could generate insights into how faculty form perceptions and subsequently respond to students' mental health challenges. Doing so may provide an opportunity to reframe more precisely what these struggles are and subsequently offer more insight into how to address them. Thus, future research should examine the discourse faculty use in describing their students and the challenges they face.

While the insights gained from the faculty perspective shed light on how *they* think students cope with variety of challenges (e.g., rejection, research process) and environmental conditions (e.g., competition, siloed research labs, faculty relationships), it is imperative to understand these challenges from the students' perspective. Qualitative research is particularly well-suited to this and may provide valuable insights into how students make sense of, and potentially internalize, their interactions with faculty, departmental leaders, and fellow students.

Lastly, this study provides compelling evidence on the importance of peer relationships in the doctoral journey and the different ways these relationships may contribute to students' persistence or consideration of departure. Future research should explore both the nature of peer interactions and their impact on students' thoughts, confidence, belonging, and behaviors, as well as how peer interactions and culture are shaped by faculty and departmental influence. Although

having peers may be one part of the story related to doctoral persistence, it seems that *how* peers interact may play a more influential role in students' persistence and is less well-understood.

Implications for Practice

Future research should continue to expand our knowledge on what supports or threatens students' persistence, as well as the tensions faculty members face in their own work to shape graduate environments. Still, this study offers many implications for practice that can be pursued now to enhance and improve graduate environments, student experiences, and outcomes.

The findings from this study reveal that students, much more so than faculty members, attribute their thoughts of departure to a lack of support and inclusion in the department. In fact, students who do feel a greater sense of belonging and department support are less likely to consider leaving. Thus, computing departments can take several steps to cultivate a stronger community among their students and faculty. First, creating more community building events and programming to foster meaningful relationships among both faculty and students in the department which could help combat isolation. In addition to cultivating a sense of community among their students, faculty and department leaders can play a role in *how* doctoral students engage with one another. By providing equitable attention to all advisees, faculty can reduce the competition for their attention between students. Faculty may also strive to foster more collegial relationships in research labs by encouraging collegial relationships with their advisees, discussing failure bios, demystifying academic processes, and engaging with students who are not their advisees.

Next, faculty members can provide more transparency into the research process to illuminate the common research challenges. By sharing examples of how papers naturally evolve, as in the series inspired by "*VH1 Behind the Music*" one institution, faculty members can

normalize challenges and rejection as redirection of intellectual scholarly development. Doing so may emphasize that rejection and failure are "the cost of doing business" in academia and are not indicators of personal capability. Also, given that faculty in this sample discussed how many students struggled in the dissertation phase, faculty advisors can discuss and set expectations for what the dissertation is and how students can approach it. Specifically, framing the dissertation as an exercise in developing as an independent researcher may reduce the pressure students feel to make it their "magnum opus." Faculty may also offer guidance, perhaps through a seminar or a structured working group, on what constitutes a viable dissertation topic as they indicated many students struggle in their middle years with uncertainty around their topic.

Also, faculty could turn the lens on themselves and their practices to identify how they might elevate their own departmental policies and advising practices, as opposed to triaging student issues individually. For example, faculty could openly share and create consensus around departmental standards for what earning a PhD means and basing advising practices in support of that. Faculty also identified several areas where additional training and professional development would be useful in their support of students. They mentioned training to better detect and refer mental health issues, training in psychosocial and "soft-skills" development to support their personal advising relationships with students, as well as management training to more effectively lead their research groups.

Further, cultivating a sense of collective responsibility for students across the entire graduate education ecosystem is important to address broader environmental threats to student persistence. Systemic problems (e.g., culture of competition, rising pressure for research productivity, inequities in completion) require system-level solutions. Generating solutions can begin with individual and organizational reflection on questions such as: What are the common

practices (logics) that may influence interactions and relationships in the department? To what extent is diminishing attention or mistreatment from advisors an issue; and what impact does this have on other faculty advisors who may shoulder a heavier advisor load? To what extent and how do faculty hiring committees contribute to the escalating demands of research productivity for doctoral students?

Next, faculty and departments should strive to build cultures of transparency and peer accountability that can affect departmental change. When discussing advisors' diminished attention or potential mistreatment of students (e.g., verbal abuse, excessive work demands), faculty remarked that helping students switch advisors is a good plan because it's "not clear" how much they can do anything about faculty who are not as dedicated to their students' well-being. Several faculty members also noted that they had little insight into how other advisors work with their students. The lack of transparency, insight, or accountability may allow for harmful interactions or abuses to continue, potentially threatening student persistence and well-being. As Dr. Pogo indicated, the issues that receive airtime in faculty meetings send a message about what is valued in the department. Departments can cultivate more transparency and accountability by more openly discussing faculty prioritization of responsibilities, advising styles, and research or dissertation expectations. Facilitating more transparent working relationships may also encourage faculty to have more direct communication when something is not working with an advisee.

Lastly, gathering more data and fostering a culture of feedback would provide valuable insights to faculty and departmental leaders on the culture and environment of their program, as well as the effectiveness of their efforts to support student persistence. One faculty member stated simply that, "we ought to have far better data on the students who don't complete." I also

suggest that having better data on how departmental environments and interactions with others affect students' psychological well-being can inform efforts to foster a productive research-environment that honors the well-being of faculty, staff, and students.

Conclusion

This study sought to better understand issues of doctoral student departure in computing. By specifically focusing on why students consider leaving their doctoral programs, I illuminate the supports and threats to students' persistence and the factors they consider when making decisions about whether to stay or leave their program. This present study makes several important contributions; most notably that it explores both student and faculty explanations for students' consideration of departure, as well as how faculty understand their role in students' experiences and outcomes.

Evidence from both students and faculty suggests that the department environment and relationships with others (e.g., faculty and peers) have a strong influence on students' persistence, particularly in shaping students' beliefs about themselves and their abilities. Specifically, I found that students attribute their consideration of departure to feeling isolated in their program, perceiving that faculty are not supportive, and feeling unwelcomed in the department. Students who felt a greater sense of belonging, or who perceived that the department is supportive, or were more satisfied with their advisor were less likely to think about leaving their program. Faculty also identified poor advisor fit as a contributor to students' consideration of departure, which is a noteworthy difference from prior literature (e.g., Gardner, 2009b; Gilmore et al., 2016) in which faculty commonly did not see their role in student attrition. Other faculty explanations focused on students' dispositions and behaviors, particularly in relation to the pursuit of industry opportunities and how they handle intellectual and psychosocial

challenges in graduate school. Faculty members identified the essential role they have in providing academic and career guidance, as well as psychosocial support to students as they navigate challenges to become independent researchers.

The training of doctoral students to become independent researchers represents a critical investment in expanding institutional and disciplinary pursuit of knowledge. Thus, doctoral student attrition compromises the advancement of science, as the perspectives and research potential of students who choose to leave are lost. Given what we now know about environmental threats that may cause students to consider leaving their program – most notably the salience and extent of supportive environments and relationships with others in the department – this study revealed opportunities for intervention, support, or organizational change. However, in order to ensure that those students who do want to complete their computing doctoral degree can successfully do so – which has broader implications for the faculty pipeline and diversity in the computing industry – computing faculty and departments must also challenge their deficit views on student struggles and examine systemic issues in doctoral education.

APPENDICES

Appendix A: 2018 Data Buddies Graduate Student Survey Instrument

Data Buddies Survey
Updated on 10/16/2018

Data Buddies Survey (Graduate Version)

Welcome to the Computing Research Association's Annual Survey for Students in Computing! In this survey, you will be asked about your experiences as a student, as well as your future plans and goals. This survey should take no more than 20 minutes of your time. For accessibility purposes, we recommend using either Chrome or Firefox web browsers for this survey.

1. Are you currently a student?
   - Yes, I am currently an undergraduate student [If selected, route for undergraduate student survey]
   - Yes, I am currently a graduate student
   - No, I am not currently a student [If selected, route to exit survey]

2. Please select the institution that you are currently attending from the list below. If you do not see your institution on the list, scroll to the bottom of the list and select 'Other'.
   - [List of institutions]

3. Before you begin, please read our consent form, which you may download for your records. [Consent form linked in-text]

4. After reading the consent form, please indicate whether or not or you wish to complete the survey. If you have any questions about this research, the study, or your participation, please email cerp@cra.org.
   - Yes, I have read the consent form and wish to complete the survey.
   - No, I have read the consent form and DO NOT wish to complete the survey.
   - I have already completed this survey THIS SEMESTER. (The CRA contacted me directly last month to complete this same survey.)

ACADEMIC BACKGROUND

5. Which of the following experiences did you have prior to entering college? Select all that apply.
   - Took an AP/Dual enrollment computer science course
   - Learned a computer programming language
   - Engaged in software or hardware related projects
   - Took part in student groups related to computing
   - Completed an online course related to computing (e.g., MOOC)

Attended a workshop or other training in computing (e.g., through your local library, community center, etc.)

6. Which of the following mathematics courses did you take prior to entering college? Select all that apply.
Algebra
Pre-calculus
Calculus
Statistics

7. What was your undergraduate major in college? If you were a double major, use the next drop-down menu to indicate your second major. If you did not have a second major, simply leave that item blank. If you have more than one undergraduate degree, answer these questions for the most recent one.
[List of majors 1]
[List of majors 2]

8. In which year did you earn your undergraduate degree?
[Drop down list of years]

9. At which institution did you earn your undergraduate degree? If you do not see your institution on the list, scroll to the bottom of the list and select 'Other'.
[List of institutions]

10. Which of the following applies to you? Select all that apply.
I temporarily withdrew from my current institution.
I have taken courses for credit at a community college.
I have completed a degree/certification at a community college.

11. What year did you first enter your first/current institution? [Asked twice]
2018
2017
2016
2015
2014
2013
2012
2011
2010 or earlier

12. In what year do you expect to complete your current degree? If you aren't sure, pick the year that seems most likely.
2018
2019
2020
2021

2022
2023
2024
2025
Later than 2025; please specify: _____

13. How are you funding your education? Please select all that apply.
Federal student loans
Private student loans
Credit (e.g., personal loans, credit cards, etc.)
Personal savings
Scholarship, fellowship, grant, or other aid (e.g., merit, need, skill, demographics based; Fulbright; state-funded financial aid programs; etc.)
Research assistantship
Teaching assistantship
Full-time work
Part-time work
Employer support (e.g., vocational rehabilitation, tuition benefits, etc.)
Military/Veterans benefits/assistance
Family support (e.g., spouse/partner, parents, etc.)
Other

14. Have you experienced any economic hardships during your college education that made you consider, or led you to, a leave of absence?
Yes
No

15. In what type of degree program are you currently enrolled?
Joint Bachelor's/Master's
Terminal Master's (will graduate and finish with a Master's degree)
Master's program that is on route to a PhD
Doctoral program
I am not earning a degree (e.g., certificate program, taking a course, etc.)

16. Is your program primarily an online program?
Yes
No

[If Yes is Selected]
17. Why did you enroll in an online program? Choose up to 3 responses.
I wanted to take course at my own pace
Online programs have lower costs
I have a job and I wanted to continue working while getting an education
I have family responsibilities
The program I was interested in was only available online
I did not want to relocate and/or commute

Another reason; please specify:

[If Master's program]

18. Will you complete a Master's thesis?
    Yes
    No; no thesis option is available
    No; a thesis option is available, but I chose to not do it
    I have not decided yet

[If Doctoral]

19. Prior to entering your doctoral program, did you complete a terminal Master's program?
    Yes
    No

20. What made you decide to pursue a doctoral program after completing a terminal Master's degree?
    [text response]

21. What is your current status?
    Full-time student
    Part-time student
    Non-degree earning student

22. Is your graduate program in a computing field? Computing field includes the fields below and other similar fields:
    Computer Science, Computer Engineering, Software Engineering, Electrical and Computer Engineering, Systems Engineering, Computer Hardware Engineering, Computing Information Systems, Information Systems, Information Science, Informatics, Bioinformatics, Cybersecurity, Data Science, Machine Learning, Robotics, High Performance Computing, Human-Computer Interaction, Computational Science/Social Science, Computational Biology, Computational Economics, Computational Mathematics, etc.

    Yes; please specify your degree program field: _____
    No; please specify your degree program field: _____

23. What is your current or expected specialty area(s)? Please avoid using acronyms.
    [text response]

24. Why did you choose your degree program? Choose up to 3 responses.
    I like learning about this field
    The courses required of this program are interesting
    The program will allow me to make an impact on society
    The job market for this field is promising
    I want to pursue research in this field
    This program will enable me to make a lot of money

I will be successful completing the coursework required of this program
My friends are enrolled in this program
I aspire to make a difference in this field
Professors/faculty at my institution influenced my decision
My family influenced my decision
Another reason. Please specify:

25. How committed are you to completing your current degree program?
Not at all
A little
A moderate amount
Quite a bit
Extremely

[If not in a computing degree program]
26. Based on your responses, you are not in a computing-related degree program. Have you ever been in a computing related degree program?
Yes
No

27. Why did you leave computing, or choose a program not related to computing? Choose up to 3 responses.
The courses are too difficult
The math requirements are too hard
I am not interested in learning about computing and technology
I do not have any friends there
The professors are not supportive
The program makes me feel isolated
The department does not make me feel welcome
I do not like the course material
My non-computing program aligns with my future career goals better
Too many people pursue computing
I do not meet the eligibility requirements
Computing is not a valuable career
Another reason. Please tell us below:

[If Yes or No is Selected]
28. This survey is targeted towards students who are in computing degree programs. However, if you have completed computing-related coursework, our survey questions are relevant to you. Have you completed any computing-related coursework?
Yes
No [proceed with raffle incentive, follow-up permission block, and end survey]

29. During your academic career, have you ever seriously considered leaving your graduate program prior to completing your degree?
Yes

No

[If Yes is Selected]

30. Why did you consider leaving? Choose up to 3 responses.

The courses were difficult
The math requirements were too hard
I did not like the course material
I was having trouble passes my courses
I did not have any friends in the major
The professors were not supportive
I felt isolated in my program
The department did not make me feel welcome
I experienced health issues that inhibited my ability to feel/be successful
I had other issues not listed above. (If you would like to elaborate, please tell us below.)

31. What helped you continue in your program when you were contemplating leaving? Choose up to 3 responses.

My family encouraged/supported me
My friends encouraged/supported me
Professors/faculty encouraged/supported me
I had already invested too much time and resources
I liked the field of study
The job market is promising
I had other issues not listed above. (If you would like to elaborate, please tell us below.)

HIGHEST DEGREE INTENTIONS

32. What is the highest degree you plan to attain?

Associate's degree
Bachelor's degree
Master's degree
Doctoral degree

33. In which field do you plan to attain that degree? Please select all that apply.

Computer Science
Computer Engineering or Electrical and Computer Engineering
Computing Information Systems or Information Systems
Other computing field; please specify:
Math/Applied Math
Business or Law
Life/Health Sciences
Arts or Humanities (including Fine Arts)
Social Science
Education
Interdisciplinary, please specify areas:
Other (non-computing); please specify:

Uncertain

CAREER VALUES

34. How important to you is it that your future career allows you to do each of the following?
(Not at all; A little; A moderate amount; Quite a bit; Very much)

- Make a lot of money
- Work independently
- Work collaboratively
- Spend a lot of time with my family and friends
- Have a social impact
- Have a flexible work schedule
- Make important decisions at work
- Be a role model
- Become well-known in my field
- Help others

35. In your opinion, to what extent would a career in computing allow you to do the following....
(Not at all; A little; A moderate amount; Quite a bit; Very much)

- Serve humanity
- Be in a position of influence in society
- Spend time with family

36. Please indicate the extent to which you disagree or agree with the following statements.
(Strongly disagree; Disagree; Neither agree nor disagree; Agree; Strongly agree)

- People have a certain amount of ability to learn computing, and they really can't do much to change it
- Anyone has the ability to learn computing and be good at it

BELONGING AND IDENTIFICATION

37. How much do you agree or disagree with the following statements?
(Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree)

- I see myself as a "computing person"
- I feel like I "belong" in computing
- I feel like an outsider in computing
- Computing is a big part of who I am
- I feel welcomed in computing
- I do not have much in common with the other students in my computing classes

SELF EFFICACY

38. I am confident that I can...
(Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree)

- clearly communicate technical problems and solutions to a range of audiences.
- articulate thoughtful answers to questions about my work during a presentation.
- successfully teach a course in my field.
- be an effective mentor.

39. I am confident that I can...
(Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree)

- discuss my work with senior members of my field.
- complete my graduate computing program. [Not displayed to non-degree earning students.]
- find employment in my area of interest.
- be a capable researcher in computing.
- become an expert in my field.
- publish in the top journals in my field.

CAREER INTERESTS

40. How interested are you in having the types of jobs listed below after you finish your highest degree?
(Very uninterested; Somewhat uninterested; Neither uninterested nor interested; Somewhat interested; Very interested)

- College/University professor in computing field (teaching focused)
- College/University professor in computing field (research focused)
- K-12 computing teacher
- Computing researcher in industry
- Computing researcher in a government lab or agency
- A non-research computing position in industry (e.g., software engineer)
- Entrepreneur (computing related; e.g., individual contractor; build a start-up)
- Non-computing career

If there is another type of computing job in which you are interested, please list that job below.
[text response]

SATISFACTION WITH AND THOUGHTS ABOUT CURRENT INSTITUTION, DEPARTMENT, COURSES

41. Please indicate the extent to which you disagree or agree with the following statement.
(Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree)

- Overall, I am satisfied with the computing program at my institution.

42. How do you feel about the computing courses you have taken at your current institution?
(Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree)

- I would recommend taking computing courses at my institution to a friend.

- The number of students in my computing classes is too large.
- I am satisfied with the technical content of the computing courses.
- The computing courses at my institution are too difficult.

43. How dissatisfied or satisfied are you with the following aspects of the computing program at your institution?
(Very dissatisfied; Somewhat dissatisfied; Neither dissatisfied nor satisfied; Somewhat satisfied; Very satisfied)

- The variety of computing courses offered
- Access to academic resources needed to do your work
- The availability of professors outside of class (e.g., office hours, answering questions via email, etc.)
- How well the program has prepared you for your future career
- The workload expected of you

44. How do you feel about the environment of the department of your computing program?
(Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree)

- I feel a sense of community in the computing department.
- The department cares about its students.
- People in the department tend to attribute my success to special treatment or luck rather than my competence.
- The environment in the computing department inspires me to do the best job that I can.
- The department is not very supportive of students.
- My ideas or opinions are minimized or ignored.
- Computer science administrators (e.g., the department chair, dean, staff) and faculty care about diversity.

45. How often to you receive the following from other students if you need it?
(Never; Sometimes; About half the time; Most of the time; All of the time)

- Help and support
- Willingness to listen to issues you are having at school
- Feedback about your work

46. Please provide any additional comments you have about your experiences in the computing department.

[text response]

ADVISOR AND MENTOR SUPPORT

47. An academic advisor is an individual, or group of people, that is responsible for helping you manage the requirements of your degree program and giving academic advice.

Do you have access to one or more academic advisors? Select all that apply.

Yes, I have an academic advisor(s) affiliated with the computing department.
Yes, I have an academic advisor(s) affiliated with another department

No, I do not have an advisor yet

[If Yes is Selected]
48. How dissatisfied or satisfied are you with the following?
(Very dissatisfied; Somewhat dissatisfied; Neither dissatisfied nor satisfied; Somewhat satisfied; Very satisfied

- How often you meet with your advisor(s)
- The academic guidance your advisor(s) provides
- The career advice your advisor(s) provides

49. A mentor is someone with whom you have an ongoing relationship, and who provides you with advice and assistance in advancing in your career.

To what extent do you have a mentor who…
(Not at all; A little; A moderate amount; Quite a bit; Very much)

- helps you improve your skills?
- shows compassion for any issues you discussed with them?
- shares personal experiences as an alternative perspective to your problems?
- explores career options with you?
- encourages you to do the best you can in your coursework?
- supports your research ideas?

50. Among the people below, who do you consider to be a mentor? Select all that apply.

My advisor
A professor within my department (not my advisor)
A professor outside of my department
A Director or administrative faculty
A graduate student (e.g., graduate teaching/research assistant, graduate student mentor)
Someone I met at a conference or mentoring program sponsored (or other professional activity)
A family member/partner, friend, pastor, or someone else with whom I have a personal relationship
A co-worker, supervisor, or someone else with whom I have a professional relationship
Someone else
No one

ACTIVITIES

51. The next three sets of questions ask you about your involvement in various activities. For each activity set, answer the following question:

How often have you been involved in each of the following groups or activities?
(Never; Once; Two or three times; Four or more times)

Activity set 1

- Visiting lectures related to computing

• Mentored students
• Taught courses
• Led an independent research project
• Received study support in computing (e.g. received tutoring; supplemental Instruction [SI])
• Provided study support in computing (e.g. provided tutoring; supplemental Instruction [SI])
• Internships related to computing

Activity set 2
• Computing-related contests (e.g., Hackathons, robotics competitions, programming competitions, etc.)
• Computing-related online social networking (listservs, etc.)
• Outreach to K-12 students related to computing
• Independent computing projects (e.g., tinkering and technical skill building outside of your coursework)
• Entrepreneurial or consulting projects (e.g., tech start-ups, client services, etc.)

Activity set 3
• Computing-related student groups (e.g., technical organizations on campus, ACM student chapters, etc.)
• Professional societies related to computing
• Technical/academic conferences related to computing
• Career mentoring programs or workshops
• Trainings or workshops in computing (other than conferences)
• Summer institutes or short courses related to computing (other than summer research programs) (e.g., Google for Education Computer Science Summer Institute, online courses/MOOCs, etc.)

52. Do (or did) you have a leadership role in any of your computing-related student groups?
Yes
No

53. Do (or did) you have a leadership role in any of the conferences or workshops in which you were involved?
Yes
No

54. During your academic career to date, have you participated in any of the following conferences or programs? Select all that apply.
ACM Richard Tapia Celebration of Diversity in Computing
ACM Programming Languages Mentoring Workshops (PLMW)
CRA-W Virtual Town Hall Meetings
CRA-W Early-career Mentoring Workshops
CRA-W Grad Cohort for Women
CRA Grad Cohort for Underrepresented Minorities + Persons with Disabilities

Discipline-Specific Workshops sponsored by the CRA-W
Grace Hopper Celebration of Women in Computing
Residential/Living Learning Community on campus
Local events related to diversity in computing

[If CRA-W Virtual Town Hall Meetings is Selected]
55. How did you participate in the CRA-W Virtual Town Hall Meetings? Select all that apply.
I watched the meeting during the live event
I watched the meeting after the live event (e.g., watched it from the CRA-W website)
My mistake, I actually did not participate in a CRA-W Virtual Town Hall Meeting

[If Grace Hopper Celebration of Women in Computing is Selected]
56. Which years did you participate in the Grace Hopper Celebration of Women in Computing conference? Select all that apply.
2018
2017
2016
2015 or earlier

[If CRA-W Grad Cohort for Women is Selected]
57. Which years did you participate in the CRA-W Grad Cohort for Women workshop? Select all that apply.
2018
2017
2016
2015
2014
2013
2012 or earlier

[If CRA-W Early-career Mentoring Workshop is Selected]
58. Which years did you participate in the CRA-W Early-career Mentoring Workshop? Select all that apply.
2018
2017
2016
2015
2014
2013
2012 or earlier

SKILLS PROFICIENCY

59. The next three sets of questions ask you about your level of proficiency (how skilled you are) in various aspects of your life. Please rate the degree of your proficiency (how skilled you are) in the following items:

(Highly deficient; Deficient; Average; Proficient; Highly proficient)

Relationship-related items
- Mentoring others
- Building/maintaining a professional network
- Dealing with conflict
- Providing constructive feedback

Work-related items
- Time management
- Speaking clearly and effectively
- Presenting research to technical audiences
- Presenting research to non-technical audiences
- Planning and organizing projects
- Obtaining funding for research
- Teaching in a classroom setting
- Writing scientific papers for publication
- Writing for non-technical audiences

Career-preparation items
- Identifying career options
- Preparing job application materials
- Interviewing techniques

60. Have you had any of the following professional experiences during your graduate training? Select all that apply.

First author on a journal publication
Co-author on a journal publication (not first author)
First author on a refereed conference paper
Co-author on a refereed conference paper (not first author)
First author on a non-refereed conference paper
Co-author on a non-refereed conference paper (not first author)
First author on a paper or presentation currently in progress
Co-author on a paper or presentation currently in progress (not first author)

[If any experience above is selected]
61. Please indicate how many of the following professional experiences you have had during your graduate training:
[displays only experiences selected above]

— First author on a journal publication
— Co-author on a journal publication (not first author)
— First author on a refereed conference paper
— Co-author on a refereed conference paper (not first author)
— First author on a non-refereed conference paper
— Co-author on a non-refereed conference paper (not first author)

— First author on a paper or presentation currently in progress
— Co-author on a paper or presentation currently in progress (not first author)

GPA AND TEST SCORES

62. Does your institution offer a GPA greater than 4.0?
Yes
No
I don't know

63. Did you take the GRE?
Yes, I took the GRE before August 2011
Yes, I took the GRE after August 2011
No, I did not take the GRE

[If Response is provided to Q61]
64. Please tell us your GPA below using numerical values. If you do not know your GPA, simply leave the space blank.
Overall GPA: _____

[If Yes is Selected to Q62]
65. Please provide us with your GRE scores using numerical values. If you do not know your scores, simply leave the space blank.
Total score: _____
Quantitative score: _____
Verbal score: _____

DEMOGRAPHICS

Thank you for answering all of those questions!
This last section asks about your demographic details and should go by quickly.

Why should you provide demographic details?
• People experience things in different ways, and these details help us understand who and why.
• Demographics help us accurately represent people from different backgrounds and experiences.

Remember, no information will be connected to you as an individual. All responses you provide are kept completely confidential. If you prefer not to answer a given question, simply skip that question.

66. What is your gender identity?
Man
Woman
Gender-queer/non-conforming

Something else

67. Are you transgender?
Yes
No

68. What is your race/ethnicity? Please select all that apply.
African American/African/Black
American Indian/Alaska Native
Arab/Middle Eastern
Caribbean/Puerto Rican
Caucasian/European/White
East Asian (e.g., Chinese, Japanese, Korean)
Southeast Asian (e.g., Cambodian, Vietnamese, Hmong, Filipino)
South Asian (e.g., Indian, Pakistani, Nepalese, Sri Lankan)
Other Asian
Mexican American/Chicano
Native Hawaiian/Pacific Islander
Other Hispanic/Latino
Something else: _____

69. What is your citizenship status?
U.S. citizen or permanent resident (includes dual-citizenship)
Non-U.S. citizen with temporary visa
Other non-U.S. citizen

[If non-citizen options are selected]
70. Of which country are you a citizen?
[Drop down list of countries]

71. In which year were you born?
[Drop down list of years]

72. Which of the following best describes your sexual orientation?
Heterosexual
Homosexual
Bisexual
Something else

73. Do you have any type of disability (e.g., physical, learning, mental, etc.)?
Yes
No

[If yes]
74. What type of disability do you have? Select all that apply.
Auditory Disability (e.g., deaf, hard of hearing, etc.)

Intellectual Disability (e.g., Autism, Down syndrome, etc.)
Mental Illness (e.g., ADHD, PTSD, anxiety, depression, etc.)
Mobility or Orthopedic Disability (e.g., paralysis, spinal disability, etc.)
Specific Learning Disability (e.g., dyslexia, dysgraphia, etc.)
Speech or Language Disorder (e.g., dysarthria, stuttering, etc.)
Visual Disability (e.g., blindness, corneal opacities, etc. [Does NOT include far/near sightedness])
Something else

75. What is your marital status?
Married/Domestic Partnership
Divorced/Separated
Widowed
Never married

76. Are you a primary caregiver to any children? A primary caregiver is the person most responsible for childcare.
Yes, I am a primary caregiver.
No, I do not have any children who need caregiving.
No, my partner/spouse or other family member is the primary caregiver.
No, I share caregiver responsibility equally with my partner/spouse or other family member.

77. Are you a primary caregiver to any family members who are not children (e.g., parents, grandparents)? A primary caregiver is the person most responsible for caregiving.
Yes, I am a primary caregiver.
No, I do not have any adult family members who need caregiving.
No, my partner/spouse or other family member is the primary caregiver.
No, I share caregiver responsibility equally with my partner/spouse or other family member.

78. What is the highest level of education attained by your any of your parent(s)/guardian(s)?
Less than high school
High school graduate or GED
Some college (no degree earned)
Associate's degree
Bachelor's degree
Master's degree
Doctoral degree
I don't know

79. Do any of your parent(s)/guardian(s) currently have, or have held, a career related to the following fields:
• Computer science/Information Technology
• Engineering
• Mathematics

• Any other STEM field (Science, Technology, Engineering, Math)

Yes
No
I don't know

80. Growing up, what do you think your family's socioeconomic status was?
Poor
Below average/Lower middle class
Average/Middle class
Above average/Upper middle class
Wealthy

81. What is your best estimate of your family's total income last year? Please select one.
[Drop down list of income ranges, with "I don't know" as last option]

Survey Incentive

If you are interested in being entered in a raffle to win a $100 gift card to Amazon, please provide your email address. The email you provide will only be used to contact you if your name is drawn for the prize; it will not be used for any other purpose.

Email address: _____

Volunteer for Future Surveys
We would like to follow up with you in the future regarding your career progression. You would receive an online survey similar to this one. If you would like to participate, please provide us with your email address so that we can contact you in the future. Your participation will help inform the computing community about how people make decisions regarding computing careers.

For information on how we will protect your privacy, please read our privacy policy.
[Privacy policy linked in-text].

We would prefer a primary email address and a secondary email address as a backup.
Primary email address that you expect to stay active long-term:
_____

Secondary email address: _____

Appendix B: Faculty Demographic Survey

Name (first, last): _____

Institution: _____

Email: _____

What is your present academic rank?

- Professor
- Associate professor
- Assistant professor
- Lecturer
- Instructor
- Graduate student/teaching assistant

What is your tenure status at your current institution?

- Tenured
- On tenure-track, but not yet tenured
- Not on tenure track, but institution has a tenure system
- Institution has no tenure system

How many years have you been at your current institution? _____

In total, how many years have you served as a faculty member? _____

How many doctoral students do you currently advise? _____

Approximately how many doctoral students have you advised over the course of your faculty career? _____

How many courses do you teach per year? _____

What is your principal activity in your current position at this institution? (mark one)

- Administration
- Teaching
- Research
- Service
- Other

Please indicate your gender:

- Female
- Male
- Non-binary category or something else, please specify: _____

What is your race/ethnicity? Please select all that apply:

- White/Caucasian
- African American/Black
- American Indian/Alaska Native
- East Asian (e.g., Chinese, Japanese, Korean, Taiwanese)
- Southeast Asian (e.g., Cambodian, Vietnamese, Hmong, Filipino)
- South Asian (e.g., Indian, Pakistani, Nepalese, Sri Lankan)
- Other Asian
- Native Hawaiian/Pacific Islander
- Mexican American/Chicano
- Puerto Rican
- Other Latino
- Other

What is your citizenship status?

- U.S. citizen
- Non-U.S. citizen with permanent residency. Other country of residency: _____
- Non-U.S. citizen with temporary visa. Country of origin: _____
- Other: _____

Appendix C: Faculty Interview Protocol

Part 1 (10-15 minutes)
This interview will have two parts, the first will focus on your experiences as a doctoral student and as a faculty member in computing.

1. Please tell me about yourself and what led you to pursue a PhD in computing.
2. How would you describe your own doctoral journey? What obstacles or challenges did you face? What supports were most critical to your persistence?
    a. Optional probe for: relationship with advisors and peers, climate of graduate program (pay attention to what's an obstacle or challenge, how did folks contribute to or enhance your ability to get through the challenge)
3. Why did you pursue a faculty career? What parts of your job were you most excited about doing (related to research, teaching, and service) when you began, and how might that be different now?
    a. Currently, how do you prioritize what responsibilities get your attention?
    b. Probe for: the extent to which their interests/passions align with the demands of the institutional context
    c. Probe for: who motivated them to pursue a faculty career
4. What does it mean for you to be a successful faculty member? What kind of support do you receive, and from whom, to help you be successful?

Part 2 (45-50 minutes)
Much of the literature on the doctoral student journey focuses either on socialization or attrition. This study focuses on doctoral students' consideration of departure and your perceptions of it. Consideration of departure refers to the thinking about leaving, followed by actually making a decision to stay or leave.

1. When admitting students to the doctoral program at your institution, do you or your department generally expect most students to make it through?
2. How do you characterize your influence on the doctoral student *experience*? What level of influence or role do you have in shaping *outcomes* for doctoral students?
    a. Probe for: influence on individual students' graduate experiences compared to broader graduate policies and procedures in the program; level of autonomy; influence in designing curriculum or program milestones
    b. Influence in (a) instructor/in classroom; (b) mentoring and supporting research, (c) mentoring and supporting writing
    c. How does your role guide your interactions with students?
3. Why do you think students consider leaving before completing their degree?
    a. Share what students reported on the CERP survey and gather their interpretations or reactions to it. If applicable, ask what faculty make of the differences between their perceptions and what students report.
4. Think about a conversation you've had with a student who has thought about leaving. What were some of their challenges and considerations? Did you see any signs that the student was thinking of leaving (e.g., becoming antagonistic, flakey)?

    a. Alternate question (if they've never had this conversation): If you haven't, why do you think that might be? How do you indirectly know or find out about students who are thinking of leaving? What might your response be?
5. Are there any policies, processes, or milestones that you see as a key barrier for students that might contribute to their consideration of departure?
6. How/when is doctoral attrition discussed in your department (among whom, focus on individuals or groups)? To what is it attributed to?
    a. Do you, and to what extent does your department discuss student struggles?
7. What changes (pedagogical, programmatic, financial, etc.) do you think you and your department could make to help more students succeed in completing their PhD?
    a. Optional probe: to what extent do you think we need more grad students in computing? More degree earners?

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