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Tapping into the Leadership Conceptions of Undergraduate Women in Computing:

A Mixed-Methods Study

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

Doctor of Philosophy in Education

by

Jennifer M. Blaney

2018

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ABSTRACT OF THE DISSERTATION

Tapping into the Leadership Conceptions of Undergraduate Women in Computing:

A Mixed-Methods Study

by

Jennifer M. Blaney

Doctor of Philosophy in Education

University of California, Los Angeles, 2018

Professor Linda J. Sax, Chair

Despite the great advances women have made in higher education, women remain underrepresented in both leadership positions and the computing major. After college, women are underrepresented across technical careers and especially in leadership positions. This study contends with these gender inequities by focusing on gender and the leadership conceptions of undergraduates in computing.

This study draws from standpoint theory, undergraduate socialization, and leadership identity development theory and utilizes a mixed-methods design to explore gender differences in how students rate and develop their leadership confidence as well as the ways women conceptualize leadership and make meaning of their leadership experiences. More specifically, this study utilizes longitudinal data from computing majors and minors who completed a pretest

and follow-up survey as part of the BRAID Research project. Additionally, I conducted interviews with 12 women who were recruited from the larger quantitative sample.

Quantitative findings reveal gender inequities in how students conceptualize their leadership abilities, highlighting key family socialization agents, non-college experiences, and college environments that predict leadership outcomes. Additionally, qualitative findings reveal that women hold multifaceted but inconsistent definitions of leadership that reflect gender essentialist understandings of both leadership and the field of computing. Further, findings highlight the nature of how women experience sexism in group assignments. Taken together, these and other findings point to implications for future research on gender in STEM, theories of college student leadership development, and practices that may foster more equitable course environments that provide students with increased opportunities to develop their leadership and technical skills.

The dissertation of Jennifer M. Blaney is approved.

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Linda J. Sax, Committee Chair

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CHAPTER 1: INTRODUCTION

Women must be part of the design teams who are reshaping the world, if the reshaped world is to fit women as well as men. – Jane Margolis and Allan Fisher, Unlocking the Clubhouse

Background

In recent decades, women have made extraordinary progress in terms of their representation and achievements on college campuses. Women currently outpace men in terms of their college enrollment as well as measures of academic achievement (e.g., college GPA; degree attainment) (Conger & Long, 2010). Despite the great strides women have made in higher education, important gender gaps remain in several areas, most notably major and career choice as well as aspects of self-confidence (Sax, 2008). Further, women lag behind men in the area of leadership, remaining starkly underrepresented in student leadership positions (Miller & Kraus, 2004) and consistently underrating their leadership abilities (Sax, 2008).

This study links together these different concepts—major selection, self-rated abilities, and leadership—by focusing on conceptions of leadership among college women pursuing one traditionally male-dominated field: computer science. The computing field is an important focus of study in part because women remain sorely underrepresented in the computing major (NCES, 2016), and also because the computing and technology industry is sorely lacking in female leadership (ABI, 2016). Further, while prior research on women in computing has focused primarily on behavioral outcomes (e.g., representation and retention in the major), less is known about the factors that promote women's affective development, such as their leadership confidence.

This study uses a mixed-methods design to examine perceptions of leadership among undergraduate women and men pursuing a computing degree (i.e., computing majors and

minors). More specifically, the quantitative portion of this study examines gender differences in perceived leadership abilities both generally and in computing, as well as the college experiences that predict perceived leadership abilities for both women and men in undergraduate computing. Additionally, the qualitative portion of this study closely examines women's perceptions and meaning making of leadership in computing. More simply, the quantitative stream of this study examines the factors shaping college students' leadership confidence, while the qualitative portion of this study considers women's perceptions of their own leadership, as well as their broader perceptions of leadership in computing.

College Student Leadership

College student leadership has been a focus of higher education research for decades. Scholars have found that how students perceive their leadership abilities predicts a myriad of outcomes, including aspirations and motivation to lead after college (Chan & Drasgow, 2001). Given the importance of student leadership, a large body of higher education literature examines how students develop their leadership perceptions. At the center of this literature is Komives and colleague's (2006) Leadership Identity Development (LID) model, which contributes to the conceptual framing of the present work. Komives et al. identify several college experiences, including faculty and peer interactions that lead college students to develop their identity as a leader and their perceptions about leadership, which will be discussed in detail in Chapter 2.

Undergraduate women's leadership confidence, in particular, is important to understand because even as women have made major gains in terms of their representation in college, they still come to college with significantly lower perceptions of their leadership abilities than men, a gender gap that only grows larger during college (Sax, 2008). This study seeks to better understand this gender gap by examining the types of experiences that predict perceived

leadership abilities among women and men within the context of college computing. It is also important to note that the gender gap in college leadership extends beyond perceptions. In fact, while women make up the majority of participants in student organizations, they remain underrepresented in campus leadership roles compared to their male counterparts (Miller & Kraus, 2004).

Women's Representation in Computing

In addition to their underrepresentation in leadership positions on campus, women are also underrepresented in the computing major. Women today make up just 18% of bachelor's degree recipients in computing (NCES, 2016). Research reveals that the gender gap in computing participation emerges prior to college, as evidenced by the underrepresentation of girls among AP computer science test-takers (College Board, 2014), and the underrepresentation of women intending to major in computing at the start of college (Lehman, Sax, & Zimmerman, 2017). Furthermore, the gender gap in computing only increases after college, as women are more likely than their male counterparts to leave the field even after earning a degree (Hewlett et al., 2008).

Women's Leadership in Computing

At the same time that women are underrepresented in both computing and leadership on campus, leaders in the field of computing have become increasingly influential (Miles, 2002). Today, leaders of tech companies have the opportunity to influence politics and oversee the creation of technologies shaping our future (Stone, 2016). For example, tech companies may have influenced the 2016 presidential election in a myriad of ways including through financial support from high-level tech executives (e.g., Peter Thiel and Elon Musk). Similarly, some have argued that social media algorithms developed by tech companies privilege viral news content,

particularly false and polarizing stories, which may have negatively influenced political discourse and potentially shaped the outcome of the recent election (Solon, 2016). At the same time, there is a stark lack of diversity within these technology companies, and women remain severely underrepresented at all levels of leadership, especially in top leadership roles. For example, of the thirty individuals named on Forbes' (2013) recent list of the most influential people in tech, the women can be counted on one hand (Sheryl Sandberg, Marissa Mayer, Meg Whitman, and Virginia Rometty). Women's representation does not fare better across the spectrum of leadership positions. For example, even among companies recognized by the Anita Borg Institute (ABI) as the most progressive and supportive of women in technical and leadership roles, women made up only 34% of entry-level positions, 29% of mid-level positions, 25% of senior-level positions, and only 18% of executive roles. These findings indicate that even at the most supportive technology companies, women remain starkly underrepresented at all levels of leadership. Due to the significant power that computing and technology leaders hold, many have argued that colleges must work to build the pipeline of women leaders in computing in order to ensure that women's voices are heard in the advancement of future technologies and policies (e.g., Frieze & Quesenberry, 2015; Margolis & Fisher, 2002).

Additionally, women make up over half of today's college-going population. As such, they represent a large pool of talented individuals who can meet growing workforce demands. By understanding their perceptions of leadership during college, we may be able to increase the pipeline of diverse and talented leaders. Given workforce demands for talented managers and leaders with technical training in computing (Bailey & Stefaniak, 1999; Bresnahan, Brynjolfsson, & Hitt, 2000; Freeman & Aspray, 1999), the field would benefit from efforts to develop women's leadership perceptions and skills along with their technical computing skills.

Furthermore, developing leadership confidence among women pursuing computing degrees may be key to closing the larger gender gap in undergraduate computing. Specifically, by promoting women's leadership confidence, women pursuing undergraduate computing degrees may become more visible and influential in shaping the culture within their computing department and ultimately the computing workforce. Additionally, these women may become role models to their peers considering a computing degree or career. This is particularly important given that prior research also suggests that women role models play a key role in recruiting more women to computing (Cohoon, 2002).

Conceptual Framework

Several overarching theories provide a frame for this inquiry. Standpoint theory (Harding, 2004) frames the study design and approach to the qualitative analyses. Standpoint theory provides an approach to research that is framed in oppressed voices (e.g., women pursuing an undergraduate computing degree). The primary tenant of standpoint theory is that all research is socially situated, and the only way to be truly "objective" is to recognize the social forces that threaten objectivity (e.g., sexism) and make explicit the political values informing the research (e.g., feminism).

In addition to standpoint theory, two theories are synthesized to provide a frame for the variables included in this study. Namely, Komives et al.'s (2006) Leadership Identity Development (LID) model provides a frame for the types of college experiences that shape how students perceive their leadership. The LID model identifies the process by which college students develop their leadership identity, and highlights the role of adult interactions, peer interactions, and meaningful involvement in developing college student leadership. Similarly, Weidman's (1989) model of undergraduate socialization provides a frame for the types of non-

college socialization experiences that shape student development more broadly. Weidman's model identifies the different forces, both on and off the college campus, that shape a myriad of student outcomes. Of particular importance to this study, Weidman notes the importance of background characteristics, parental socialization, and non-college references (e.g., employment experiences). I use this model in conjunction with the LID model to frame the types of off-campus experiences that may shape how undergraduate women and men make meaning of their leadership in computing.

Purpose

Given the stark lack of research on gender and leadership among computing students, this study explores student perceptions about leadership within the computing context, focusing specifically on women's experiences. This study will examine how experiences during college shape computing majors' and minors' perceptions of leadership, both generally and in computing. While research and reform efforts in computing have largely focused on how to recruit and retain women in computing majors, less has been done to examine affective outcomes among women in undergraduate computing. By examining the leadership confidence gap among women and men computing students, this study contributes to our understanding of how to best support women in computing. Finally, this study considers undergraduate women's meaning making around leadership in computing to provide a more comprehensive view of how undergraduate women pursuing computing degrees think about leadership in their field. The following research questions frame this inquiry:

1. How do computing majors and minors rate their leadership abilities (both generally and in computing)?
 - a. How does this differ for women and men?

- b. Among the genders, does self-rated leadership ability differ by SES, race/ethnicity, parents' education, or computing majors versus minors?
2. What factors predict perceived leadership ability (both generally and in computing) among computing majors and minors, and how does this vary between women and men?
3. How do undergraduate women computing majors and minors make meaning of their leadership (both generally and in computing)?
 - a. How do they make meaning of their leadership skills and abilities?
 - b. How do they aspire to leadership?
 - c. How do they make meaning of their leadership experiences, if any?
4. How do undergraduate women computing majors and minors make meaning of leadership in computing?
 - a. What traits do they perceive computing and technology leaders as having? Do they think that they have those traits? Do they desire those traits?

Methods

This study uses a mixed-methods convergent triangulation design (Creswell, 2009). For the quantitative portion of this study, the primary outcomes of interest are 1) self-rated leadership ability and 2) self-rated leadership confidence in computing. To answer the first two research questions, the study relies on existing longitudinal survey data from the Building, Recruiting, and Inclusion, for Diversity (BRAID) research project, a study of 15 universities engaged in efforts to diversify their computing majors. Specifically, Analysis of Variance (ANOVA) and Bonferroni post-hoc tests were used to examine the first research question, which asks about how leadership perceptions vary by gender, with consideration of intragroup variation among the genders. Research question two asks about the experiences that predict changes in leadership

confidence among both women and men. To explore this research question, blocked linear regression was used with separate models for women and men to examine differential impacts by gender.

The qualitative stream of this research is framed in phenomenology. Specifically, I recruited women from the larger quantitative sample to participate in interviews focused on their meaning making around leadership in computing. Interview data was examined to explore the third and fourth research questions. Additionally, in accordance with a convergent triangulation approach to mixed-methods research, the qualitative and quantitative findings will be combined in the discussion of this study, and qualitative findings will be used to further interpret the quantitative findings.

Significance

Research

This study increases the knowledge base regarding how college students, and women in particular, are thinking about leadership in computing, an area of which very little is known. Additionally, findings from this study provide a better understanding of the factors that lead to increased leadership confidence among all students, and whether those factors depend on the student's gender. Thus, this study more broadly contributes to research on the differential impacts of college.

Additionally, the mixed-methods approach of this study provides insight into women's meaning making around leadership in computing. This is particularly important given that previous research on gender and confidence has assumed that self-rated confidence is a desired outcome. This study further examines this assumption by exploring how women make meaning of their leadership abilities and how they are thinking about leadership in computing more

broadly. Findings from this study provide a more nuanced framework for the vast body of literature that examines gender differences in confidence and self-rated abilities.

Theory

By testing aspects of Komives et al.'s (2006) LID model and Weidman's (1989) undergraduate socialization model, I examine the extent to which these theories are applicable to computing students. Thus, this study contributes to our theoretical understanding about how college student development might be unique to a particular major, in this case the male-dominated field of computer science. In addition to testing the utility of existing theories for computing undergraduates, this study also adds to our theoretical understanding of the conditional impacts of college. Specifically, I examine how the college experiences that lead women computing students to develop their leadership confidence compare to those that predict men's leadership confidence. While prior research has already examined this among students across all majors (e.g., Sax, 2008), this study adds to our theoretical understanding of the differential impact of college in the male-dominated context of computer science.

Practice

Practitioners have been working to increase women's representation in the computing major for decades. Most efforts to diversify computing have focused on recruiting and retaining women in the computing major. This study is unique in that, instead of focusing on recruitment and retention, I focus on an affective outcome – specifically, self-reported leadership confidence. This is important because the predictors of women's retention in computing may not be the same as the predictors of leadership confidence among women in computing. Therefore, findings from this study are relevant to practitioners seeking to support and build leadership confidence among undergraduate women pursuing a computing degree in addition to increasing their representation

in the field.

Outline of this Study

This study examines gender differences in perceived leadership confidence and the college experiences that predict leadership confidence among women and men. Additionally, women's meaning making of their leadership as well as their perceptions of leaders in the field of computing are explored. In this chapter, I have reviewed the purpose and significance of the present work. The next chapter will review the relevant literature and theories framing this study, and Chapter 3 will include a discussion of research methodologies, including details about the research questions, data sample, and analytic procedures. Chapters 4 and 5 will review the quantitative and qualitative research findings, respectively. Finally, Chapter 6 will bring the quantitative and qualitative findings together, focusing on implications for research, theory, and practice.

CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMEWORKS

The focus of this study is on gender and college student leadership development within the context of computing. More specifically, this study examines gender differences in leadership confidence among computing majors and minors with an emphasis on how women make meaning of leadership in computing. While little is known about women's leadership within college computing specifically, this chapter synthesizes literature from a variety of fields related to gender and leadership, higher education, the state of women in computing, feminist theory, and theory on college student development, providing a framework for the present work.

The first half of this chapter will review the relevant literature including a discussion of the gender gap in computing and leadership, highlighting the state of women in computing, research on women in leadership studies, and what is known more specifically about women's leadership within higher education, STEM, and computing in particular. This discussion will highlight several gaps in the current literature, some of which will be addressed by the present study. The second half of the chapter will draw upon three theories to provide a conceptual framing for the study. Namely, feminist standpoint theory (Harding, 2004), Komives and colleague's (2006) Leadership Identity Development (LID) model, and Weidman's (1989) model of Undergraduate Socialization each inform the present work. Finally, this chapter will conclude with a summary of the literature and theoretical framework and a preview of the methodology, which will be reviewed in more detail in Chapter 3.

Part I: Literature Review

The State of Women in Computing

It is important to consider undergraduate women's perceptions of leadership in computing within the larger context of their representation in the field. While women's

representation in STEM has been steadily increasing over time (Rosser, 2012), they remain underrepresented in computing, and this gender gap has increased over the last few decades. While women made up over 30% of computer science degree recipients in the 1980s, women represented only 18% those earning computer science degrees in 2016 (NCES, 2017). Given that prior research reveals that women face the greatest obstacles to leadership when they are in male-dominated fields (Eagly & Carli, 2007), women's underrepresentation in computing likely shapes how women make meaning of their leadership as they pursue their degree in computing.

Due to women's lack of representation in the computing major, broadening women's participation in computing has been a focus of recent research. The majority of this work has examined behavioral outcomes, focusing on recruitment and retention in the major. At the same time, very little work has examined affective outcomes for women in computing (e.g., their perceptions of leadership in the field). This lack of research is concerning given that the gender gap in undergraduate computing will only be bridged when women reach parity in terms of their support and wellbeing in addition to their representation in the major. Still, the broader literature on recruitment, retention, and graduation rates for women in computing provides some context for the environment in which women develop their perceptions of leadership in computing. This literature has focused primarily on the impact of precollege experiences, college experiences, and the larger computing culture. These three areas are discussed below as they relate to the present work.

Precollege experiences. Compared to men, women enter college with less prior exposure to programming (College Board, 2014; Margolis, Fisher, & Miller 2000; Sax, Lehman, and Blaney, 2016) and different socialization experiences related to computers (Frieze & Quesenberry, 2015; Margolis & Fisher, 2002). Research reveals that these precollege

experiences are key to developing a student's initial interest in a computing major (Margolis et al., 2000). However, less is known about how these precollege experiences might shape undergraduate women's perceptions of leadership in computing.

College experiences. Other research on women's representation in the computing major considers the impact of college experiences. For example, faculty interactions are associated with intention to major in computing (Barker, McDowell, & Kalahar, 2009; Cuny & Aspray, 2002). At the same time, research reveals that women may be deterred from the computing major when they see that their classmates are predominately male and that they are one of only a few women in their computing classes (Margolis, et al., 2000). While little is known about how faculty and peer interactions may shape women's perceptions of leadership in computing, this research is especially important to consider alongside research on the role of peers and faculty in college student leadership development, which is discussed later in this chapter.

Computing community. Faculty and peer interactions also contribute, in part, to the larger culture of computing and technology that shapes women's representation in the computing major and may shape their perceptions of leadership. Research has found that many computing departments maintain a "brogrammer" culture that is too often hostile toward women (Kumar, 2014). Beyond the culture at the departmental level, the larger culture of computing shapes women's experiences both during and after college. Ensmenger (2010) argued that the culture in computer science has become increasingly masculine, which has led to a decline in women's representation in the field. As women are considering their major and career choice, they may question whether they will be able to find a supportive career in the field of computing (Scragg & Smith, 1998). Thus, the larger computing culture and a fear of sexist and hostile work environments may deter women from the computing major. Further, even when women are

retained in the computing major, their perceptions about leadership may be shaped by the gender gap in the broader field of computing. Specifically, research reveals that women in computing and technology careers are underrepresented at all levels of leadership, but especially at the senior- and executive-level where they make up just 25% and 18% of the workforce, respectively (ABI, 2016). Furthermore, women in computing careers face a variety of obstacles related to discriminatory practices and a hostile culture that may inhibit their advancement in the field (Teague, 2002) or lead them to leave their career altogether (Hewlett et al., 2008). Prior research has not yet examined how these aspects of the broader computing community might shape undergraduate women's perceptions of leadership.

The State of Women in Leadership

Beyond the numerical representation of women in computing leadership noted above, very little is known about women's leadership within computing and technology. Even Facebook COO Sheryl Sandberg's (2013) much-publicized book *Lean In* focuses more on leadership among women in business and other fields more generally than in the tech sector specifically. Certainly, much can be learned from the larger literature on gender and leadership across fields. The next section reviews early approaches to studying leadership and how that early work has shaped the way researchers have considered gender in studies of leadership over time. This section will also review literature related to leadership specifically among college students.

Historical approaches to gender and leadership studies. The present work examines women's perceptions of leadership, and therefore it is important to situate this work in the larger context of how scholars have examined gender in leadership studies. Historically, research on leadership has focused on examining strategies of effective leadership without a specific focus on diversity or inclusion. Early work focused on personality traits that predict and influence

leadership. Perhaps the most popular modern example of this *trait* approach to leadership studies is the identification of the “Big Five” model and its connection to leadership effectiveness. This model identifies the five most influential traits (i.e., openness, conscientiousness, extraversion, agreeableness, and neuroticism) that shape personality and, as some researchers posit, leadership emergence and effectiveness (Judge, Colbert, & Iles, 2004). Over the years, scholars began to also consider contexts in understanding leadership, often still emphasizing the traits and characteristics of leaders. One of the earliest examples of this is Fielder’s (1967) theory of leadership effectiveness, which identifies two personality types or orientations that shape leader effectiveness in different leadership contexts: task-orientation and people-orientation (i.e., task-oriented people are more effective in certain contexts, and people-oriented individuals are more effective in other contexts). While many scholars have since developed more complex theories to understand leadership, Fielder was influential in advancing a tradition of studying personality traits and also considering contexts as a way of understanding leadership and leadership effectiveness, which has been particularly impactful as scholars began to consider the role of gender in leadership.

When researchers began to consider gender in studies of leadership, they built on the approach established largely by Fielder (1967) and earlier work on leadership traits, now considering gender. Thus, early research on gender and leadership focuses primarily on women and men’s different orientations toward leadership (i.e., trait approach) and how that shapes their abilities to lead effectively in a variety of contexts (i.e., context approach). For example, researchers have examined gender differences in the “Big Five” model of personality traits (listed above), finding only marginal gender differences (Costa, et al., 2001). Other scholars have examined gender differences in leadership approaches and behaviors (as opposed to personality

traits). For example, research suggests that women, on average, tend to take on more democratic and less autocratic approaches to leadership compared to their male counterparts (Eagly & Johnson, 1990). It is important to note that modest gender differences in leadership behaviors only provide information about averages and are not reflective of all individuals' experiences.

Despite some research revealing moderate gender differences in approaches to leadership, there is no indication that those gender differences impact leadership effectiveness (Eagly, Karau, & Makhijauni, 1995; Gastil, 1994). In other words, both women and men are capable of effective leadership. In fact, in the mid-1990s, Eagly, Karau, & Makhijani (1995) conducted a meta-analysis on gender and leadership effectiveness, finding that women and men were equally effective leaders. Perhaps as a result of the vast amount of research finding no significant differences in effectiveness between the genders (e.g., Eagly, et al., 1995), recent research on gender and leadership has taken on a more feminist perspective, which is in line with the present study. Many scholars have also come to view the role of gender differently, recognizing the fluidity of gender and viewing it as a construct that is not a primary determinant of leadership capacity. Furthermore, there is recognition that leadership approaches vary within the genders in addition to between the genders. As a result of these shifts, the focus of recent work has been on how to develop and encourage leadership among all individuals, and women in particular, given their underrepresentation in leadership roles.

In this vein, Eagly and Carli (2007) published their now seminal work on how women navigate a complicated “labyrinth” to become leaders. Eagly and Carli examine the state of women in leadership roles across fields and the ways in which organizations create challenges to women's leadership. Some of these barriers highlighted by Eagly and Carli include discrimination and implicit bias, family obligations, and hostile work environments. Similarly, in

efforts to understand and remove barriers to women's leadership and increase the pipeline for women leaders, other scholars have examined gender with regard to affective aspects of leadership, including leadership identity, self-confidence (e.g., Kolb, 1999), self-efficacy (e.g., Sloma-Williams, McDade, Richman, & Morahan, 2009), and aspirations (e.g., Davies, Spencer, & Steele, 2005). This approach to examining the affective components of leadership has been prominent within the context of leadership in higher education and is discussed in the section below on student leadership.

Related to work that examines the barriers to women's leadership, some research on gender and leadership also considers gendered social constructions of leadership. For example, prior research reveals that the agentic traits associated with leaders (e.g., power, ambition, assertiveness, etc.) are more commonly associated with men (Eagly & Johannesen-Schmidt, 2001). Furthermore, when women exercise leadership, they are more likely to experience discrimination and backlash; this is due, in large part, to the fact that women are traditionally expected to possess more communal attributes (e.g., helpful, caring, nurturing, etc.) (Rudman & Glick, 2001). This literature is relevant to the present work, as this study examines women's perceptions of leadership in the field of computing in addition to their perceptions of their own leadership abilities.

Higher Education and Student Leadership Development

Given that this study focuses on how women and men computing majors and minors perceive their leadership abilities, it is important to examine the literature on leadership more specifically within the higher education context. While no research within higher education has examined the impact of college on perceived leadership in computing and technology, there is a large body of literature related to leadership development in higher education more generally.

Much of this research has focused on developing leadership identity and social orientations toward leadership among college students. Specifically, Komives and colleague's (2006) Leadership Identity Development (LID) model (discussed at length in the theoretical section of this chapter) and Dugan and Komives's (2010) work on socially responsible leadership capacity (i.e., one's capacity to approach leadership in a way that prioritizes social justice and shared power), have shaped our understanding of leadership within higher education. This research has revealed the types of experiences that matter in developing college students' leadership, which are reviewed below.

Faculty interactions. Earlier in this chapter, faculty interactions were discussed in relation to women's retention in computing. It is also well documented that faculty interactions are positively associated with self-rated leadership ability among college students (Astin, 1993; Kezar & Moriarty, 2000; Pascarella & Terenzini, 1991). Even more relevant to this study, student-faculty interactions are key in shaping how students develop their identity as leaders (Komives et al., 2006). Furthermore, in Dugan and Komives's (2010) study of the college experiences that predict socially responsible leadership capacity, faculty mentorship was one of the strongest and most consistent predictors of students' capacity for socially responsible leadership. The impact of student-faculty interactions has also been documented for women in particular. For example, Whitt (1993) found that women leaders on campus attributed much of their leadership development to their interactions with faculty. Notably, some prior research has shown that the impact of student-faculty interactions may be different for women and men (Sax, Bryant, & Harper, 2005), but more research is needed to better understand how student-faculty interactions might differentially impact women in college, and no research has examined the differential impacts of faculty interactions on women's leadership in college computing.

Peer interactions. Higher education researchers have examined the impact of student-peer interactions on developing leadership identity and confidence. According to Komives and colleague's (2006) LID model, peer interactions play a large role in shaping students' leadership identity development. According to the LID model, processing experiences with peers can help students make meaning of their leadership experiences and aids in their leadership development. Komives et al.'s findings with regards to the role of peers in moving students along the different phases of leadership development will be discussed at length in the theoretical section of this chapter. In addition to Komives et al.'s LID theory, there is quantitative support of the important role peers play in shaping student leadership. Specifically, hours spent socializing each week, studying with peers, and working on group projects predict increases in self-rated leadership ability (antonio, 2001). Additionally, some more recent research also reveals that time spent socializing with peers may predict leadership development among women, but not men (Sax, 2008). Beyond the role of time spent socializing, students appear to benefit from interacting with peers across difference. Specifically, students who interact with peers of different racial and ethnic backgrounds tend to experience larger gains in how they perceive their leadership abilities (antonio, 2001).

Involvement. Closely related to the literature on peer interactions, much of the research on college impact focuses on the role of involvement and engagement on campus on a myriad of outcomes for college students, including leadership. For example, involvement in student government and other student groups positively predicts self-rated leadership abilities (antonio, 2001; Kezar & Moriarty, 2001). In addition, participation in service learning is predictive of both self-rated leadership abilities as well as leadership behaviors (Astin, Vogelgesang, Ikeda, & Yee, 2000). Some research also reveals that the impact of certain types of involvement may be

conditionally impactful for women. Specifically, Sax (2008) found that participating in racial/cultural workshops predicts leadership orientation for women, but not men. Additional gender differences in leadership development are discussed below.

The role of gender. While much of the research on the impact of college on leadership has examined students in the aggregate, there is a growing body of literature that considers the role of gender. This research has revealed that students come to college with preconceived views of their leadership that are largely a product of their gender, as evidenced by differences in how women and men rate their leadership abilities at the start of college (Sax & Harper, 2007). Unfortunately, even when controlling for experiences in college, women report lower leadership abilities than their male counterparts (antonio, 2001). Furthermore, not only do women enter college with lower perceptions of their leadership, but this gender gap also increases during the four years of college (Sax, 2008).

One aspect of college student leadership development that appears unique to women is the role of family. Notably, distance from family (i.e., the geographical distance between the student's parents and where the student attends college) predicts gains in leadership confidence for women, but not men (Sax, 2008). The impact of parents and family is a key aspect of college student development included in the theories that frame this study (i.e., Weidman, 1989 and Komives et al., 2006). However, these theories do not posit that family influences are differentially impactful for women and men, something that will be further examined in the present work.

It is important to note that gender gaps in college student leadership extend beyond individual perceptions of their abilities. Research reveals that gender gaps in leadership behavior are present and pervasive among college women and men. For example, while women have

reached, or even surpassed, parity in terms of their participation in student government and student organizations, they remain underrepresented in student leadership on campus (Miller & Kraus, 2004). In other words, while are active in student organizations, they continue to make up the minority of student leaders on campus.

Self-Rated Abilities

The present study examines self-perceptions of leadership both generally and in computing. As such, it is important to recognize the connection between self-rated leadership and actual leadership behaviors, aspirations, and achievement. Prior research reveals that perceptions of one's abilities predict academic achievement (Pajares & Schunk, 2001; Valentine, DuBois, & Cooper, 2004). With regards to self-rated leadership abilities in particular, researchers have found that perceptions of leadership abilities are a strong predictor of leadership aspirations and motivation to lead after college (Chan & Drasgow, 2001). Related to this phenomenon, some research has found that women undergraduates are less likely than their male counterparts to aspire to managerial positions after college, and that this gender gap was larger for women and men in male-dominated majors (e.g., science and engineering) (Schweitzer, Ng, Lyons, & Kuron, 2011). Thus, addressing gender gaps in how students perceive their own leadership may be a critical to reducing the gender gap in leadership both during and after college. This is particularly important for fields in which women are most underrepresented in leadership roles (e.g., computing). While it is important to also recognize and attend to the systemic and structural barriers (e.g., discriminatory policies and practices) that inhibit women's advancement in leadership within computing, developing women's confidence in their leadership abilities might be one way to increase the pipeline of women leaders in the field.

Gender and self-rated abilities. Self-rated leadership ability is related to the larger phenomenon of how individuals construct perceptions of their skills, abilities, and identities. Thus, a large body of literature on the role of gender in self-concept is relevant to this study. Like self-rated abilities, self-concept is important to examine, as it is related to a myriad of college outcomes, including college retention and success (Marsh & Craven, 1997; Marsh, 1990). More recent research has also found that self-concept is a predictor of course selection and enrollment as well (Nagy, et al., 2006). Gender differences in self-concept are pervasive and vary across domain types. When it comes to general academic self-concept, men rate themselves higher than women, even when controlling for actual academic performance (Wilgenbusch & Merrell 1999). Women consistently report lower math self-concept than their male counterparts (Sax, 2008; Sax et al., 2015; Wilkins, 2004), while men tend to report lower social self-concept on average (Sax, 1994). While much is known about how academic self-concept varies across domains, less is known about how self-perceived leadership abilities might vary across domains (e.g., computing vs. general leadership ability).

It is important to recognize that these gender differences in how women and men rate themselves are part of a pervasive systemic gender gap in how women and men over- and underrate their abilities in different contexts. This has been documented in Pomerantz and colleague's (2004) study, *Making the Grade, but Feeling Distressed: Gender Differences in Academic Performance and Internal Distress*, which reveals that even when controlling for girls' higher academic performance, girls report greater concerns about their academic abilities, a phenomenon that has since been reiterated in research on students of all ages (e.g., Niederle & Vesterlund, 2010; Sax & Harper, 2007). The present study is closely related to this larger

phenomenon of gender differences in self-rated abilities that has been well documented over the years.

Some limitations of examining gender differences in self-rated abilities and confidence are relevant to the present work. Because of the reliance on self-ratings, the vast literature on gender differences in confidence and perceived abilities might be a result of differences in how women and men *report* their confidence as opposed to actual differences. Furthermore, some scholars have argued that research on gender and confidence is too often deficit-focused (Bastalich et al., 2007; Blickenstaff, 2005; Rosser, 1998). At the same time, however, researchers have argued that the gender gap in confidence needs to be addressed, given that lower perceptions of confidence may lead to more distress and missed opportunities due to diminished risk-taking (Pomerantz, Altermatt, & Saxon, 2002). The present work is exploratory in nature and assumes that gender differences in perceived leadership ability in computing need to be more closely examined in order to assess the meaning and impact of such differences.

Leadership in STEM and Computing

STEM. A small body of research exists within higher education that examines leadership in STEM fields, some of which considers gender. Most of this research has examined faculty and department chairs, and little is known about STEM leadership outside of academia. This existing research has centered on women's numerical underrepresentation in STEM leadership, barriers to their leadership in STEM fields, and the importance of advancing women's leadership in STEM in order to increase the representation of women in the next generation of STEM scholars.

While women's representation in STEM has grown in recent decades (NSF, 2016), women remain sorely underrepresented in certain fields and in leadership across all STEM fields (Niemeier & Gonzalez, 2004). As of 2004, women made up fewer than 3 percent of engineering

department chairs (Niemeier & Gonzalez, 2004). More recent data reveals that women make up 19 percent of engineering assistant professors, but only 4 percent of full professors (NSF, 2010). Outside of academia, as discussed earlier, women remain underrepresented in high-level STEM careers. For example, not only are women retained in science, engineering, and technology careers at lower rates than men (Hewlett, et al., 2008), but women are also underrepresented at all levels of leadership within computing and technology jobs (ABI, 2016).

Much of the research on barriers to women's leadership in STEM fields pulls from the larger body of work on gender and leadership across fields (e.g., implicit bias and discrimination, family obligations, etc.). At the same time, some have argued that women in leadership roles within STEM represent a doubly disadvantaged group. That is, women STEM leaders face the challenges associated with being underrepresented in their field in addition to the challenges associated with being a woman pursuing a leadership role (Niemeier & Gonzalez, 2004). This is consistent with the larger leadership literature, as Eagly and Carli (2007) posit that women face the greatest resistance to leadership within male-dominated fields (e.g., engineering, computing, etc.).

Within the small body of literature that exists related to women's leadership within STEM, researchers have highlighted the importance of advancing women's leadership within STEM fields. Given the abundance of literature on the importance of role models for women pursuing STEM (e.g., Cheryan, et al., 2011), scholars argue that increasing the representation of women leaders is key to recruiting and retaining the next generation of women pursuing a STEM career. Not only do women serve as role models for young women considering a STEM major, but women may also be instrumental in shaping policies and fostering inclusive environments

within their particular STEM field (Gorman, Durmowicz, Roskes, & Slattery, 2010; Margolis & Fisher, 2002).

Computing. Much of the literature on gender and leadership, both generally and in STEM fields, may be applicable to the field of computing. However, there are some key ways in which leadership in computing is unique from leadership in other fields. For example, pathways into leadership in computing may vary greatly from person to person. In fact, when we look at today's most influential leaders in computing, the list includes both former programmers and MBA graduates (Martin, Stranger, Loudenback, 2015). The focus of the present study is on leadership among women computing majors and minors, recognizing that a computing degree is only one of the many pathways into leadership in the field.

In addition to the unique pathways to computing leadership, there are other factors that make the computing context unique. Borrowing from student development research, Jones and McEwen's (2000) model of the multiple dimensions of identity (MMDI) reveals some ways in which computing might be a unique context for women's leadership. The MMDI tells us that college students have a myriad of identities that shape their experiences (e.g., race, gender, religion, sexual orientation, etc.), and that different identities may be more or less salient depending on the context. In computing, women may experience particularly high gender salience due to the fact that they are so sorely underrepresented compared to other spaces on campus where they have reached or surpassed parity. This application of the MMDI to gender in computing is consistent with recent research on first-generation women in computing, which found that introductory course experiences were shaped by the intersection of both gender and first-generation status (i.e., first-generation women had a unique experience from both continuing generation women and first-generation men). However, gender differences were

much greater than differences for first-generation students (Blaney & Stout, 2017). Therefore, the notion of intersecting identities and saliency in different contexts may be particularly important in the context of computing.

Summary of the Literature

The first half of this chapter has reviewed several bodies of literature that are relevant to the present study, revealing that little is known about women's leadership specifically in computing and technology. Literature on women's representation in computing, both during and after college, provides context for this study. Similarly, research on gender and college student development inform the present work, and the large body of literature related to women and leadership reveals the ways in which gender has been considered in the study of leadership across fields. Finally, literature on leadership in STEM reveals the importance of women's leadership particularly in STEM fields, and some research suggests that women's leadership in computing may be unique from other STEM fields.

Part II: Theoretical Framework

Given that no prior research has examined women and leadership specifically among college computing students, the theoretical framework for this study must pull from three primary areas: feminist theory; leadership development theory; and college impact.

Feminist Standpoint Theory

Unlike traditional approaches to studying leadership among women and men, I take a feminist perspective. Specifically, feminist standpoint theory informs the methodological approach and interpretation of the findings from this study. Sandra Harding (1993), in her book *Whose Science? Whose Knowledge? Thinking from Women's Lives*, writes that politically informed research yields a better empiricism. Harding explains that, in keeping with feminist standpoint theory, all scientific knowledge is “socially situated” and that knowledge production must include a critical evaluation of social situations. Harding further criticizes traditional notions of objectivity in scientific research, calling for a redefining of the term. According to Harding (2004), standpoint theory can maximize objectivity, in a non-traditional way, by recognizing that not all values and interests harm empiricism, and that some values may, in fact, reveal more truth. Harding asserts that engaging multiple standpoints, particularly those of oppressed groups, helps to overcome biases such as those rooted in sexism and heteronormativity, and also to make explicit the political values that frame the research (in the case of this study, feminism).

It is an assumption of this study that women and men are both equally capable of effective leadership in the field of computing and technology, and that differences in leadership behaviors and perceptions are related to the ways women and men are socialized both during and prior to college. While much of this study is focused on how women and men perceive their

leadership abilities, both generally and in computing, these perceptions should not be assumed to reflect actual ability or innate gender differences.

Leadership Identity Development (LID)

Susan Komives and colleague's (2006) influential model of leadership identity development (LID) has shaped the way higher education scholars study leadership among college students and frames the present study. Komives et al. use a grounded theory approach to identify the six stages of college student leadership identity development. According to Komives et al., students first develop self-awareness (stage 1), which is shaped by peer influences (stage 2), leading students to view themselves in terms of others (stage 3). Students then shift from dependent relationships with others to more interdependent ones (stage 4), which broadens their perspective on leadership (stage 5). Lastly, students internalize their leadership identity, thus no longer viewing leadership as external (stage 6).

Most useful to this study, Komives et al. (2006) also identify four developmental influences of leadership identity development during college: adult influences (e.g., interactions with faculty); peer influences (e.g., student interactions); meaningful involvement (e.g., involvement in student organizations); and reflective learning (e.g., structured critical reflection). Komives et al. posit that exposure to these four influences can lead to developmental experiences that move students along the six phases of identity development. The four developmental influences identified by the LID model highlight the social nature of how students develop their perceptions of their own leadership, especially as they relate to their interactions with faculty, peers, and organizations. The developmental influences identified by Komives and colleagues will be used to frame the variables included in the present study, which will be explained further in Chapter 3.

Relevant to the present study, some scholars have adapted the LID model to study leadership development among subgroups of college students. For example, Beatty (2014) used the LID model along with critical race theory (CRT) to examine how students of color at selective liberal arts colleges develop their leadership identities, finding that campus climate played a key role in how students of color differentially developed their leadership identities. Another recent study within the field of higher education used Komives et al.'s LID theory to examine leadership identity among leaders of identity-based student groups (e.g., women's organizations, LGBTQ organizations, etc.). In this study, Renn and Ozaki (2010) find that student leaders of identity-based groups experience leadership identity development in keeping with Komives et al.'s LID model in many ways. However, in some cases, the student leaders had experiences within their identity-based group that influenced the saliency of that identity in relation to their leadership identity development (e.g., women leading women's organizations sometimes developed an identity as a female leader or a feminist leader). This may be relevant to the present study; given women's stark underrepresentation in computing, women may experience increased gender salience, which may in turn shape how they perceive their own leadership. Renn and Ozaki's (2010) adaption of the LID model will be used to inform the interview protocol and how identity saliency is considered.

Undergraduate Socialization

While Komives et al. highlight the role of different social interactions on leadership (i.e., faculty interactions, peer interactions, and experiences in student organizations), Weidman's theory of Undergraduate Socialization (1989) provides a helpful framework for considering how to study the many different social pressures students experience and how those experiences predict student outcomes. Weidman identifies socialization agents inside the university (e.g.,

students, faculty, etc.) and outside the institution (e.g., peers, employers, parents, etc.), organizing the college socialization experiences into both academic and social. Weidman also recognizes that socialization happens in both formal (e.g., student organizations) and informal ways (e.g., peer groups) during college. According to Weidman, the socialization process begins prior to college, which highlights the important role of precollege characteristics. While Weidman's model does not explicitly focus on computing students or even students in STEM majors, researchers have used Weidman to examine a myriad of college student outcomes among college students in STEM.

Weidman is used in addition with the LID model to frame the variables included in this study in two primary ways. Specifically, in accordance with Weidman, this study considers the important role of background characteristics in the socialization process as well as the external socialization that college students' experience. Komives et al.'s (2006) LID model and developmental influences provides a framework for the on-campus college experiences that influence student perceptions of leadership (namely, adult interactions, peer interactions, and meaningful involvement). Similarly, Weidman (1989) and Komives et al. (2006) provide further framing for the qualitative interview protocol and data analysis. As such, student participants were asked questions about how they make meaning of social pressures and their impacts as well as the types of college experiences (e.g., peer and faculty interactions) that shape their perceptions. A visual representation of how Weidman and Komives are synthesized is included below in Figure 2.1.

In summary, the three theoretical frameworks discussed above shape the present study in several specific ways. Feminist theory informs the research design with regards to the data sample (i.e., use of survey data from women and men; interview sample of women) as well as

the decision to utilize a mixed-methods design. Additionally, feminist standpoint theory frames the analysis of the interview data, which will be discussed in greater detail in the following chapter on research methods. The LID theory and Weidman’s theory of undergraduate socialization is used to provide a frame for the variables included in the quantitative analysis. Furthermore, all three theories shape the qualitative protocol, qualitative data analysis, and the interpretation of both quantitative and qualitative findings. More information about the analysis and protocol will be discussed in Chapter 3.

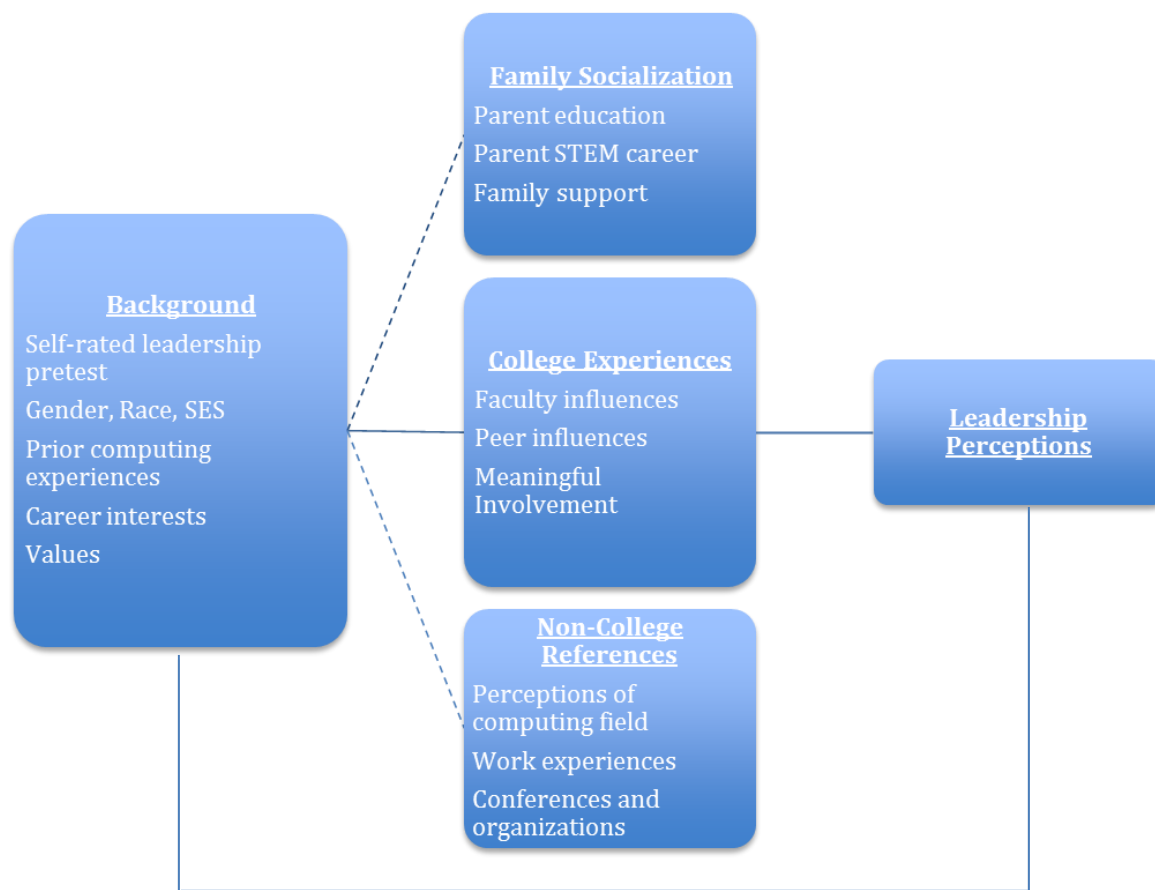


Figure 2.1. The development of college student leadership perceptions in computing. Adapted from “Undergraduate Socialization: A Conceptual Approach,” by J. Weidman, 1989, *Higher Education: Handbook of Theory and Research*, V., and “A Leadership Identity Development Model: Applications from a Grounded Theory,” by S. Komives, S. Longerbeam, J. Owen, F. Mainella, & L. Osteen, 2006, *Journal of College Student Development*, 47(4).

Summary and Concluding Thoughts

This study focuses on women's perceptions of their leadership abilities and their meaning making regarding leadership in the computing field. Prior research reveals that women are underrepresented in computing across all levels of leadership, but especially in top leadership positions. Prior research on the gender gap in computing has primarily focused on the different experiences before and during college that lead men to develop a greater interest in computer science, and the college experiences that lead to women's recruitment and retention in the field. This study bridges these two issues by examining women's conceptions of leadership within the field of computing.

Scholars have spent decades examining the role of gender and leadership and have concluded that women and men are equally capable of effective leadership, despite women's underrepresentation in top leadership positions across fields. In light of women's underrepresentation, researchers have examined the importance of women's leadership across disciplines and in STEM fields in particular, concluding that women leaders play a key role in developing inclusive policies and serving as role models for the next generation of women. Still, little is known about how to develop women's leadership in computing and technology.

The present study addresses gaps in the literature by examining how computing majors and minors perceive their leadership abilities, how this varies by gender, and how women, in particular, make meaning of leadership within computing and technology. Given that very little is known about women's leadership in computing, this study relies on mixed-methods, and is quite exploratory in nature. As such, standpoint theory is used to frame the study design and analysis so that women's voices guide the findings and direction of the study. Additionally, Komives et al.'s LID model and Weidman's model of undergraduate socializing provide a

framework for this study, particularly the quantitative analyses. The following chapter will review the methods for this study, including information about the sample, data collection, and data analysis.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

Introduction and Research Questions

This study utilizes a mixed-methods convergent triangulation design (Creswell, 2009) to examine how computing majors and minors conceptualize leadership, with a focus on the experiences of women. Specifically, descriptive quantitative analyses are used to examine gender differences in how computing students perceive their leadership abilities. I used regression analysis to examine the characteristics and college environments that predict perceived leadership abilities among women and men computing majors. Finally, I conducted interviews to gain more information about how women make meaning of leadership both generally and in computing. I examined the qualitative data using a phenomenological approach in order to answer additional research questions and enhance the interpretation of the quantitative findings. The following research questions frame this study:

Quantitative

1. How do computing majors and minors rate their leadership abilities (both generally and in computing)?
 - a. How does this differ for women and men?
 - b. Among the genders, does self-rated leadership ability differ by socioeconomic status, race/ethnicity, parents' education, or computing majors versus minors?
2. What factors predict perceived leadership ability (both generally and in computing) among computing majors and minors, and how does this vary between women and men?

Qualitative

3. How do undergraduate women computing majors and minors make meaning of their leadership (both generally and in computing)?

- a. How do they make meaning of their leadership skills and abilities?
 - b. How do they aspire to leadership?
 - c. How do they make meaning of their leadership experiences, if any? What experiences do they attribute to their development as leaders?
4. How do undergraduate women computing majors and minors make meaning of leadership in computing?
 - a. What traits do they perceive computing and technology leaders as having? Do they think that they have those traits? Do they desire those traits?

Mixed Methods

This study utilizes a mixed-methods convergent triangulation design (Creswell, 2009). Accordingly, quantitative and qualitative data were analyzed separately and brought together to create a more complex interpretation to examine the research questions. The quantitative and qualitative procedures will be reviewed separately in the remainder of this chapter.

Quantitative

Data Source

The quantitative portion of this study relies on existing data from the Building, Recruiting, and Inclusion for Diversity (BRAID) research project, which surveys students at fifteen research universities across the United States. Specifically, this study utilizes a sample of students who took a pretest survey at the beginning of an introductory course as well as a follow-up survey, which was administered the following academic year. The analysis dataset was limited to only those students who completed both the introductory course pretest and the follow-up survey and indicated that they were a computing major or minor on at least one of the two surveys. Complete survey instruments are included in Appendix A.

The BRAID research team administered the pretest to introductory course students enrolled at the 15 participating institutions during the 2015-2016 academic year. The research team administered the survey during the first few weeks of the fall and spring terms. The research team incentivized survey participation by rewarding the first 400 respondents with a \$15 Amazon gift card. Additionally, all students who completed the survey had the opportunity to win one of two \$125 Amazon gift cards, which were raffled off at the end of each administration. In December 2016, all pretest respondents received a follow-up survey about their experiences and perceptions since taking the introductory computing course. All respondents to the follow-up survey received a \$10 Amazon gift card for their participation. Of the 11,944¹ students enrolled in an introductory course during the 2015-2016 academic year, 3,656 completed the pre-test survey (a response rate of 31%). Among those, 44% went on to complete the follow-up survey, or 1,593 matched responses.

As previously mentioned, the sample was limited to only those students who indicated that they have a major or minor in computing. Students indicated up to two majors and two minors on the pretest and follow-up surveys. Zweben and Bizot (2016) define computing broadly as computer science, computer or software engineering, information technology, information studies, and interdisciplinary computing programs (e.g., computational biology, computing and business, etc.). Adapting Zweben and Bizot's definition (2016) to accommodate the specific computing majors and minors offered at the participating BRAID institutions, computing in the present work is defined as students who selected any of the following: Computer Science; Computer Information Systems/Informatics; Bioinformatics; Computing and Business;

¹ Students enrolled in an introductory course during the fall 2015 and spring 2016 term are counted twice in this number.

Information Technology; Data Science; Game Design; Computer/Software Engineering; or Other Computing.

Sample. The final sample included longitudinal data from 1,081 computing majors and minors, including responses from 326 women and 755 men. Among the women in the sample, approximately two thirds were White (31.9 %) or Asian (33.4%); 10.7% were Hispanic or Latinx; 7.4% were Black or African American; 14.1% indicated two or more races; and the remaining 2.5% indicated that they were Arab, Middle Eastern or Persian; Native American, Native Hawaiian, or Pacific Islander; or “Other”. Among men in the sample, 45.0% were White; a quarter (25.7%) were Asian; 10.5% were Hispanic or Latinx; 6.0% were Black or African American; 11.7% indicated two or more races; and the remaining 1.1% of men indicated that they were either Arab, Middle Eastern or Persian; Native American, Native Hawaiian, or Pacific Islander; or “Other”. Due to small numbers of students from Arab, Middle Eastern, and Persian; Native American, Native Hawaiian or Pacific Islander; and “Other” groups, these racial/ethnic categories are not shown in the analyses that follow in Chapter 4. For regression analyses, students who selected more than one racial/ethnic group were counted in more than one category (e.g., students who were White and Asian are given the higher value on both the White and Asian variables), thus eliminating the “two or more races” category.

Over half (54.5%) of students received the first survey while they were in their first year of college, nearly a quarter (23.5%) were in their second year, 13.0% were in their third year, 2.1% were in their fourth year, and the remaining students were in their fifth year or greater. Just over 80% of the sample began the course with a computing major (the remaining students either had a computing minor or became a computing major by the time of the second survey).

Before exploring Research Question 2, I used missing data analysis to examine and replace missing data. Prior to this step, the sample was already restricted to only students who completed the major/minor question and indicated their gender and race/ethnicity. Before conducting the regression analyses, the sample was further restricted to include only students who had complete responses to the two pretest variables and dependent variables. The remaining independent variables had less than 5% missing data, and so Expectation-Maximization was used to replace the missing values. For variables that are factors, data was replaced on individual items before computing composites. This resulted in a final analytic sample of 977 students for all regression analyses (294 women and 683 men).

Measures. The quantitative analyses for this study focus on two outcome variables: self-rated leadership ability (general) and self-rated leadership confidence in computing. In order to assess general self-rated leadership ability, students were asked to rate their leadership ability compared to the average person their age on a five-point scale: lowest 10%; below average; average; above average; highest 10%. In order to assess self-rated leadership confidence in computing, students indicated their agreement with the following statement: If I pursue computing, I am confident that I can become a leader in the field of computing. Students responded on a five-point scale: strongly agree; somewhat agree; neither agree nor disagree; somewhat disagree; strongly disagree. Both outcome variables were directly pretested on the introductory course pretest survey.

For all regression analyses, I selected independent variables in accordance with the theoretical framework described in Chapter 2. Together, these frameworks emphasize the social nature of student development and leadership development in particular. A visual representation of the framework and associated variables is included in Chapter 2, Figure 2.1. In accordance

with my conceptual framework, I organized all independent variables into the following categories: background characteristics; family socialization; non-college references; and college experiences. Additionally, I used factor analysis to reduce the number of variables included in the final analysis. All variable categories are described in the following paragraphs and a complete list of independent variables is included in Appendix B.

Background. The first group of variables includes background characteristics, which can be subdivided into the following categories: the pretest, demographics, incoming major, prior achievement, and values. Weidman's (1989) model of undergraduate socialization highlights the importance of considering the experiences and characteristics that students bring with them to college, especially for those variables related to the student outcomes of interest. Weidman (1989) identifies socioeconomic status, aptitude, career preferences, aspirations, and values as the key background characteristics and experiences that students bring to college, but states that this is not an exhaustive list. While Weidman does not explicitly state that the pretest of the dependent variable should be included in the background characteristics, other higher education research emphasizes the importance of controlling for the pretest (e.g., Astin & Antonio, 2012). Therefore, pretests of the dependent variables (i.e., perceived leadership ability (general) and perceived leadership in computing) are included first in the variable list. Gender and race are also included as demographic background variables. Gender was treated as a dichotomous variable (Woman/Man) and race groups were aggregated into the following categories for descriptive analyses: African American/Black; Asian/Asian American; Latinx; White; and two or more races. For regression analyses, students were allowed to exist in more than one group (i.e., the two or more races category was not necessary); White was treated as the reference group.

High school GPA was included to control for prior achievement and was followed by a control for whether or not the student began the introductory course with a computing major. Additionally, Astin and Antonio (2012) note the importance of controlling for background characteristics that may be predictive of college experiences and outcomes. For this reason, prior computing experiences were examined along with background characteristics. In accordance with Weidman (1989), career interests and values were also included, as they are likely to shape college experiences as well as outcomes.

Family Socialization. The next group of variables relates to family socialization and includes variables related to parent's education, parent's career, and family support to pursue computing. According to Weidman (1989), parent-child relationships play an important role in shaping student career interests and orientations and may mediate the relationship between college experiences and student outcomes. In addition to parental variables, this study included a measure of family support and time spent on household/family responsibilities to more inclusively examine the role family (parent or otherwise) may play in how students consider leadership during college. In the present work, family socialization is conceptualized along with the non-college references described below.

Non-College References. Weidman (1989) notes that a variety of non-college pressures shape the way students are socialized during college, noting the role of peers, employers, and off-campus organizations in particular. For the purposes of this study, non-college references include measures of student perceptions of the computing field (i.e., endorsement of gender stereotypes in the field, sense of belonging and fit in computing) as well as time spent working for pay and experiences with computing conferences (e.g., attending the Grace Hopper conference). While attending conferences related to computing could be categorized as a college

experience, these variables are included with the non-college references because attending conferences provides students with experiences beyond the college computing department and may shape the way students view the computing community more broadly.

College Experiences. In order to examine the college experiences most relevant to student perceptions of their leadership, I relied on the developmental influences identified in Komives et al.'s (2006) Leadership Identity Development (LID) model to select and organize the college environmental variables. Specifically, this study focuses on three types of experiences: faculty/adult influences (i.e., interactions with faculty and other mentors); peer influences (e.g., peer interactions in the classroom; time spent socializing; etc.); and meaningful involvement (e.g., involvement in student leadership, time allocation, etc.). According to Komives et al. (2006), these developmental influences lead students to develop their leadership identity by serving as the forces that disrupt previous notions of leadership and move students along the stages of leadership identity development.

Adult and peer influences in this study were measured primarily through interactions with faculty and other computing students. To examine faculty interactions, this study includes measures of the frequency of interactions with computing instructors as well as the quality (e.g., mentor support), general mentorship experiences (not specific to computing), and the student's perception of gender diversity among the faculty. Peer interaction variables included peer support, time spent interacting with peers and in student groups, and perceptions of gender diversity in the student body. Additionally, this study included variables that may be a product of both faculty and peer interactions. These experiences are included in an additional group of peer and faculty interaction variables. This block included student reports about departmental support

as well as classroom experiences and perceptions that may be shaped by both computing faculty and students.

Finally, Komives et al.'s (2006) LID model emphasizes the importance of meaningful involvement in providing students with an opportunity to develop perceptions of their leadership. For the purposes of this study, meaningful involvement was assessed using variables related to leadership experiences and how students use their time (e.g., studying, playing video games, volunteering, social networking, etc.).

Data Reduction. To reduce the number of independent variables in the analyses, I created composite variables (factors and scales) to capture the different components of the conceptual framework. After creating all composite variables, I examined bi-variate correlations and removed variables that were highly correlated ($r < -0.5$ or $r > 0.5$). The final list of potential independent variables, including descriptions of composite variables, is included in the Appendix B.

Data Analysis

Research Question 1 asks how computing majors and minors rate their leadership abilities both generally and in computing and how this varies among different groups of students. To address this question, I first examined frequency distributions of self-rated leadership ability and self-rated leadership in computing to determine how students rate their abilities on both outcomes of interest. Next, I used analysis of variance (ANOVA) and Bonferroni post-hoc tests to examine differences among groups on the two outcomes of interest. Specifically, I examined differences by gender and among the genders by major (computing/non-computing), socioeconomic status (SES), race/ethnicity, and parents' education.

Research Question 2 asks about the predictors of self-rated leadership abilities (both generally and in computing). To examine this question, I used blocked linear regression. As discussed above, variables for the regression models were selected in accordance with the theoretical framework. Next, I used interaction terms to test for conditional effects by gender. Before running the final regression models and testing for interaction effects, I ran exploratory models separately by gender; variables that entered any exploratory model were then included in the final regression models. Running these exploratory models by gender was important for several reasons. Most importantly, because no prior research has examined gender and leadership confidence among students in undergraduate computing, much is unknown about how women and men may differentially develop their leadership perceptions in this context. Thus, variables that enter the model for only one gender may not enter the model if students are examined in the aggregate. This is particularly problematic because women are underrepresented in the field of computing and the sample used in the present work. Running exploratory models separately by gender ensured that variables that are relevant for only one gender are included in the model, which is especially important given the exploratory nature of this study. Variables that entered any of the exploratory models were then included in the final model. Finally, I computed two-way interaction terms (Gender * IV) to determine whether any of the independent variables differentially predicted the dependent variables.

Qualitative Methods

Phenomenology

The qualitative stream of this work was guided by phenomenology. Phenomenology is an approach to qualitative inquiry that emphasizes the lived experiences of participants (Moustakas, 1994). In phenomenology, the emphasis of the inquiry is on perceptions held by participants

more so than factual descriptions of the phenomenon as understood by the researcher (Nieswiadomy, 1993). Many scholars of phenomenology describe the approach as beginning with “the things themselves” (e.g., Steeves, 2006). For this reason, phenomenological research typically does not include hypotheses, which may cloud the interpretation of the phenomenon as it is. Additionally, phenomenology emphasizes the importance of maximizing variation in the sample, describing participant experiences in detail, and using those descriptions to generate themes across the data (Moustakas, 1994).

I selected phenomenology for this study because of its focus on the voices of participants. This aligns with the purpose of this study, which is to understand how students perceive and make meaning of their leadership. It is important to note that a phenomenological approach is also very much in line with standpoint theory, which also frames this study. Standpoint theory, explained at length in Chapter 2, asserts that we should begin inquiry from the perspective of our participants, including their voices as much as possible (Harding, 1993). In accordance with standpoint theory, interviews with women were examined to help interpret the quantitative findings, so that my interpretation of the data is framed in the voices of women themselves.

One way in which phenomenology and standpoint theory diverge is in the role of the researcher. While a more traditional goal of phenomenological research has been to remove the biases of the researcher in an effort to focus on the phenomenon (e.g., through bracketing) (Tufford & Newman, 2010), standpoint theory and feminist approaches to phenomenology emphasize the importance of including the researcher in the analysis and making the positionality of the researcher known (Stanley & Wise, 1993). The feminist approach to phenomenological inquiry is more consistent with the approach of the present work. In this study, I grapple with how to balance centering women’s voices, while also making my own

political motivations known and explicitly incorporating my voice in the analysis and interpretation.

Sample

Interview participants were recruited from the larger quantitative sample. In order to be eligible to participate in an interview, students must have previously taken the introductory course pretest and follow-up surveys and indicated that they 1) are willing to participate in interviews, 2) identify as a woman, and 3) intend to major in a computing field. Interview participants were then selected purposefully to maximize variation in terms of their specific computing major, leadership perceptions, race/ethnicity, and other demographic characteristics. Purposeful sampling for maximum variation is key to phenomenology, as participants must represent diverse experiences in order to capture the essence of the phenomenon (Creswell, 2009; Moustakas, 1994).

As shown in Table 3.1, twelve women were selected for an interview, ten of whom were currently a computing major at the time of the interview (the remaining two had switched to a non-computing major before the date of the interview). Half of the computing majors indicated a major in computer science at the time of the interview. The other half were a mix of computational biology/bioinformatics, computer systems (including finance and computer systems), and information technology. A third of the participants were White, two were African American/Black, two were Latinx or Mexican American, three were Asian American, and one identified as more than one race/ethnicity (White and East Asian). The interviews were conducted during the summer of 2017, and the majority of participants were rising third-year students at the time of the interview, indicating that they were first year students when they took their first BRAID survey during the 2015-2016 academic year.

Table 3.1 Summary of Participants

Name	Major	Race/Ethnicity	Class Standing	General Leadership Pretest	General Leadership Follow-up	Computing Leadership Pretest	Computing Leadership Follow-up
Mariam	Computer Science	Latina/Mexican American	Second year	4	3	4	3
Lana	Computer Science (Psychology Minor)	White	Third year	2	2	2	3
Sue	Chemistry (left CS major)	African American/Black	Second year	4	3	4	4
Maddie	Computer Systems	East Asian and Southeast Asian	Third year	4	2	5	4
Lisa	Computer Science	East Asian	Third year	5	4	4	4
Anna	Computer Science	White and East Asian	Graduated	3	3	3	3
Liz	Computational Biology	White	Senior	3	4	4	2
Sarah	Finance and Computer Systems	East Asian	Junior	4	5	4	3
Sheryl	Bioinformatics	White	Third year	4	3	3	1
Rosie	Computer Science	White	Third year	2	3	2	3
Katie	Social Work (left CS major)	Latina	Third year	5	4	5	4
Sara	Information Technology (left computer engineering major)	Black	Third year	3	3	5	2

Note. Students provided their pseudonym and current major during the interview. Race/ethnicity, class standing, and the measures of leadership confidence were measured using the participants' existing survey data. Because interviews were conducted in the summer, rising class standing is used. Both measures of leadership were measured on a 5-point scale where higher numbers indicate greater confidence.

Data Collection

Prospective participants who met all qualifying criteria described above were contacted in Spring/Summer of 2017 via email. Participants were offered a \$10 gift card of their choice for participating in the interview. Interviews were conducted on the phone or via Google Hangout/Skype. In advance of the interview, participants were sent the study information sheet via email. At the start of the interview, participants were asked for verbal consent to participate in the study and have their interview recorded. Additionally, students were asked to provide a pseudonym to be used throughout the interviews to maintain their confidentiality. Interviews were then transcribed verbatim, and any names other than the pseudonym were redacted from the transcript.

Interviews followed a semi-structured protocol that was pilot tested with 3 computing students prior to the data collection. The protocol included questions about the participant's background experiences with computing, perceptions of leadership (both generally and in computing), leadership aspirations, and experiences that have shaped how they conceptualize leadership. Komives et al. (2006) provided a frame for the types of questions and probes included in the protocol. Namely, Komives et al. identify four developmental influences of leadership identity development during college: adult influences (e.g., interactions with faculty); peer influences (e.g., student interactions); meaningful involvement (e.g., involvement in student organizations); and reflective learning (e.g., structured critical reflection). These developmental influences, explained in more detail in Chapter 2, were used to frame the interview questions, specifically those questions related to the types of experiences that have shaped how participants think about leadership. The full protocol is included in Appendix C.

Data Analysis

I used phenomenology to guide the qualitative data analysis. Data was analyzed while conducting the interviews to allow for discussions of preliminary findings with the interview participants. The focus of phenomenology is on lived experiences and typically relies on an inductive approach to data analysis (Moustakas, 1994). As such, I read transcripts multiple times to allow themes to emerge. Next, I developed a codebook of emergent themes, descriptions, and examples, which was used to code each transcript for themes using NVivo software. Data was analyzed to maximize objectivity in accordance with Harding (1993). That is, objectivity requires that researchers recognize that not all values and interests threaten objectivity and that by beginning from the lives of oppressed groups (i.e., women, in the case of this study), we can yield a better empiricism (Harding, 1993).

Trustworthiness

Not only does member checking improve the validity of qualitative findings (Creswell, 2009), but it also ensures that participant voices are heard in the interpretation of data, which is central to phenomenology as well as Standpoint Theory. While I had originally planned to conduct member checks with each participant, I ultimately decided to stop the member checks after completing the first two under the consultation with some of my committee members. These member checks were planned in the form of informal phone conversations where I would ask participants for feedback on preliminary themes as well as topics that did not emerge in the initial interviews (e.g., faculty mentorship). Several factors informed the decision to halt these member checks, including concerns that continued discussion of my project might negatively impact participants' view of themselves and their place in computing and technology. Namely, the two students who did participate in a member check expressed concern when they learned about the

extent to which sexism persists in their field. This is also related to some of the findings that will be discussed in Chapters 5 and 6. Without having completed all member checks, I rely on the recordings and verbatim transcriptions to ensure trustworthiness.

Positionality

It is important to note the ways in which my positionality as a researcher may shape the analysis and interpretation for this study. As is the case in all research, the various identities that I occupy influence the types of research questions that I ask, the study design, and other aspects of the research of which I may or may not be aware. I am a doctoral candidate in higher education and the data manager for the Building, Recruiting, and Inclusion for Diversity (BRAID) project, a multi-institution, longitudinal study of women and students of color in computer science, from which the data for this study is drawn. While I do not have a background in computer science, my professional experiences have shaped the ways in which I think about gender inequity the field of computing and technology. Thus, my personal investment in broadening women's participation in computing has shaped the questions I ask and the way I approach this research.

Further, as someone who studies gender equity and women's experiences in college, I am familiar with the vast literature that clearly demonstrates the ways in which women and men are equally capable of engaging with computer science and leadership. Further, I am driven by scholarship that challenges gender essentialism, and I reject any notion that women naturally have different talents, interests, or personality traits than those of men. These viewpoints certainly influence the methodological decisions, data analysis, and interpretation of findings included in the present work.

Limitations

The dependent variables for this study are both single-item, self-reported measures of leadership confidence. Thus, it is impossible to determine whether any gender differences on the dependent variable are due to actual differences in leadership confidence or differences in how students *report* their confidence. Future research should further examine the utility of these types of self-reported measures of confidence; comparing leadership self-ratings and leadership behaviors (e.g., experiences leading a group assignment, student organization, etc.) may be a way to provide more insight into the meaning of these self-ratings in the future. Additionally, quantitative data was collected at two points in time, and many of the environmental variables used in this study (e.g., faculty interactions, peer interactions, etc.) were measured at the same time as the dependent variables. Therefore, it is not possible to infer causation between the independent and dependent variables. To mitigate this, I rely on established theories to identify independent variables, and I include a direct pretest of each dependent variable to provide additional control. Future research should examine the predictors of leadership abilities using data from more than two time points in order to infer causality. Furthermore, future research should consider the role of self-rated leadership ability over time to determine how, if at all, leadership confidence in college affects behaviors over time.

All students in the dataset are from one of fifteen institutions across the United States. While the institutions are diverse in terms of geographical location, all fifteen participating institutions are research universities. Therefore, findings from this study cannot be generalized to other institutional types (e.g., community colleges, liberal arts colleges, etc.).

Additionally, I conducted interviews over the phone or online, which might have made it difficult for participants to feel comfortable sharing their personal experiences and perceptions.

This may be further shaped by my positionality, which is discussed above. More specifically, a participant's knowledge of my identity as a higher education and gender researcher likely influenced the way participants responded to the interview questions.

Finally, the qualitative data collection focused exclusively on women's experiences and perceptions related to leadership in computing. While this allows for a deep examination of women's experiences and consideration of intragroup differences among women, it is not possible to determine from the qualitative data if women's perceptions and experiences are different from those of men. More importantly, because of the way gender is defined for the quantitative analyses, the experiences of trans* women and those identifying as gender non-binary may be masked in the analysis. Future research should examine gender differences among all students including men, trans*, and gender non-binary students.

Summary

Using a mixed-methods convergent triangulation design (Creswell, 2009), this study examines the role of gender in how computing students conceptualize their leadership. Quantitative analyses focus on gender differences in how students perceive their leadership abilities (both generally and in computing), as well as the college experiences and other factors that predict these perceptions for women and men. Qualitative inquiry was used to provide a more nuanced understanding of how women studying computing make meaning of leadership.

Quantitative and qualitative data were collected and analyzed separately and will be brought together Chapter 6 to provide a more comprehensive understanding of how computing students, and women in particular, perceive their leadership abilities and make meaning of leadership within the field of computing. Before bringing the quantitative and qualitative streams

of inquiry together in Chapter 6, Chapter 4 will review the quantitative findings, and Chapter 5 will describe the qualitative findings.

CHAPTER 4: QUANTITATIVE FINDINGS

This chapter reviews findings from the first two research questions, both of which require quantitative inquiry to examine the following leadership outcomes: self-rated leadership ability and self-rated leadership confidence in computing. The first half of this chapter presents the descriptive results associated with the first research question, which asks about the extent to which leadership outcomes vary by gender and within the genders (i.e., intragroup differences among women and men). The second research question asks about the factors that predict more positive self-rated leadership scores; the regression results associated with this question are discussed in the second half of this chapter. I conclude the chapter with a summary of the quantitative results and a preview of Chapters 5 and 6.

Research Question One

Frequency Distributions

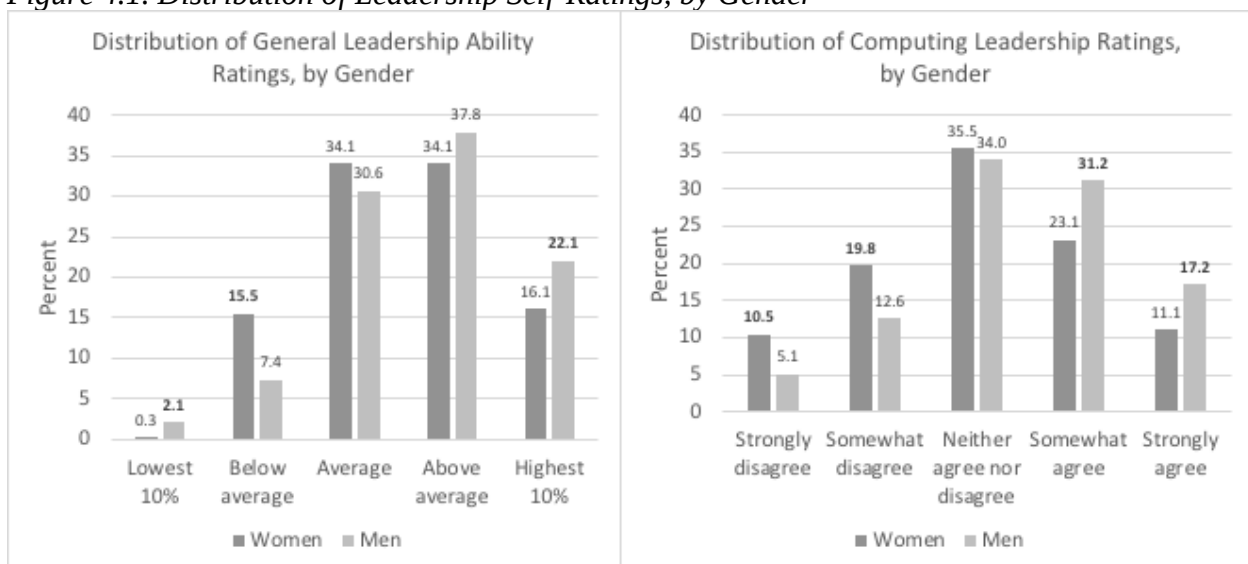
The first question guiding this inquiry asks about the ways that computing majors and minors rate their leadership abilities (both generally and in computing), focusing on how this differs by gender and among the genders. Table 4.1 shows the distribution for all students on both outcomes of interest. As shown in the table, students' perceptions of their leadership were more positive when they were responding about their general leadership abilities compared to their computing leadership confidence.

Table 4.1 Distribution of Self-Rated Leadership Outcomes

	Percent	
	General Leadership (N=1,071)	Computing Leadership (N=1,075)
Highest 10%; Strongly agree	20.3	15.3
Above average; Somewhat agree	36.7	28.7
Average; Neither agree nor disagree	31.7	34.4
Below average; Somewhat disagree	9.8	14.8
Lowest 10%; Strongly disagree	1.6	6.7

Next, I used Chi-square tests and z-tests with the Bonferroni correction to examine how the distribution on both outcomes of self-rated leadership might differ by gender. As shown in Figure 4.1, there were fewer gender differences in terms of how students report their general leadership abilities. Women were less likely to select the lowest option but were more likely to indicate that they were below average; on the other hand, men were more likely than women to indicate that their leadership abilities were in the highest 10%. When we examine gender differences on the computing-specific leadership measure, the gender differences follow a more consistent and striking pattern. Women and men were equally likely to “neither agree nor disagree”, while women were significantly more likely to be in the bottom two categories, and men were more frequently in the top two categories.

Figure 4.1. Distribution of Leadership Self-Ratings, by Gender



Note: Bold indicates significant differences at the $p < .05$ level. The higher number is bolded.

Mean Comparisons

Consistent with the Chi-square tests, analysis of variance revealed significant mean differences between women and men (see Table 4.2). Specifically, women reported lower confidence in their leadership on both the general and computing-specific measures. As a

reminder, the sample for this study includes students who indicated a computing major and/or minor on at least one of the surveys. Therefore, gender differences in mean leadership confidence in computing might be due to the fact that a greater proportion of men than women were computing majors (as opposed to computing minors or students who left computing after taking the first survey).

Table 4.2 Mean Leadership Ratings by Gender

	Mean (SD)			F	Sig.
	All	Women	Men		
General leadership	3.64 (.963)	3.50 (.950)	3.70 (.963)	9.978	**
Computing leadership	3.31 (.963)	3.05 (1.138)	3.43 (1.071)	27.604	***

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

To test this possibility, I repeated the analysis, this time controlling for whether or not the student was a current computing major (as opposed to computing minors or students who switched out of computing since the pretest survey). Consistent with the previous findings, male computing majors reported significantly higher scores on self-rated computing leadership ($M=3.65$; $SD=9.74$) compared to women computing majors ($M=3.41$; $SD=0.967$), $F(1, 752)=9.368$, $p=.002$. Among non-computing majors (i.e., computing minors and students who switched out of computing), men also reported more positive leadership in computing ($M=3.30$; $SD=1.117$) compared to women ($M=2.70$; $SD=1.146$), $F(1, 319)=19.793$, $p<.000$. In short, the gender gap in computing leadership confidence was present regardless of whether or not students were computing majors.

Intragroup Differences

The second half of Research Question One asks about how both leadership measures differ among women and among men. To examine this question, I used analysis of variance to compare average scores on both outcomes by race and ethnicity, parents' education,

socioeconomic status, and major. All of these analyses were run separately by gender to examine intragroup differences and are summarized below in Table 4.3.

Race and Ethnicity. Women's leadership scores did not significantly differ by race and ethnicity, which is likely a product of small sample size. Though not significant, some differences do emerge. Specifically, Black women rated their leadership abilities higher than all other groups, but their computing leadership confidence was lower than women from other racial/ethnic groups, highlighting the importance of examining these two measures of leadership confidence separately. Turning to differences among men, White men reported the highest leadership abilities compared to men from other groups, though White men were only significantly higher than Asian men. On the other hand, Black men reported the highest capacity for computing leadership compared to other groups, though they were only significantly higher than their Asian peers.

Parents' Career and Education. Women's and men's leadership ratings did not differ as a product of whether or not they had a parent with a STEM career. Among men, having a parent with a bachelor's degree was associated with greater confidence in one's capacity for computing leadership compared to students whose parents had an education level of high school or less (this did not hold true among women). No other differences emerged, which might be related to small sample sizes among groups.²

Socioeconomic Status. Women's reports of their leadership did not differ by socioeconomic status. Men who indicated that their socioeconomic status was "above average"

² To mitigate sample size restrictions, I also computed a first-generation variable to see if significant differences might emerge when students were aggregated into two groups (first and continuing generation). These analyses did not offer additional significant differences. First-generation men reported lower general leadership ability compared to men with college-educated parents. There were no significant differences among women. Note that I defined first-generation students as those whose parents did not have at least a bachelor's degree even if they did have some college education.

reported higher general leadership ability compared to men from “average” backgrounds. No other significant differences were observed.

Current Computing Major. The most consistent intragroup differences were observed by major. Specifically, both women and men who reported a non-computing major (i.e., they either left computing after taking the pretest or had a computing minor) had more positive ratings of their general leadership abilities compared to computing majors. As one might expect, current computing majors did score higher on the computing-specific measure of leadership confidence, compared to their peers who were not majoring in computing.

Pretest Computing Major. As a reminder, this study included students who indicated a computing major or minor on either the pretest survey or the follow-up survey. Whether or not the student started their introductory course with a computing major was only determinant for men. Specifically, men who started the course with a major in computing had more confidence in their computing leadership compared to their male peers who were either computing minors or became a computing major at a later time. No other significant differences were observed.

Table 4.3. Perceptions of Leadership Among Women and Men by Demographic Variables and Major

	Women						Men					
	General Leadership			Computing Leadership			General Leadership			Computing Leadership		
	N	Mean	Sig	N	Mean	Sig	N	Mean	Sig	N	Mean	Sig
<i>Race/Ethnicity</i>												
Asian (a)	108	3.39		108	3.06		193	3.52	d	194	3.29	b
Black (b)	24	3.63		24	2.67		44	3.73		44	3.82	a
Latinx (c)	35	3.60		35	3.31		77	3.57		79	3.46	
White (d)	103	3.48		103	2.97		337	3.86	a	337	3.48	
Two or more races (e)	45	3.60		46	3.13		80	3.60		45	3.60	
<i>Parent Career</i>												
STEM	143	3.57		144	2.97		271	3.74		272	3.47	
Non-STEM career	180	3.44		180	3.11		477	3.68		479	3.40	
<i>Parent's Education Level</i>												
High school or less (a)	40	3.53		40	3.03		117	3.44		118	3.27	c
Some college or associate's degree (b)	53	3.57		53	3.23		104	3.76		103	3.29	
Bachelor's degree (c)	91	3.55		92	3.22		211	3.79		211	3.40	a
Graduate/Professional degree (d)	101	3.43		101	2.87		241	3.71		243	3.50	
<i>Socioeconomic Status</i>												
Poor (a)	17	3.88		17	3.06		31	3.55		32	3.31	
Below average (b)	58	3.43		58	3.19		120	3.65		120	3.38	
Average (c)	142	3.37		143	2.99		336	3.59	d	337	3.39	
Above average (d)	91	3.65		91	3.04		230	3.87	c	231	3.50	
Wealthy (e)	11	3.64		11	2.91		26	3.96		26	3.54	
<i>Current Major</i>												

Non-computing	108	3.68	*	108	2.70		211	3.84	*	213	3.30	
Computing	215	3.41		216	3.22	***	537	3.65		538	3.48	*
<i>Pretest Major</i>												
Non-Computing	85	3.59		86	2.99		115	3.77		116	3.16	
Computing	238	3.47		238	3.07		633	3.69		635	3.48	*

Note: For groups with three or more categories, letters indicate significant differences from corresponding group at the $p < .05$ level (e.g., White men reported significantly higher general leadership abilities than Asian men). For dichotomous groups, asterisks indicate significant differences between the two groups, $*p < .05$, $**p < .01$; $***p < .001$; the larger number is marked (e.g., women with non-computing majors reported higher general leadership abilities compared to women from computing majors). Note that the significance testing compares the means of subgroups *among* women and *among* men (e.g., the first three columns under the “general leadership” heading compare women’s general leadership self-rating by race/ethnicity).

Summary of Research Question One

This research question asked about how computing students perceive their leadership both generally and in computing and how this varies by gender and among women and men. The findings discussed above reveal gender gaps, such that men report more confidence in both their general self-rated leadership ability and their self-rated leadership in computing. Relatively few significant intragroup differences emerged among women, with the exception being that women computing majors (compared to computing minors and non-computing majors) reported lower confidence in their general leadership abilities and higher confidence in their computing leadership. As discussed above, men’s leadership confidence differed modestly by race/ethnicity, socioeconomic status, parent education, and major.

Research Question Two

The second research question asks about the different college experiences and other factors that predict self-rated leadership ability and self-rated computing leadership confidence. To examine this question, I ran separate regression models for each dependent variable (self-rated leadership ability and self-rated capacity to become a leader in the field of computing), using my conceptual framework (discussed in Chapters 2 and 3) to select and organize independent variables. A list of all possible variables is included in the Appendix B. In this section, I discuss the results of each regression analysis separately.

Regression One: General Self-Rated Leadership Abilities

The first regression model focused on general self-rated leadership ability as the dependent variable to explore how self-rated leadership develops over the year after the introductory computing course. This model explained approximately 36% of the variance in the outcome of self-rated leadership ability ($R^2=0.364$) and is shown in Table 4.4. It is important to note that the vast majority of that variance (34%) was explained by the pretest alone.³ In other words, differences in self-rated leadership ability outcomes are largely due to differences that exist at the start of the introductory computing course, often students' first exposure to college computing.

Control Measures. The model controlled for incoming self-rated leadership ability, self-rated computing leadership, and whether or not the student started the introductory course with a computing major. Not surprisingly, the strongest predictor of self-rated leadership ability was the pretest of self-rated leadership at the start of college computing, indicating that self-rated

³ Additional paired sample t-tests revealed that mean self-rated leadership ability did not significantly change over time. In other words, general self-rated leadership abilities remain relatively stable, which explains why much of the variance in the outcome was explained by the pretest.

leadership ability outcomes are largely a product of the leadership confidence that students bring with them to introductory computing. Incoming *computing* leadership ratings and major were not significant in predicting overall self-rated leadership ability. However, several additional variables, beyond the pretest, significantly contributed to the model and are discussed below in the context of all variables considered in each block.

Background Characteristics. After controlling for incoming self-rated leadership abilities and all other variables in the model, gender was not a significant predictor. In other words, gender did not account for variation in leadership ratings on the follow-up survey beyond the role played by all other independent variables (most notably the pretest, where women's ratings were significantly lower than men's). There were, however, some modest differences by race and ethnicity. Consistent with the descriptive findings discussed above, Asian students had lower self-rated leadership abilities compared to their White peers (reference group). While the analysis also considered variables including high school achievement and prior programming experience, no other background characteristics were significant in the final model. Next, I examined blocks of variables testing for values (e.g., social career orientation) and family socialization (e.g., parent career).⁴ None of those variables were significant in the final model, though family and other precollege experiences were also examined in the qualitative stream of this work and will be discussed at length in Chapter 5.

Non-College References. Among the non-college references, students who attended diversity conferences (e.g., the Grace Hopper Celebration of Women in Computing) reported lower self-rated leadership abilities. This finding is somewhat counter-intuitive and may be due

⁴ Importantly, parent career had a significant *conditional* effect, which is discussed below.

to reasons discussed in Chapter 6. Notably, attending diversity conferences appears to be beneficial in other ways discussed below.

College Experiences. Only two measures of college experiences had significant main effects in the final model of general self-rated leadership. Not surprisingly, students who reported greater support from their mentors had more positive perceptions of their leadership abilities, which is consistent with existing research underscoring the importance of faculty and other mentors. On the other hand, students who spent more time playing video games tended to have lower confidence in their leadership abilities.

Table 4.4 Regression Predicting Self-Rated Leadership

	Self-Rated Leadership Ability				Self-Rated Computing Leadership			
	Beta	b	Std. Error	Sig.	Beta	b	Std. Error	Sig.
<i>Pretest and Control Variables</i>								
Pretest: Self-Rated General Leadership Ability	0.550	0.534	0.028	***	0.156	0.173	0.030	***
Pretest: Self-Efficacy for Computing Leadership	-0.007	-0.007	0.030		0.205	0.226	0.033	***
Computing Major (reference group=computing minors)	-0.018	-0.046	0.070		-0.042	-0.123	0.076	
Gender: Woman	-0.050	-0.106	0.060		-0.034	-0.083	0.065	
Race: African American/Black	0.003	0.010	0.096		0.039	0.158	0.105	
Race: Asian	-0.076	-0.157	0.059	*	-0.043	-0.101	0.065	
Race: Latinx	-0.032	-0.087	0.079		-0.033	-0.104	0.086	
Socioeconomic Status	0.018	0.017	0.028		0.034	0.038	0.031	
<i>Background Characteristics</i>								
Career Value: Social Orientation	-0.016	-0.015	0.030		0.076	0.084	0.033	*
Career Value: Family	0.032	0.031	0.028		-0.057	-0.063	0.031	*
Parent STEM Career	0.019	0.038	0.054		-0.009	-0.020	0.059	
<i>Non-College References and Family Socialization</i>								
Fit and Belonging in Computing	0.034	0.033	0.030		0.402	0.444	0.032	***
HPW: Household/Family Duties	0.047	0.046	0.028		0.061	0.067	0.030	*
Attended Diversity Conference(s)	-0.091	-0.089	0.029	**	0.002	0.002	0.032	
<i>College Experiences</i>								
Computing Faculty Interaction: Frequency	0.008	0.007	0.030		0.053	0.058	0.032	
Computing Faculty Interaction: Mentorship	0.037	0.036	0.030		0.067	0.074	0.032	*

General Mentorship (not computing specific)	0.074	0.072	0.029	*	0.004	0.005	0.031	
HPW: Computing-Related Student Groups	-0.003	-0.003	0.032		0.077	0.085	0.035	*
HPW: Other (Non-Computing) Student Groups or Clubs	0.036	0.035	0.030		0.062	0.069	0.032	*
Contentious Classroom Climate	0.034	0.033	0.030		0.075	0.083	0.032	*
Perceived Gender Diversity Among Student Body	0.028	0.028	0.026		-0.030	-0.034	0.028	
HPW: Playing Video/Computer Games	-0.075	-0.073	0.028	**	-0.060	-0.067	0.031	*
<i>Adjusted R²</i>			0.364				0.419	

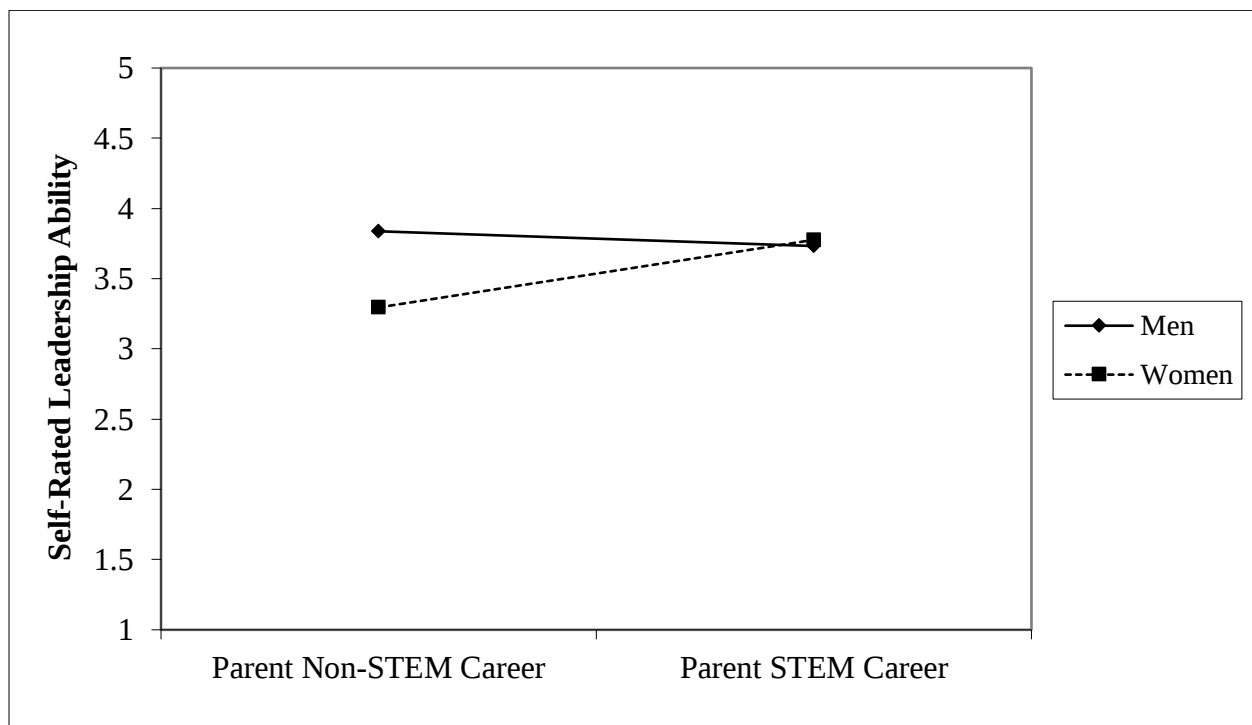
Conditional Effects. The second half of this research question asks about how the predictors of leadership ratings might differ by gender (interaction effects). To examine this part of the question, I ran another linear regression model, this time testing for conditional effects using two-way interaction terms. These tests revealed two additional factors that predict the dependent variable of self-rated leadership ability: having a parent with a STEM career and perceiving the computing student body to have gender diversity (see Table 4.5). As shown in the table below, adding these two interaction terms to the model significantly increased the amount of variance explained to 37.1%.

Table 4.5 Main Effects and Interaction Effects Predicting Self-Rated Leadership Ability

	Model 1 (Main Effects)	Model 2 (Interaction Effects)
<i>Pretest and Control Variables</i>		
Pretest: Self-Rated General Leadership Ability	0.550	0.556
Pretest: Self-Efficacy for Computing Leadership	-0.007	-0.010
Computing Major (reference group=computing minors)	-0.018	-0.021
Gender: Woman	-0.050	-0.117
Race: African American/Black	0.003	0.009
Race: Asian	-0.076	-0.074
Race: Latinx	-0.032	-0.033
Socioeconomic Status	0.018	0.014
<i>Background Characteristics</i>		
Career Value: Social Orientation	-0.016	-0.017
Career Value: Family	0.032	0.038
Parent STEM Career	0.019	-0.027
<i>Non-College References</i>		
Fit and Belonging in Computing	0.034	0.040
HPW: Household/Family Duties	0.047	0.047
Attended Diversity Conference(s)	-0.091	-0.092
<i>College Experiences</i>		
Computing Faculty Interaction: Frequency	0.008	0.007
Computing Faculty Interaction: Mentorship	0.037	0.035
General Mentorship (not computing specific)	0.074	0.076
HPW: Computing-Related Student Groups	-0.003	0.001
HPW: Other (Non-Computing) Student Groups or Clubs	0.036	0.033
Contentious Classroom Climate	0.034	0.032
Perceived Gender Diversity Among Student Body	0.028	0.074
HPW: Playing Video/Computer Games	-0.075	-0.074
<i>Interaction Terms</i>		
Interaction: Gender*Parent STEM Career		0.105
Interaction: Gender*Perceived Gender Diversity Among Student Body		-0.081
<i>Adjusted R²</i>	0.364	0.371

As shown in Table 4.5, having at least one parent with a STEM career was a positive predictor of self-rated leadership for women but was not significant for men. In other words, women who had at least one parent with a STEM-related career tended to have greater confidence in their leadership abilities, but men's confidence in their leadership was not related to whether or not they had a parent with a STEM career. This relationship is illustrated below in Figure 4.2. This is closely related to some of the findings that will be discussed in the next chapter; namely, the qualitative findings highlight the importance of having role models in STEM prior to college (see Chapter 5).

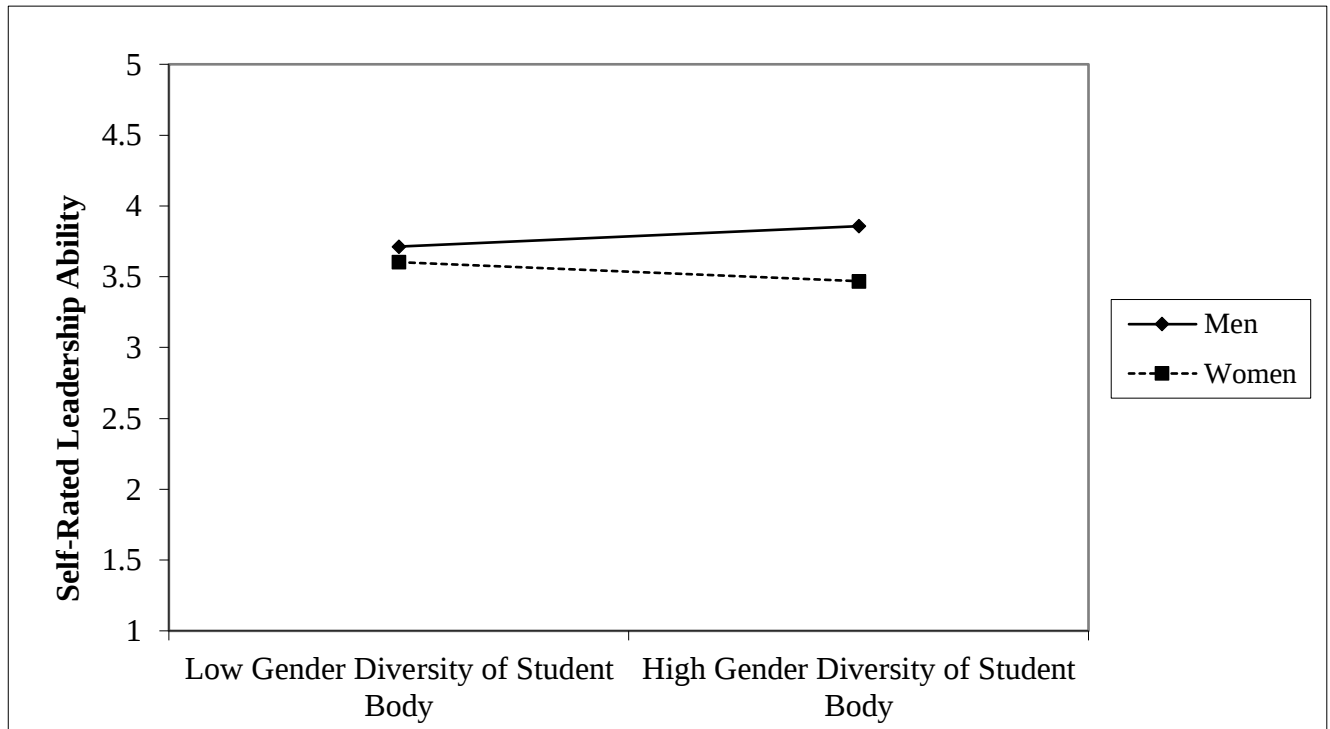
Figure 4.2 Conditional Effect of Parent Career on Self-Rated Leadership Ability



On the other hand, perceiving that the computing student body is diverse in terms of gender was a positive predictor for men but was non-significant for women. In other words, men who perceived their department to be gender diverse tended to have more confidence in their leadership abilities (see Figure 4.3). Women's self-rated leadership abilities were unrelated to the

extent to which they perceived their department to be gender diverse. This finding relates to several findings from the qualitative portion of this study and will be discussed at length in Chapter 6.

Figure 4.3 Conditional Effect of Perceived Gender Diversity of Computing Student Body on Self-Rated Leadership Ability



Regression Two: Self-Rated Computing Leadership

The second research question also asks about the background characteristics and experiences that predict self-rated *computing* leadership confidence. The final model predicting self-rated leadership in computing is shown above in Table 4.4. As shown in the table, the final model explained approximately 42% of the variance in the dependent variable ($R^2=0.418$). It is important to note that approximately 22% of that variance was explained by the pretests of incoming leadership ratings alone, meaning that the other variables in the model account for an additional 20% of the variance. Importantly, additional analyses revealed that self-rated computing leadership actually declined over time. In other words, students had lower confidence in their computing leadership on the follow-up survey ($M=3.48$; $SD=1.102$) relative to their pretest scores ($M=3.31$; $SD=1.105$); $t(985)=4.601$, $p<0.001$. For this reason, positive predictors in the model indicate variables that predict smaller declines in computing leadership confidence, while negative predictors can be interpreted as variables that predict greater declines.

Control Variables. Both measures of incoming leadership confidence (general self-rated leadership ability and self-rated computing leadership confidence) were positive predictors of the outcome. In other words, students who enter college computing with more positive perceptions of their leadership tend to, unsurprisingly, have more confidence that they can become a leader in the field of computing a year later, compared to students who begin with lower leadership confidence. I also included a control measure to indicate whether or not the student began their introductory computing course as a computing major (compared to if they became a computing major later or were a computing minor), which was not significant in the final model.

Incoming Perceptions. In addition to incoming leadership confidence, there are other perceptions that students bring with them to college that predict computing leadership

confidence. Specifically, students who come to their introductory computing course wanting to find a career where they can have a social impact have greater confidence in their capacity to become a leader in the field of computing. On the other hand, students who come to college valuing a career where they can spend time with their family reported significantly lower confidence in their computing leadership a year later; related findings are discussed below (see interaction effect).

Family Socialization and Non-College References. The regression analysis also tested for variables related to how students view the field of computing and experience the world outside of the campus context (e.g., time spent working, time spent on family and household responsibilities). Notably, feeling that one *fits* or *belongs* in the field of computing was the strongest positive predictor of feeling confident in one's ability to become a leader in the field. Interestingly, students who spent more time each week on household and family responsibilities tended to feel more confident in their capacity to become a leader in the field of computing.

College Experiences. The analysis revealed several key college experiences that predict computing leadership confidence. Notably, feeling supported by computing faculty and spending time in student groups (both computing-related and non-computing) were each significant positive predictors of computing leadership confidence. In other words, students who felt supported by faculty mentors in computing and spent more time each week in student groups saw fewer declines in their confidence to become a leader in computing, controlling for all other variables. This underscores the importance of interactions with both computing faculty and peers, which is consistent with prior research and theory on leadership development. Notably, the frequency with which students interacted with the computing faculty was not significant in the final model, suggesting that it is the *quality* of faculty interactions that matter as opposed to the

frequency. These findings should also be interpreted in light of the qualitative findings that are discussed in Chapter 5, as the qualitative stream of this study provides more insight into the types of classroom and peer environments that shape women's experiences.

Counterintuitively, students who perceived a more contentious computing classroom climate had more confidence in their computing leadership, holding other variables constant. Importantly, this measure of climate included items asking students the extent to which they felt that "people tend to attribute your success to special treatment or luck rather than to your competence". Perhaps students who have more confidence in their abilities and competencies are more likely to feel that those competencies are questioned in academic spaces; this will be discussed further in Chapter 6.

Finally, playing video games was a negative predictor of leadership confidence in computing. That is, students who spent more time playing video games tended to feel less like they could become a leader in their field of computing, holding other variables constant. This finding is consistent with the findings above (i.e., time spent playing video games was also a negative predictor of general leadership self-ratings).

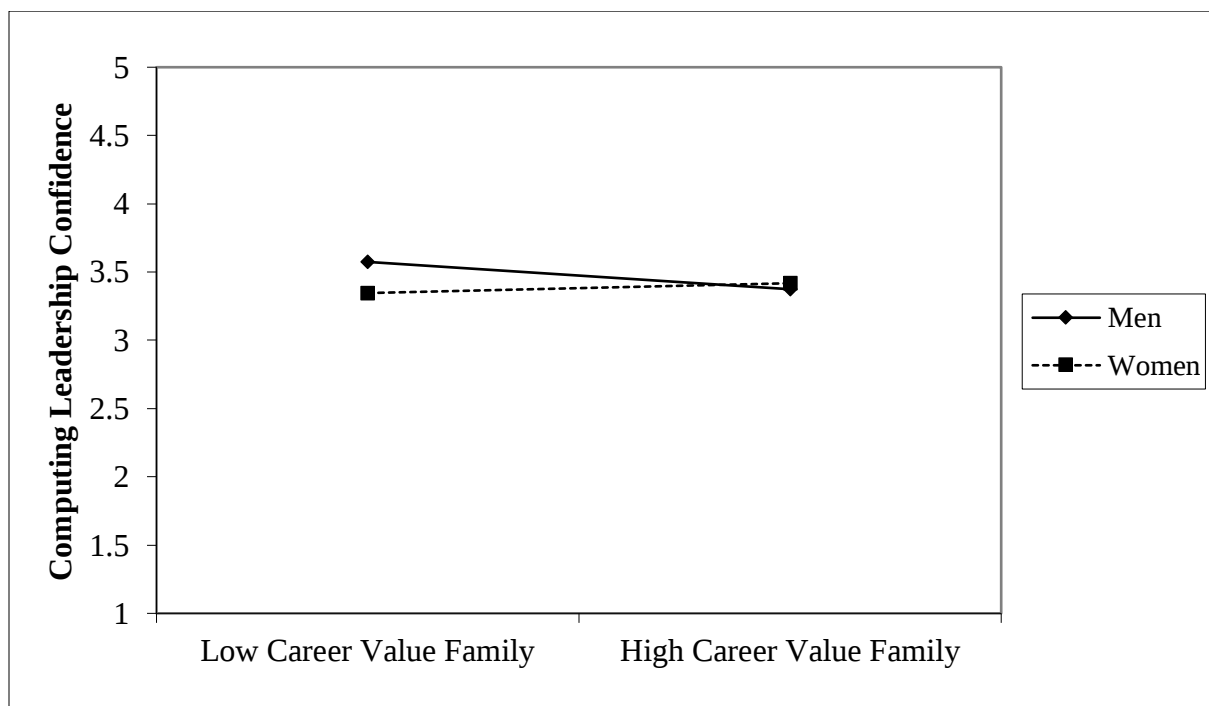
Conditional Effects. A goal of this study is to examine how the predictors of computing leadership confidence might be different for women compared to men. To examine this, I ran another linear regression, this time testing for conditional effects using two-way interaction terms. This revealed two significant interaction effects, shown in Table 4.6.

Table 4.6 Main Effects and Interaction Effects Predicting Computing Leadership Confidence

	Model 1 (Main Effects)	Model 2 (Interaction Terms)
<i>Pretest and Control Variables</i>		
Pretest: Self-Rated General Leadership Ability	0.156	0.157
Pretest: Self-Efficacy for Computing Leadership	0.205	0.207
Computing Major (reference group=computing minors)	-0.042	-0.043
Gender: Woman	-0.034	-0.038
Race: African American/Black	0.039	0.044
Race: Asian	-0.043	-0.043
Race: Latinx	-0.033	-0.031
Socioeconomic Status	0.034	0.035
<i>Background Characteristics</i>		
Career Value: Social Orientation	0.076	0.078
Career Value: Family	-0.057	-0.091
Parent STEM Career	-0.009	-0.005
<i>Non-College References</i>		
Fit and Belonging in Computing	0.402	0.396
HPW: Household/Family Duties	0.061	0.063
Attended Diversity Conference(s)	0.002	-0.030
<i>College Experiences</i>		
Computing Faculty Interaction: Frequency	0.053	0.048
Computing Faculty Interaction: Mentorship	0.067	0.070
General Mentorship (not computing specific)	0.004	0.000
HPW: Computing-Related Student Groups	0.077	0.073
HPW: Other (Non-Computing) Student Groups or Clubs	0.062	0.067
Contentious Classroom Climate	0.075	0.078
Perceived Gender Diversity Among Student Body	-0.030	-0.031
HPW: Playing Video/Computer Games	-0.060	-0.063
<i>Interaction Terms</i>		
Interaction: Gender*Family Career Value		0.065
Interaction: Gender*Diversity Conferences		0.071
<i>Adjusted R²</i>	0.419	0.425

Family Career Value. In general, the analyses above revealed that valuing a career where one can spend time with family is a negative predictor of computing leadership confidence. However, tests for interaction effects revealed that this relationship only held true for men. That is, men who value finding a career where they can spend time with family (high career value family) tended to be less confident in their capacity to become a leader in the field of computing; this relationship was not significant for women (see Figure 4.4).

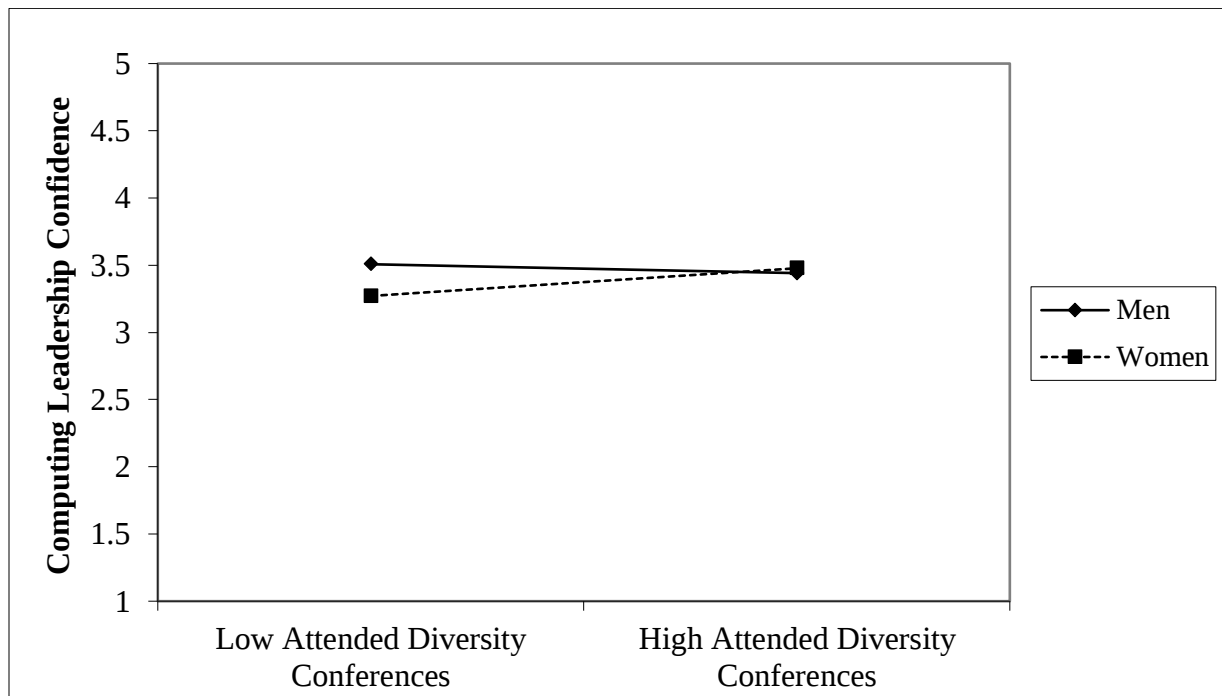
Figure 4.4 Conditional Effect of Family Career Value on Computing Leadership Confidence



Attending Diversity-Related Conferences. Additionally, the role of attending diversity-related conferences depends on gender. While attending diversity-related conferences (e.g., the Grace Hopper Celebration of Women in Computing) was associated with greater computing leadership confidence for women, the relationship was not significant for men (see Figure 4.5). This makes intuitive sense, given that men may see themselves represented in computing leadership on their campuses and in popular media, while women may be more likely to see

significant representation of women in tech leadership roles for the first time when they attend conferences like the Grace Hopper Celebration of Women in Computing.

Figure 4.5 Conditional Effect of Number of Diversity Conferences Attended on Computing Leadership Ratings



Summary of Research Question Two

The findings discussed above reveal the background characteristics and experiences that predict both general self-rated leadership abilities and self-rated confidence for computing leadership. While there were some similarities between the two models, there were also some important differences. Notably, general self-rated leadership was strongly predicted by incoming leadership confidence, while self-rated computing leadership appeared to be more malleable (i.e., the pretest was not as strong of a predictor and explained less of the total variance in the outcome). Similarly, the model predicting computing leadership ratings does a better job of explaining the variance, compared to the model predicting general leadership self-ratings. These findings suggest that general self-rated leadership abilities are more fixed, while domain-specific

leadership confidence (e.g., computing leadership) may be more easily influenced by experiences in that domain. Additionally, there may be a wider array of factors contributing to general self-rated leadership abilities that are not captured in this study, though some of these factors may be more fully captured in the qualitative stream of this inquiry (see Chapter 5). In general, these analyses confirm prior research and theory emphasizing the important role of peers and faculty in computing, while also providing insight into new experiences that have not been as widely studied like time spent playing video games, perceptions of gender diversity in the student body, and incoming values that also relate to leadership outcomes.

Summary of Quantitative Findings

The quantitative stream of this study explores how self-rated leadership confidence differs by gender, intragroup variation in leadership confidence among women and men, and the predictors of self-rated leadership among computing majors and minors. Findings reveal gender differences in self-rated leadership (general and computing-specific) that are consistent with prior literature on self-ratings. While few significant intragroup differences emerged, those that did primarily pointed to differences in self-rated leadership confidence among men.

The results reviewed in this chapter underscore the importance of studying domain-specific leadership confidence separately from general self-rated leadership, as the predictors of the two dependent variables differed. The model predicting general self-rated leadership identified few significant college experiences, suggesting that students' confidence in their general leadership abilities is largely a product of the confidence they bring with them to college. On the other hand, the model of self-rated *computing* leadership pointed to several environmental predictors, including the importance of feeling supported by computing faculty mentors and spending time in student groups, which were significant even after controlling for incoming

leadership ratings. Still, incoming leadership confidence and the values and beliefs that students bring to college computing are among the strongest predictors of leadership confidence in computing.

In several instances, the predictors of leadership confidence also depended on the student's gender. Having a parent with a STEM career positively predicted women's general leadership self-ratings but not men's, while perceiving the computing student body to be diverse positively predicted men's general leadership self-ratings but not women's. Among men only, placing high value on finding a career where one can spend time with family negatively predicted computing leadership ratings. Finally, attending diversity-related computing conferences positively predicted women's computing leadership confidence but was not significant for men. These findings, in particular, point to the importance of examining gender differences in how computing students develop during college. Women and men experience undergraduate computing differently; in light of women's underrepresentation and marginalization in the field of computing, experiences that have no impact on men might be influential for women and vice versa.

The next chapter will more closely examine women's experiences, using qualitative inquiry to explore how women develop their perceptions of leadership. The qualitative stream of this study will also provide more context for the findings in this chapter. Finally, Chapter 6 will include a discussion of how the quantitative and qualitative streams of inquiry converge to provide a richer interpretation of how computing students develop their perceptions of leadership.

CHAPTER 5: QUALITATIVE FINDINGS

Introduction

This chapter reviews the findings associated with Research Questions 3 and 4, both of which used qualitative inquiry. Research Question 3 asked about how undergraduate women make meaning of their leadership (i.e., abilities, aspirations, experiences), while the final research question asked about women's conceptions of computing leadership. Both of these questions utilized interview data from a purposefully selected sample of 12 undergraduate women who took both the pretest and follow-up surveys and indicated a computing major (see list of participants in Chapter 3, Table 3.1). Data were analyzed to identify emergent themes in accordance with the feminist standpoint and phenomenological framework that is described in Chapter 3.

As illustrated below, participants often discussed their own leadership and how they conceptualize leadership in their field simultaneously; thus, many emergent themes relate to both of the qualitative research questions. For this reason, the findings are organized into two sections. First, I review each of the themes as they relate to both research questions. In accordance with a phenomenological, the themes are described using quotes in an effort to keep the findings in the voices of the participants. While feminist standpoint theory stresses the importance of centering women's voices, it also requires me, as a researcher, to acknowledge my own positionality and the political nature of the research; for this reason, I balance the participants' voices with my own voice, noting where my interpretations diverge from those of the participants. I conclude the chapter with a discussion of how the findings address each research question.

Review of Qualitative Findings

Women Held Multifaceted Definitions of Leadership

The way participants discussed leadership revealed a multifaceted understanding of what it means to be a leader. Discussions of how leadership is multidimensional were present in nearly all interviews (9 participants) and typically included a discussion of the interpersonal nature of leadership, how leadership is distinct from management, and/or how gender influenced their thinking. Some described different facets of leadership as being specific to computing and tech fields, but others noted that computing leadership is similar to leadership in other disciplines.

Leadership Requires Interpersonal Skills. Most women identified the interpersonal nature of leadership. This is illustrated by Anna, a recent graduate with a computer science degree. As illustrated below, Anna defined a leader as being someone who is a *teacher* and *role model*, and who works to encourage and advance others on their team.

When I think leader, I guess I think of someone who progresses others simultaneously while progressing themselves, someone who is a good resource to others. Basically, a teacher and someone who is a good role model, someone who is encouraging, supportive.

(Anna)

Anna's comments were echoed by Lana, a third-year computer science major who emphasized the importance of working *alongside* others and recognizing the talents and needs of individuals on the team.

I think about leadership as someone who works kind of alongside you and shows you what to do rather than just tells you... A leader can recognize the differences between people and how they learn best or how they respond best. I think that defines who a great leader is, recognizing that everyone is different, and [knowing] how to make that personal relationship, and knowing how to make their employees grow. (Lana)

Leadership as Distinct from Management. Participants also saw management and leadership as two distinct concepts. Specifically, participants defined a manager as someone who delegates tasks and typically has positional authority but is not necessarily a *leader*. In their view, someone who is a manager may or may not have the ability to motivate others. Some participants noted that managers tend to be more “task-oriented” as opposed to “people-oriented”. These distinctions are illustrated by Lisa and Maddie, two rising third-year students majoring in computer science and computer systems, respectively.

So, a manager would just make sure that whoever they’re in charge of is getting what they need to get done, while a leader is more hands on, not just task-oriented anymore. (Lisa)

I think [leaders and managers] could be similar in that, in the workplace, you have managers, but not all managers are leaders. So, I think the difference is that a leader allows their coworkers to express their ideas, and they know how to communicate well with them. With managers, I think it's like someone who's like out of business school and they follow certain orders. (Maddie)

Later in our conversation, Maddie went on to use the term “emotional IQ” as being key to the distinction between leaders and managers. As illustrated by these comments, the participants identified some key components of leadership. Again, participants acknowledged the social nature of leadership, noting that the difference between a leader and a manager is that a leader goes beyond delegating tasks. Rather, leaders take individuals into account and adjust their approach so that everyone in a group feels valued and motivated.

The Role of Gender. When asked if they felt like gender influenced how they think about leadership, about half of women said that it did not. The remaining half had different beliefs about how gender plays a role. Some participants acknowledged that men are *falsely* assumed to be better leaders, saying things like,

Men are kind of being chosen to be leaders over women just because it’s the background of American society. (Lana)

In other words, some women recognized that gender stereotypes about leaders exist, while also rejecting those stereotypes in favor of a more egalitarian understanding. Others felt strongly that how they think about leadership is not masculine, noting that, if anything, *women* tend to gravitate toward leadership more frequently because women tend to be “more responsive to emotions”, according to Liz, a fourth-year computational biology major. In this case, Liz and others rejected traditional gender stereotypes about leadership in favor of alternative gender stereotypes, namely, that women are better at managing emotions and supporting others.

Mismatch Between Definition of Leadership and Perceptions of Leadership Abilities

Despite the way participants defined leadership around interpersonal traits, when I asked about the extent to which each participant felt that they had the leadership traits that they had just described, a third of participants' descriptions changed, now focusing primarily on the ability to have "authority" over others and/or the need to be comfortable being in the "public eye". In other words, the participants relied more on masculine stereotypes when they were discussing their own leadership abilities compared to when they were talking about leadership as a general concept. For example, when asked about the extent to which she identified with the leadership traits she had just described, Lana responded,

I don't see very much of these [leadership traits] in myself... I feel like I'm friendly enough with people, so that's good, but I guess I'm not very controlling, the way a leader might be.
(Lana)

In Lana's comment, she mentions that she does not see herself as controlling, despite the fact that the concept of controlling others was not mentioned in her previous description of leaders. Similarly, Liz, a computational biology major, had previously described effective leaders as being people who are able to respond to others' emotional needs so that everyone feels valued and motivated. However, when asked about her own leadership abilities, she expressed somewhat of a contradictory viewpoint, identifying the importance of reasoning over emotions in order to be viewed as a leader.

Everyone, well not everyone, but society generally views women as being more responsive to emotions and one of the things about leadership that people generally mention are like levelheadedness and being able to reason instead of following your emotional thoughts about things. I feel that's sort of more favoring masculine traits than feminine. (Liz)

While Liz is not talking specifically about her own leadership, she quickly changed the way she conceptualized leadership when she was asked to talk about leadership traits in herself. Both Lana and Liz illustrate the way that participants may revert to masculine stereotypes about leaders when they were asked about their own leadership abilities and identity, despite the fact that they had previously described leadership with fewer masculine stereotypes.

Women Aspire to Tech Leadership

Despite the way that women described their leadership traits (or *perceived* lack thereof), over half of participants (8) expressed a clear desire for leadership in tech; often participants mentioned that they wanted to pursue a leadership role so that they can make an impact on the tech field. For example, both Anna and Sarah mentioned diversity and women's representation in their discussion of why they wanted to pursue leadership in their field.

I mean I definitely care about diversifying computer science. I would like to see more women in there. So yes, I can see myself pursuing leadership down the road. (Anna)

Yeah, leaders in tech have -- like I said, they have a mindset and the goals in which to achieve -- to make a difference in the world, like they don't think small, they think big and how it could affect different areas of the world. And as a computing major, I really want to

make a difference, especially because, you know, when you see women in leadership in tech, like you hardly see them. It's still sort of a male-dominated field right now. (Sarah)

Somewhat related to Anna's and Sarah's comments, others noted that the desire to "prove others wrong" or "prove that women can do tech" motivated them to pursue leadership in their computing courses and in their future careers (see the next theme related to this). Still, other participants did not discuss diversity or women's representation as a motivator for leadership. For example, Maddie and Sara emphasized the importance of influencing others without mentioning diversity or women's representation specifically.

I think what is appealing is like you are able to influence a group of people, and...when you have like an idea or something you're passionate about, you can get other people to be passionate about it too. I think that's really cool. (Maddie)

I think what I'm looking for in career is somewhere that I can honestly impact as many people as I can. That's broad, just because I am open right now as far as career choice goes. I have to remind myself to not exclude [career options], so that's kind of broad as far as it could go for a career, to be able to influence and attract as many people as I can. (Sara)

Regardless of the specific motivation, the vast majority of participants expressed a strong desire to become a leader in their field. Importantly, and as illustrated by some of the themes below, women discussed already being a leader in their computing major and described various

leadership roles that they have held in their computing department, student groups, and off-campus experiences (e.g., at work, internships, summer programs, etc.).

Need to Prove that Women Can “Do Tech”

Related to some of the other themes reviewed in this chapter, women sometimes felt that they needed to prove gender stereotypes wrong by doing well in computing and pursuing leadership in their computing courses and department. While this was sometimes described as a source of stress, others mentioned that this was a source of motivation.

I feel like the reason why women do have those leadership skills is because they want to prove to others, to not just men, but society itself that they are capable of tackling certain challenges. (Katie)

The thing that is appealing [about leadership in tech] is...that you're using it to prove that you are able to do the work. (Sarah)

Here, Katie and Sarah are both talking about leadership in computing as part of a larger discussion about how women in computing tend to stand out as leaders in their computing courses. Specifically, they note that women in computing might pursue leadership because they are motivated by a need to prove that women can be successful in computing or be a role model for other women and girls in the field. For both Katie and Sarah, the desire to prove others wrong served as a source of motivation, shaping their aspirations for leadership and motivating them to speak up in class. Notably, Katie eventually left the computer science major, citing experiences of sexism and feelings of isolation in her introductory computing course.

Importantly, other participants described this need to prove others wrong as a source of distress, saying that they feared that if they shared a wrong answer or made a mistake when working with their peers, they would reinforce stereotypes about women in computing. However, on the whole, women felt that the need to prove that women can be successful in computing was a source of motivation.

The Importance of Early Experiences

When discussing how their leadership developed during college, most women emphasized the importance of their early experiences. Many participants said that college was the first time they personally encountered sexism in computing. While this first encounter with sexism was described as difficult, participants noted that their high school experiences helped them to maintain their confidence. In that sense, women's responses focused not on how college impacted them, but rather on how their precollege experiences made them more resilient to negative college experiences.

Yeah, I guess before I came to college, I wasn't that exposed to a lot of [gender stereotypes about computing]. I mean I went to that one computer programming class in high school and there was an even distribution of girls and boys. So, I think I was in a pretty progressive county or school district. I really think that my perception has changed not much, even though I've been exposed to like way more people, and a lot of those people have told me like, "oh, I never met like a girl computer engineer before" or stuff like that.

(Lisa)

But going from an all-girls school for several years to a university that was primarily men in the college of engineering department. It was sort of like an eye-opener. I forgot that men were primarily doing [computing]. (Mariam)

Both Mariam and Lisa credited their progressive high school experiences as providing a foundation that made it easier to tolerate sexism in their college computing courses and pursue leadership roles in their courses and department in the face of hostile climate toward women. Because they were first exposed to computing in a more egalitarian environment, they felt that they were not as negatively impacted by exposure to gender stereotypes in college. Both Mariam and Lisa described ways that they took on leadership in their computing courses and department, which they attributed, in part, to the confidence they gained before college.

Pervasive Gender Differences in Group Assignments

One of the most pervasive concepts that emerged in the interviews is the way students described their experiences with group assignments. Women consistently discussed the way that instructors tended to assign students to groups of about four to complete assignments, and that there tended to be only one woman in each group; that woman was typically the one who coordinated her peers and ensured that the group assignment went smoothly. Such descriptions of group dynamics became predictable and emerged as a key part of the conversation in nearly every interview. Less predictable was the way women made meaning of these experiences. Some participants described this as a positive experience (e.g., women are natural leaders and are demonstrating their success in computing courses), while others described this as a burden or a sexist experience; many grappled with how to make meaning of these experiences. These dynamics and varying interpretations are described in the following two overlapping themes. Note

that I have broken this into two separate themes below to preserve the positive experiences women described (first subtheme) while also including my own critical interpretation of these dynamics (second subtheme).

Women Gravitate Toward Leadership in Group Assignments. Over half of participants (7) noted that they and/or other women in their classes tend to take on *leadership* roles in most or all group assignments. Some attributed this to the importance of grades; they felt that men sometimes “slacked” and would not take the initiative necessary to complete the assignments. Other times, women said that they naturally took on leadership because their male classmates tended to not have the interpersonal skills necessary to coordinate people and projects. Katie, a rising third year student who left the computer science major described this, saying that,

I feel that, yes, that males do have more dominance in the STEM field, but that doesn't necessarily mean that they have leadership skills. Some may, but I feel when I was in my intro to programming class, for example, I didn't necessarily see a lot of leadership within the male classmates that I had. So, I feel that they're lacking that, but they are dominant in the STEM fields. But I also see that the female classmates that I had in that intro class actually showed more engagement... Whenever I was in a group or my friend was in a different group with four or five guys, she would mostly come up with ideas and then I would mostly come up with ideas as to how to plan a certain project or finish a certain assignment. So, I mean really it's just very sad that society is depriving women and showing that stereotype that women can't really necessarily have that capacity to go into STEM fields and gain that knowledge or leadership. (Katie)

In this quote, Katie is grappling with two contradictory ideas. First, she has heard that men have “dominance in the STEM fields”, but at the same time, she sees women excelling in her classes, observing that women in her classes tend to show more leadership in group assignments compared to her male classmates who she described as lacking leadership skills. Other participants described a similar dynamic. While Katie noted that women tend to have strong leadership skills and so they pursue leadership in class, other participants described that they would not necessarily have chosen to take on leadership roles in group assignments, but they ended up being somewhat forced into such a position. Taken together, the comments below from Lisa, Rosie, Sheryl, and Mariam illustrate the pervasiveness of this dynamic.

So, in those situations [when no one in the group steps up], I oftentimes just kind of step up and be like, okay, like we have to have a presentation done in a week, like let’s meet tomorrow and figure out. (Lisa)

It was scary at first because I didn’t really want [to lead the group], but I obsess about my grades, so I couldn’t let this group fall apart. And I knew no one else in the group was going to step up. (Rosie)

In my opinion from what I heard, right or wrong, I think it’s more or less females may be taking the leadership in classes and in academics, because they care more about their grades, which is their stereotype I think. I think it’s almost that leadership kicks in when

it's like, "I have to do well in this group project, I have to do this to get a good grade".

(Sheryl)

You know, you have to say, "okay well nobody is responding, nobody is doing that so I will just start planning", and so sometimes you have to say, "I am going to do this. I'm just going to start planning things", and...you do get pushed into it. (Mariam)

As illustrated in the quotes above, many participants described being somewhat forced into leadership when no one else in their group "stepped up". In some cases, women described how the men in their group would not say anything during group meetings or would be otherwise uncommunicative. Katie, who eventually left computing, went as far as to say that she did not see leadership among male introductory computing students. Despite being thrown into a leadership role, most participants noted that serving as a leader in class assignments became "natural" for them and was, at least partially, a positive experience. Sometimes women discussed this as being an opportunity to develop their leadership skills or demonstrate to their professor and classmates that "women can do computing" (see theme above).

Group Assignments Reinforce Gender Stereotypes. While women often initially discussed their role in group assignments as a positive experience, many of them either explicitly identified or described gender stereotypical roles, such that the women were *expected* to coordinate assignments and take on more of a "secretarial role", while the men in the group completed the technical aspects of the assignment. Women said that they took on the administrative aspects of the group assignment for a number of reasons that are discussed in the theme above (e.g., women seemed to care more about grades). Sara, a third-year student who

switched out of the computer engineering major to study information technology, further explained this phenomenon by describing differences between how women and men approach group assignments.

You know, how we women, we're kind of sometimes perfectionists, so we don't want things to go wrong in our group project and, you know, sometimes men can be a little sloppy sometimes in some areas. So, we tend to make sure everything goes right so we don't miss anything. (Sara)

Related to this, some participants mentioned that men in their assigned groups simply assumed that if there was a woman in their group, then she would organize and coordinate the different aspects of the assignment. Katie described this phenomenon, discussing the outright sexism that she encountered in her computing courses before she left the computer science major to study social work.

[My male peers] would expect me to like take notes and kind of listen in and be on the side and just like mind my own, you know, business and not really get involved, but that wasn't the case. I actually got involved and started telling them what to do and how to do it and how we should tackle certain projects a certain way and how if we need to get help then we should just go to the professor for help. And they were just shocked kind of like, "oh, we didn't expect you to say anything" or "we didn't expect you to kind of tell us what to do"....That's like the major problem because a lot of men actually consider a lot of women to not be their equals, so [men] expect [women] to do small little things such as like

organizing a schedule for everyone to meet up at the same time and work on the project and expect her to like take notes and kind of, you know, just sit there quietly and not share any ideas. (Katie)

Other participants noted that they ended up coordinating assignments for other reasons, including that men seemed more confident in their technical abilities, and so they felt that it made sense for men to complete the more technical parts of the project. Yet, women also noted that sometimes they eventually ended up completing the entire assignment alone because they had to also “fix the guys’ code” at the last minute. In some cases, fixing their male classmate’s work is what helped the participants to realize that they had the same or better technical abilities as others in the group and that the dynamics of their group were sexist.

While the two themes related to these group dynamics are largely overlapping, they are kept separate to preserve the way that participants described their experiences. In some cases, women described being in charge of their group assignments as a positive thing—they had the opportunity to gain leadership experience. However, as we talked more about what this experience was like and how it felt, they started expressing some of the negative aspects, noting that maybe the role they played in group assignments aligned with their definition of *management* more so than *leadership*. Not only did these experiences limit their opportunities to complete the technical aspects of group assignments and place a disproportionate workload on women in the group, but it also sometimes seemed to make women feel isolated in their computing courses.

Students Are Impacted by the National Focus on Women in Tech

The last theme that emerged is related to the awareness that women have of the larger national dialogue on women in computing. This final theme does not directly relate to

perceptions of leadership but provides useful context for understanding the research questions. Though it was not always the case, most participants were well aware of the national conversation on women's representation in tech. Five women described situations in which they were very much influenced by that national dialogue. Specifically, they seemed to be influenced primarily by deficit-frameworks of understanding women's underrepresentation (e.g., assumptions that women are unprepared for the computing major) and conversations related to affirmative action or receiving "special treatment". Sometimes the national dialogue was a source of motivation (e.g., they wanted to prove others wrong). Other times, the dialogue led them to question their ability to be successful in computing. Some women rejected the national focus on women in tech, noting that conversations related to women in computing are not representative of their experiences. This belief was most strongly endorsed by Rosie, a third-year computer science major who expressed concern over research and initiatives related to increasing women's representation in computing.

If you hear something enough, you start to really think this has got to be true and it's totally subconscious in feeling. Like I said, like even though I've started to have an awareness about doing it and I catch myself doing it. So, I do, I don't know, I worry about...research like this [on women in computing]. I worry that it is just kind of perpetuating false ideas. I'm not saying it is, but I don't know you know, what you do, or how you do it. (Rosie)

This comment was part of a conversation where Rosie identified negative experiences she frequently has when she takes surveys on women in computing, noting that she catches herself internalizing negative survey statements about women's abilities to do computing. During our

interview, Rosie rejected the notion that women experience discrimination in computing or leadership roles. In alignment with her largely postfeminist thinking, Rosie expressed a larger concern that focusing on gender discrimination or women's underrepresentation in computing is not useful. While I, as a researcher, do not agree with this assessment, Rosie's insights certainly merit careful consideration. We should be mindful of the ways that college students are impacted by national dialogues and, perhaps most importantly, how students are affected by our work. Importantly, when I had another conversation (member check) with Rosie 6 months after the initial interview, she expressed a very different viewpoint, no longer endorsing postfeminist beliefs about computing.

Somewhat related to Rosie's concerns, other participants explained that they worry about being perceived as receiving "special treatment" because of their gender. Some participants described specific examples when they had been told that they benefit from special treatment. In these instances, I probed further to ask if they found those comments offensive. Despite my assumption that they would be offended, that is not what participants described. For example, Lisa, a computer science major, noted that she agreed that she might benefit from special treatment, saying,

I'm not offended [by being told I receive special treatment] or anything. I kind of agree because I feel like companies, you know, they have their quotas... I would say I think that gives me a leg up because everyone's always saying like oh, you're a girl computer scientist, like you're going to be getting a job, no problem. (Lisa)

Both Rosie's and Lisa's comments are examples of how undergraduate women in computing might internalize things that they hear about women in computing. While Rosie, explicitly acknowledged that she sometimes caught herself internalizing negative stereotypes that she sees on surveys, Lisa did not acknowledge any negative feelings but certainly internalized the notion that she receives special treatment in computing. Still, other participants expressed more negative feelings and distress related to whether or not they had earned their accomplishments, leading them to question their abilities and fear leadership. These findings highlight the importance of understanding the way students make meaning of leadership in light of what they perceive as the broader context for women.

Summary of Findings and Research Questions

Research Question Three: Self-Perceived Leadership

As a reminder, Research Question Three asks about how women conceptualize leadership in themselves, focusing specifically on their self-perceived leadership abilities, their aspirations for leadership, and how they make meaning of their leadership experiences. Many of the themes discussed above begin to address the ways in which women make meaning of these different aspects of their leadership.

Perceived Leadership Abilities. The women in this study frequently provided examples of times when they were successful in various leadership activities. Yet, when directly asked about their leadership abilities, they tended to be critical of themselves, often focusing on concerns about their *perceived* inability to be authoritative or concern about being under the scrutiny of the public eye. Importantly, participants began the interview by defining leadership around relationships and interpersonal skills without mention of authority or public scrutiny (see “Mismatch Between Definition of Leadership and Perceptions of Leadership Abilities”).

Leadership Aspirations. Consistently, the women in this study expressed a strong desire for leadership. Though these aspirations were sometimes described broadly, many of the participants hoped to become a leader in the tech field. Some students mentioned specific leadership positions, such as project manager or business owner, but this was less common. Importantly, the majority of students were interviewed in the summer before their third year of college; we might expect that aspirations for leadership might become more specific as students near the end of college and transition into their careers. In short, students were in different places in terms of their plans for their future careers, but they consistently saw themselves as eventually pursuing leadership in some capacity.

As reviewed in the themes above, women identified different forces that motivated them to pursue leadership. Some described a desire to prove that women can be successful in computing, while others used slightly different language to express a similar desire to be a role model for girls and women. Others described more general goals, noting that leadership in computing would position them to impact society and influence others.

Leadership Experiences. One of the most pervasive themes across participants was the notion that participants saw themselves (and sometimes women generally) as being leaders, or at least managers, in their courses. The way women experienced leadership was certainly gendered, with students describing sexism in the ways that students were expected to engage in group assignments. As discussed above, women consistently gravitated toward coordinator roles in the classroom and in group assignments, but the way they understood and made meaning of these experiences differed.

While students grappled with how they understood group experiences, as an outsider, I interpret these experiences as very blatant experiences of sexism. Though some women referred

to these classroom dynamics as leadership, the description of these activities aligned more closely with how they defined management, which they viewed as distinct from leadership. These findings also beg the question, what would leadership in the classroom look like? A couple of participants touched on this idea by briefly distinguishing between intellectual leadership and project coordination, though this did not emerge as a theme.

In addition to college experiences with leadership, students also frequently discussed precollege experiences as being important in building their leadership confidence and/or confidence in computing. Being exposed to more egalitarian computing environments in high school or having a family member with a STEM career are examples of the types of experiences students mentioned as being impactful, especially when they encountered sexism in their college computing courses.

Research Question Four: Perceptions of Leadership in Computing

While Research Question Three asked about how women view their leadership abilities and experiences, both generally and in computing, the final research question focuses on women's conceptions of leadership in computing. Specifically, Research Question Four asks about how undergraduate women computing majors define and make meaning of leadership in computing. The findings discussed in this chapter provide some insight into how women identify the traits of leaders in computing and the extent to which they identify with those traits themselves.

The Traits of Computing Leaders. The women in this study discussed many leadership traits, primarily focusing on those related relationships and interpersonal skills. Specifically, participants focused on the ability to motivate others and respond to the individual needs of people on a team. As discussed above, participants often used words like emotional intelligence

and empathy to describe the traits of leaders. Interestingly, it was not until I asked about the extent to which they saw those traits in themselves, that women also brought up characteristics related to being “authoritative”. Participants had conflicting beliefs about the extent to which computing leadership was or was not distinct from leadership in other fields. In general, they did not distinguish between leadership in computing and leadership in other disciplines.

Self-Perceived Computing Leadership. As previously discussed, participants tended to be critical of their leadership when I asked them about the extent to which they see leadership traits in themselves, often bringing up their perceived “lack of authority”. However, when I probed further and asked them about the extent to which they saw the specific leadership traits they had identified (e.g., empathy, emotional intelligence, etc.) in themselves, their answers became more positive.

Additionally, women consistently aspired to leadership, though their aspirations for specific aspects of leadership were more varied. When asked about the extent to which leadership in computing is appealing to them, women tended to return to the discussion of having authority and being in the public eye, noting that these aspects of leadership are unappealing. Again, it is notable that these aspects of leadership did not emerge when women were initially asked to define the traits of leaders in computing.

Conclusion

In this chapter, I reviewed the findings associated with the qualitative stream of this inquiry. Findings discussed in this chapter reveal insights into both how women view their leadership abilities and experiences as well as the ways that women conceptualize what it means to be a leader in computing. These students recognized the multifaceted nature of leadership, though their definitions of leadership tended to become narrower when asked to talk about their

own leadership abilities. While students did not always believe that gender influenced the way they think about leadership, they described sexist experiences in the classroom, expressed an awareness of gender stereotypes about leadership and computing, and sometimes acknowledged the way the larger dialogue on women in computing shaped their experiences. In the next chapter, I will expand on these findings, focusing on the convergence of the quantitative and qualitative streams of this inquiry.

CHAPTER 6: DISCUSSION AND IMPLICATIONS

This chapter summarizes the findings of this study, focusing on the ways in which the quantitative and qualitative streams of inquiry converge. After reviewing the purpose of the study, I discuss the key findings, implications, and suggestions for future inquiry.

Summary of the Study

This study explores the ways in which computing majors and minors develop their leadership confidence during college, focusing on how this differs by gender. Further, I examine women's experiences and meaning making more closely to consider the ways in which women define leadership, identify with leadership traits, and make meaning of their experiences with leadership. To examine these different concepts, this study relies on a convergent mixed-methods design.

The quantitative stream of the inquiry focuses on two dependent variables measuring: general self-rated leadership abilities (not specific to computing) and self-rated confidence in one's ability to become a leader in the field of computing. This portion of this study was heavily influenced by Komives and colleagues' (2004) Leadership Identity Development (LID) Model and Weidman's (1989) model of Undergraduate Socialization (discussed in Chapters 2 and 3). Together, these theories form a conceptual framework that highlights the role of background characteristics, family socialization, non-college references, and college experiences.

The qualitative stream of inquiry is guided by a feminist standpoint and phenomenological approach, which centers the voices of women to provide a nuanced understanding of how women make meaning of leadership and their experiences. Feminist standpoint theory is an important focus of this inquiry, as described in Chapter 3. In short, standpoint theory, along with phenomenology, provides a framework for giving agency to participants as they guide the

inquiry. While phenomenology emphasizes the importance of centering participant voices, standpoint theory requires that we center *oppressed* voices, which enables research to challenge existing assumptions and distorted views of reality that privilege dominant groups. In this case, standpoint theory provides an approach to challenging assumptions about the nature of gender, computing, and leadership.

The quantitative and qualitative streams are guided by different research questions, with the quantitative questions focusing on how students report their leadership confidence and the predictors of those reports, while the qualitative questions ask about women's meaning-making regarding leadership. However, the streams of inquiry also converge to provide a nuanced understanding of how gender shapes students' perceptions of leadership and the types of experiences that influence leadership development for women and men. More specifically, the feminist phenomenological framework that guides the qualitative stream enables me to explore the LID and Undergraduate Socialization models, with findings both confirming and extending existing research and theory. While the previous two chapters have reviewed the quantitative and qualitative findings separately, this chapter will discuss the two simultaneously to provide a more comprehensive interpretation. Part I of the discussion will focus on how students conceptualize leadership and perceive their leadership abilities, while Part II will focus on the different experiences and factors that shape the way leadership confidence develops and how women make meaning of their leadership development.

Discussion Part I: Conceptualizing Leadership

When examining the gender gap in leadership confidence, it is important to understand how students conceptualize and define leadership, as students' understandings of leadership certainly shapes how they indicate their leadership on surveys. Findings reveal ways in which

women defined leadership around interpersonal characteristics (e.g., emotional intelligence, ability to inspire others, etc.), though their definitions became more focused on their (*perceived* lack of) ability to maintain authority and manage being in the public eye when students were asked to discuss their own leadership characteristics. Perhaps this finding is related to “stereotype threats” that students experienced during the interview; that is, discussing gender during the course of the interview may have activated stereotypes and led them to internalize and/or express masculine stereotypes when asked about their own leadership abilities. This would be consistent with a large body of research that has found that exposure to negative stereotypes about a given group threaten both the academic performance and self-concept among members of that group (see Steele & Aronson, 2005). In fact, some research has explored stereotype threat in the context of women’s leadership, finding that exposure to gender stereotypical TV commercials negatively predicted women’s leadership aspirations (Davies, Spencer, & Steele, 2005). Future researchers might consider how participation in research about stereotypes and inequity might have unintentional negative consequences for individuals from oppressed groups.

Gendered Definitions

When students were asked about the extent to which their definition of leadership was gendered (or not), responses varied. Some students felt strongly that gender was not relevant and went on to endorse largely postfeminist beliefs (i.e., beliefs that sexism no longer persists) about computing and leadership. Other students identified leadership as being stereotypically masculine, while others identified leadership as being more accessible to women who they perceived to be more responsive to emotions, which was an important component of their definition of leadership. Many women I spoke with otherwise articulated advantages related to

being a woman in computing (e.g., they receive special treatment, women are “naturally” better leaders, etc.). Regardless of whether students saw their conceptions of leadership as postfeminist, masculine, or feminine, students tended to endorse gender essentialist thinking about leadership; that is, even when they rejected negative gender stereotypes about computing, they replaced those stereotypes with alternatives (e.g., women are more responsive to emotions and thus better leaders). In other words, students tended to articulate ways in which women and men have inherent differences; this was expressed even by participants who believed we are in a postfeminist era.

These findings are somewhat consistent with prior literature that has documented ways in which students hold postfeminist beliefs, simultaneously articulating both sexist experiences and stereotypes about ways in which women and girls are privileged or “have it all” (Pomerantz, Raby, & Stefanik, 2013). Pomerantz and colleagues posit that such beliefs have limited girls’ ability to identify sexism and inequity. Similarly, the women I interviewed seemed to lack the vocabulary to describe the sexism they faced in computing, often commenting at the end of the interview that our conversation was the first time they began to find words that describe their experiences. Perhaps providing students with the vocabulary to identify sexism would be a first step in challenging gender essentialist thinking about women’s and men’s abilities to lead and pursue computing.

It is also useful to consider these qualitative findings in light of the quantitative analyses. That is, the quantitative analyses revealed gender gaps in how students rate their leadership, both in general and in the field of computing. Perhaps the way students conceptualize leadership (e.g., adopting gendered definitions) might explain gender gaps in self-reported leadership confidence,

though more research would need to be done to determine the extent to which this might be the case.

Race and Intragroup Differences

Another goal of this study was to examine intragroup differences in leadership confidence among women and men. Few significant differences emerged by race, socioeconomic status, and parent education/career in the quantitative inquiry, and students largely did not discuss race in the interviews, even when specifically probed. Perhaps my whiteness and other aspects of my positionality (see Chapter 3) did not direct students to talk about or reflect on racialized experiences in computing. At the same time, a large part of how students discussed the role of gender was related to discussions they had heard about women in computing (e.g., in the national discourse, initiatives in their department, etc.). Perhaps conversations about racial/ethnic diversity in computing might be less prevalent on their campus; students of color have certainly received less attention within the literature on computing education. Given the reality that women, and students more broadly, are influenced by the privileges and/or oppressions associated with their race/ethnicity, socioeconomic status, and other identities and experiences (see Crenshaw, 1997; Reynolds & Pope, 1991), future research on computing should examine the messages that are being sent about race and how this might impact women of color in particular.

Part II: Developing Leadership Confidence

Before discussing the key independent variables and developmental experiences that shape how computing students conceptualize their leadership, it is important to first consider the larger social forces at play. Namely, qualitative and quantitative findings suggest that both

gender and the unique disciplinary context of computing shape the way students develop their leadership confidence.

The Role of Gender

A primary goal of this study was to understand how gender shapes students' perceptions of leadership. This study points to two key ways that gender influences how computing students develop their leadership confidence. First, even when women and men are exposed to the same environments, those environments are sometimes moderated by gender (e.g., interaction effects). One example of this is that the extent to which students perceive the computing student body at their institution to be "gender diverse" predicted leadership confidence for men only. Perhaps men perceive the student body to be gender diverse if they interact with students who identify as a gender other than their own, while women may report that the environment is gender diverse if they have the opportunity to interact with other women. Further, cis students might define gender diversity in a binary way that emphasizes women's representation, while trans* students may define gender diversity as also related to the representation and inclusivity of trans* and gender non-binary students. Thus, the experience of "gender diversity" may be dependent on whether or not a student belongs to the dominant group. In fact, perceiving the computing student body as gender-diverse predicted leadership confidence for men only, which may be due to differences in how women and men experience or define "gender diversity".

In addition to women's and men's leadership confidence being differentially impacted by certain environments, gender also shapes the environments that women and men are *exposed* to. For example, increasing collaborative pedagogies and group activities have been identified as a way of broadening participation in computing (Barker & Cohoon, 2009). However, the qualitative stream of this inquiry points to significant ways that women and men might

experience leadership in group activities differently, with groups frequently reinforcing stereotypes (e.g., women are expected to schedule meetings and take notes). Similar group dynamics have been documented in recent research on gender in engineering. Namely, Smith and Gayles (2018) identified sexism in group work such that women were excluded from conversations about technical components of the assignment and were continually underestimated by their male peers. Exposure to such stereotypical and sexist environments in college certainly perpetuates gender inequity and reinforces stereotypes about women's place in computing. Thus, in considering best practices to broaden participation, it is important to critically consider the quality and nature of such practices.

Disciplinary Contexts Matter

In addition to gender, the nature of the discipline may also shape how students conceptualize leadership. For example, findings reveal ways in which computing leadership confidence develops differently than general confidence in one's leadership abilities. Notably, computing leadership confidence actually declined during college while general leadership confidence remained relatively stable. These findings expand upon prior literature demonstrating that men in STEM majors tend to decline in their leadership personality during college (Sax, 2008). While there are many reasons why this might be the case, these findings point to the importance of considering the unique disciplinary context of computing separately from general leadership development. While this study reveals ways that domain-specific leadership differs from general perceptions of leadership, future research might also examine how leadership in computing might differ from leadership in other disciplines, especially in light of prior literature revealing that women face the greatest obstacles to leadership in male-dominated fields (Eagly & Carli, 2007).

Non-College References and the Unique Context of Computing

The quantitative and qualitative findings in the present work highlight several non-college references that shape leadership confidence for computing students. These findings emphasized the role of women's larger experiences with their field including their understanding of national issues related to gender in computing, their general feelings of belonging in the field, experiences engaging with the field through diversity-related conferences, and experiences with their families; I also posit that video games may be another tool that students use to engage with the larger computing community. Engagement with the computing field and other non-college references might explain why computing leadership confidence declines during college despite the fact that general leadership confidence remained relatively stable during college.

Conversations on “women in computing”. Interview participants were well aware of their underrepresentation in the tech field, but they were not consistently aware of the extent of the national focus on this topic. For example, during the time that elapsed between the initial interviews and the member checks, Silicon Valley faced a large scandal when former Google executive, James Damore, shared an anti-diversity memo where he expressed strong disdain for broadening women's representation in computing. Between the time of the interview and the member check, one participant had read a blog post I wrote where I cited the recent events at Google (see Wakabayashi, 2017). During her member check, this student expressed shock to learn of this event, noting that she was deeply disturbed and had not heard of this story prior to reading my blog post. This experience is related to larger findings discussed in Chapter 5 about the way that women experience computing in light of research, diversity initiatives, and other conversations that focus on their experiences. Together, these findings point to questions that researchers and activists might ask when working with students. For example, what role should

the researcher play in informing undergraduate women about sexism and inequity in their discipline?

Fostering a sense of belonging. The strongest predictor of feeling confident in one's ability to become a leader in computing is more generally feeling like one fits and belongs in the field. This suggests that efforts to foster a sense of belonging would also benefit computing students' leadership confidence (see Sax et al., in progress). It is also important to consider this in light of the ways that women experience research and diversity initiatives related to their participation in computing (discussed above). Participating in research and learning about national conversations related to their place in computing seemed to, at least sometimes, make women feel like they did not “naturally belong” in their discipline, leading them to internalize negative stereotypes, fear that they benefitted from special treatment, and/or question whether or not they deserve their accomplishments in computing. Perhaps this is related to larger societal beliefs about affirmative action or women's belonging in computing. Regardless, these findings should resonate with researchers who study gender in computing or college more broadly. As a researcher myself, these findings led me to ask how I can continue my inquiry in a responsible way that does not cause harm or reinforce gender essentialist thinking about computing.

Diversity conferences. Attending diversity-related conferences like the Grace Hopper Celebration of Women in Computing or the Richard Tapia Conference might also provide students with a reference for understanding the larger field of computing. Such conferences may provide a venue for students to reflect on gender equity and interact with leaders who challenge dominant assumptions about women in computing. Interestingly, attending such conferences actually negatively predicted general leadership self-ratings for all students, but positively predicted computing-specific leadership confidence for women. Perhaps when students attend

diversity conferences, they may initially be intimidated and become more critical of their leadership abilities; at the same time, women's exposure to successful role models at such conferences, though potentially intimidating, may inspire them to pursue leadership and enable them to visualize themselves as leaders in the future. Future research is needed to determine the extent to which this might be the case. In the interviews, women discussed the importance of women role models in computing, particularly during their early computing experiences (e.g., in high school computing).

Family. Families also serve as a non-college reference that shapes how students perceived their leadership. Among women only, having at least one parent with a STEM career positively predicted computing leadership confidence. This relates to the qualitative findings where women discussed how having a parent, teacher, or other role model in STEM enhanced their leadership confidence and made them more resilient to hostile climates that they encountered in their college computing courses. At the same time, entering college computing valuing a career that allows one to spend time with one's family negatively predicted computing leadership confidence among men only. Perhaps it is the case that men who do not value spending time with their families have other attributes that lead them to overrate their computing leadership. However, actually spending more time on family and household duties was a positive predictor of computing leadership confidence for both women and men. Taken together, the findings related to family socialization begin to challenge assumptions about the congruency between spending time with family and pursuing leadership.

Playing video games. Perhaps one of the more surprising and novel findings from this study is the consistent negative role of frequently playing video games. There are many ways to interpret this finding. First, it might be the case that hours spent each week on video games

represent hours that students are not in student groups or doing other activities that predict leadership confidence. On the other hand, students with less confidence in their leadership or social abilities might be more inclined to play video games more frequently, which could explain the finding. However, the negative relationship between video games and leadership confidence holds true even after controlling for the pretests of leadership confidence, time spent in student groups, and all other variables in the model, suggesting that it may be something about the actual nature of video games contributing to this relationship. Perhaps students who frequently play video games might have negative interpersonal experiences with the gaming community that explain this consistently negative relationship. More inquiry is needed to determine whether this finding might be a product of negative social interactions with gamers, the content of video games (e.g., violence, sexism), or something else.

Research might also examine the extent to which this finding is unique to computing students; that is, experiences with the gaming community might be particularly influential for computing students, as this may be a way these students engage with the larger computing field. While I conceptualized playing video games as a student activity, in this way, video games may actually serve as a non-college reference (i.e., another way that students engage with the broader community beyond the campus context). It is important to note that playing video games may be only one example of how students engage with online communities (in computing or otherwise) and that the nature of students' online behaviors evolve quickly, which should be accounted for in future research and theory (see Heiberger & Harper, 2008; Junco, 2011; Junco & Mastrodicasa, 2007).

The Importance of Early Experiences

Both the quantitative and qualitative streams of this inquiry highlight the important role of background characteristics and precollege experiences. The regression analyses reveal that incoming leadership perceptions were among the strongest predictors of both outcomes of self-rated leadership. Precollege experiences were also an important part of the interview findings. In fact, when directly asked about their college experiences, women tended to revert to a discussion of earlier precollege experiences that have made them more resilient during college, as opposed to actual college experiences. Notably, the participants emphasized early gender egalitarian experiences with their family and education. While many participants had programming experience before college (e.g., computing camp, AP Computer Science, etc.), they noted that college was the first time they encountered sexism in computing. Perhaps women and girls who do *not* perceive sexism in computing before college are more likely to pursue computing in college (self-selected group). Regardless of the reasoning, these findings do *not* suggest that college experiences are unimportant. Rather, the next sections of this chapter will highlight several key college experiences identified in this study.

Confirming and Challenging What We Know About Peer Interactions

Regardless of whether or not they were related to computing, involvement in student groups predicted leadership confidence; this is consistent with prior research and theory on the importance of both peer interactions and student involvement (e.g., Weidman, 1987; Komives et al., 2004). At the same time, perceiving the computing student body to be more “gender diverse” positively predicted general leadership confidence for men only. Interestingly, prior research suggests that having a greater proportion of women *faculty* also positively predicts “leadership

personality” for men (Sax, 2008). Future research might explore how gender shapes peer and faculty interactions to further understand the nature of these findings.

While men appear to benefit from being in a computing department with a greater proportion of women, the qualitative findings reveal that women’s interactions with men are not always positive. More specifically, the most pervasive college experience that students described is related to how they experienced computing courses and, more specifically, group assignments. Nearly every interview participant discussed the experience of being the only woman in her group and being tasked with managing and coordinating the assignment, while men were expected to complete the technical components of the project. Not only do such dynamics reinforce gender stereotypes about computing, but they also limit all students’ access to developmental opportunities (e.g., men miss out on opportunities to develop their own management skills). In the section below on developing leadership confidence in the classroom, I suggest some specific recommendations for practice.

Faculty Interactions: Quality Over Frequency

The frequency with which students interacted with computing faculty had no bearing on their leadership confidence, generally or in computing. However, this finding could be, in part, due to the fact that participants were enrolled at large research universities and may have less frequently been exposed to meaningful interactions with faculty; this became apparent in the qualitative stream of inquiry, as faculty interactions did not appear to be particularly salient for participants, even when I probed on this topic. Yet, having quality mentoring relationships with faculty was important for computing leadership confidence in the quantitative findings. It is important to note the way computing faculty mentorship was measured; namely, care was taken to ensure that the measure included only items that indicated positive interactions (e.g., items

like “instructors provide feedback beyond grades” were not included because such feedback could be positive or negative). Thus, in thinking about how this translates to practice, it is important to focus on high quality and positive mentorship experiences as opposed to merely increasing the frequency with which students interact with instructors.

The Counterintuitive Role of Classroom Climate

Related to both faculty and peer experiences, perceiving a more contentious classroom climate (e.g., frequently feeling that others challenged or denigrated one’s ideas) was a *positive* predictor of computing leadership confidence. This might be related to the qualitative finding that women felt a strong need to prove themselves and demonstrate that women can “do computing”, which served as a source of motivation to pursue leadership. It is also important to consider how this finding relates to prior literature. Somewhat similarly, Sax (2008) found that “challenging a professor’s ideas” predicted gains in “leadership personality” among college students across disciplines. Taken together, these findings suggest that students may define leadership in terms of antagonistic traits, at least to a certain degree.

Implications

This study has implications for how we think about student leadership development, computing education, and gender equity. Throughout this chapter, I have described ways in which the present work extends existing literature and theory to the computing context, confirming existing theories, while also highlighting the unique nature of computing. Below, I describe some of the key implications and how they relate to research, theory, and practice.

(Re)Defining Leadership

Findings from this study highlight ways that conceptualizations of leadership are inconsistent both among and within participants. For example, interview findings documented

ways in which women tended to gravitate toward management, coordinating, and note-taking. Interestingly, some women referred to their experiences coordinating group assignments as leadership, despite previously defining leadership as distinct from management such that managers delegate and organize tasks while leaders motivate and inspire others. Certainly, taking notes, organizing, and scheduling tasks for group assignments more closely align with participants' original definition of management, revealing that conceptualizations of leadership vary by context, even among individuals. These findings beg the question, if the experiences that women described are not leadership, then what would leadership in the computing classroom look like? A few students named a distinction between intellectual leadership and other forms of leadership that might resemble management; this may be a consideration in how future researchers consider and understand student leadership in the classroom. That is, future research and theory might contend with the different facets of leadership (e.g., intellectual leadership) to develop a clearer definition and ways of understanding leadership development. As part of developing such definitions, it is also important to consider the ways in which leadership has been constructed around gender stereotypes to avoid unnecessarily gendered definitions.

Domain-Specific Leadership Development and the Role of Technology

The present work highlights the importance of considering specific disciplinary contexts in research and theory on college student leadership development. Even among computing students, computing leadership confidence developed differently relative to confidence in their leadership abilities more generally. Not only were the predictors of general leadership self-ratings different than the predictors of computing-specific leadership confidence, but some of the independent variables might be uniquely influential for computing students.

For example, the consistently negative effect of playing video games might be related to the computing context. While this paper conceptualized time spent on video games as a student behavior, playing video games might be one way that computing students engage with the larger computing community, making it a non-college reference group (see Weidman, 1989). Future research might consider the nature of how computing students connect with the computing community via video games and other online activities. Perhaps certain experiences with the broader computing community via video games negatively shape how students view themselves in the computing field. Further, researchers might also consider the extent to which video games and other online experiences may or may not uniquely affect computing students. Beyond the computing context, findings from the present work suggest that technology might be changing the way students engage with different communities more generally. Future research and theory that utilizes Weidman's model of Undergraduate Socialization might consider students' online experiences when conceptualizing non-college references and how students might be engaging with non-college communities. This may be especially important in studies of gender, race/ethnicity, and equity, given the hostile nature of many online communities toward women and people of color (Gray, 2012). When connecting these concepts to practice, it is also important to consider other findings related to sexist classroom experiences. That is, while it is important to understand ways that students are engaging with different communities, online or otherwise, practitioners might first contend with hostile environments on their campuses. The following section provides implications for how practitioners can consider reform efforts in their own departments and classrooms.

Developing Leadership in Computing Classrooms

This study documented a decline in both women's and men's computing leadership confidence over time. In other words, students tend to feel less like they have the capacity to become a leader in computing a year after their introductory computing course. Practitioners and researchers alike should contend with the extent to which developing students' leadership confidence is a goal of computing education. Regardless of the extent to which leadership development should or should not be a focus of computing education, it is important that computing departments provide students with equitable opportunities for student development. Findings from this study point to ways in which such opportunities are not equitably available to computing students, particularly in group activities and assignments.

For example, while much research on computing education has focused on the benefit of group work, this study demonstrates a need to question the presumed benefit of group assignments and activities, revealing sexism in the way that group members take on different roles (e.g., women take notes, men complete the technical parts of the assignment). Attending to gender stratification in group assignments is critical, as these sexist experiences may be related to students' larger experiences in the field. For example, even after women enter the tech field, they disproportionately leave tech roles for administrative or management positions (Hewlett et al., 2008). Perhaps this is connected to earlier college experiences where women were disproportionately expected to take on administrative aspects of group assignments, leaving men to tackle the more technical components. Further, when women are expected to take on the responsibility of organizing and coordinating groups, then undergraduate men may miss out on the opportunity to develop leadership, management, and interpersonal skills. Creating more egalitarian college experiences would both provide all students with more equitable opportunities

to develop themselves and would also benefit the tech field by producing graduates with greater experience in *both* technical and non-technical skills.

It is important to note that these findings certainly do not suggest that group work is inherently negative. Rather, findings reveal that instructors should carefully consider how they are structuring assignments so that students do not get tracked into gender stereotypical roles. Given the sexism that women may experience from their peers when working in group assignments, instructors should provide training that teaches students how to work collaboratively and support each other prior to beginning a group assignment. Such training may be most impactful when it is also met with accountability, which might be done through peer assessments of group dynamics. In addition, instructors can structure assignments so that students rotate roles and thus have the opportunity to develop a wider array of skills (e.g., management and technical). Alternatively, the assignment could be structured such that all students participate equally in both managing the group and completing the technical aspects of the assignment. Future research should also examine these different interventions to determine which approaches may be the most effective.

Gender Equity vs. Women's Representation: Changing the Narrative

A goal of this study was to use standpoint theory to give voice to women's lived experiences as a marginalized group in computing and provide insight into their experiences and meaning-making, particularly related to leadership. Given the national focus on this topic, undergraduate women in computing are constantly bombarded by messages related to their very personal experiences as part of a marginalized group. Standpoint theory provided a way for me to identify harmful narratives and assumptions and replace them with a more accurate understanding of women's experiences in computing. The present work identified two related

but distinct aspects of the narrative on women in computing that participants described as harmful: 1) the dominant narrative that men are better at or more interested in computing and 2) the less dominant, but still problematic, narrative that women may be equally capable of computing but require extra support to “catch up” or understand how computing aligns with their talents and goals. While it is easy to challenge the former as explicitly sexist, the latter also perpetuates gender essentialist thinking about women and men, though more implicitly. I myself have reiterated this narrative, asking questions about how we can demonstrate to women the ways in which computing aligns with their goals to have work-life balance or benefit the social good. While the answers to such questions might treat the symptom of women’s underrepresentation in computing, they do little to challenge the causes of gender inequity in computing (e.g., a hypermasculine culture, sexist policies and structures, etc.) and may even perpetuate false narratives about essential differences between women and men.

Perhaps one way to challenge the dominant narratives highlighted in the interview findings is to shift away from focusing on women’s representation to consider gender equity more broadly. While much of the work on gender in computing has focused on the experiences of women, it is also important to understand how all students (including men) experience undergraduate computing and think about concepts including gender and leadership in computing; understanding gender beyond women’s experiences might be key to addressing inequities in the field. This might also be part of a larger goal to shift the conversation away from women’s individual characteristics to focus more on the structural barriers and sexism in the field of computing.

The Utility of Self-Ratings in Gender Research

The present work provides insight into how researchers interpret self-ratings, particularly in relation to leadership abilities. Findings revealed that women tended to describe specific examples where they demonstrated effective leadership in difficult situations. However, when directly asked about their leadership traits and abilities, the participants tended to be more negative, relying on masculine stereotypes to describe their perceived lack of leadership, even when such stereotypes were not part of their original definition of leadership. Researchers have long questioned whether the gender gap in leadership confidence is due to women underrating their abilities or men overrating their abilities (e.g., Van Velsor, Taylor, & Leslie, 1993; Boud & Falchikov, 1989); these findings suggest that women may be, to some extent, underrating their abilities or relying on narrow definitions of leadership. Future research might also examine how the gender gap may or may not persist when students are asked to rate themselves on more specific criteria related to leadership or other desired outcomes. Perhaps women would report more positive leadership abilities when they were prompted with specific examples (e.g., recognizing the needs of others, showing empathy, etc.). In fact, prior research has shown that women actually tend to report their social self-concept more favorably than men (Sax, 1994), which is related to the way women defined leadership in this study.

Further, researchers must consider the extent to which developing women's self-ratings should be a goal. While the present work revealed gender inequities in leadership self-ratings, the meaning of self-ratings remains somewhat unclear. Future research might explore the factors that predict different leadership behaviors (e.g., leading a student group). Comparing leadership confidence with leadership behaviors may provide some additional insight into the way researchers interpret self-ratings.

Additional Directions for Future Research

Throughout this chapter, I have offered suggestions for future research. These include: focusing more closely on the role of race and how dialogues on racial/ethnic diversity in computing intersect with conversations related to gender equity; considering the ways in which women are impacted by research participation related to their experiences; identifying the different facets of leadership and operationalizing leadership in different contexts (e.g., leadership in the classroom, in group assignments, etc.); examining how students might use video games and other online activities to connect with non-college communities; and comparing leadership development across disciplines and examining the role of different disciplinary contexts.

It is also important to reiterate several key limitations of the present work when considering research implications (as discussed in Chapter 3). Notably, all participants in this study were from four-year research universities. Thus, an important next step in this inquiry is to incorporate the perspectives of students at community colleges as well as baccalaureate and master's-granting institutions. Research might also include students across a broader range of fields to explore the extent to which findings from the present study might be applicable to other STEM fields or college students more broadly. Further, this study relies on survey data collected at two time points; if inferring causation between certain college experiences and leadership outcomes is the goal, then more controlled research is needed.

An important contribution of the present work is the focus on women's voices and standpoint theory. According to Harding (2004), centering the voices of oppressed groups is necessary so that we can achieve a stronger empiricism that corrects distorted views of reality. This approach might have been particularly important in identifying the way women experienced

different stereotypical course dynamics and the role of larger narratives about women in computing. While the present work incorporates feminist standpoint theory in order to politically situate the inquiry, future research might expand upon this work to incorporate more critical methods and/or involve computing students more actively in the inquiry. Looking to the robust literature from critical scholars, including Ladson-Billings (1998), Fine (2006), and Crenshaw (1997), and considering critical race theory, engaged methodologies, and intersectionality may be particularly important. Such methods provide insights into the types of questions researchers should ask and how researchers can design studies in ways that are politically informed and responsible (see Overton, Pasque, & Burkhardt, 2016).

Conclusion

Research and reform efforts on equity in computing have largely focused on the numerical representation of women; this study provides needed insight into gender (in)equity and college student *development* among computing students. By examining leadership confidence among women and men in computing, this study contributes to our understanding of how to best support students and women in particular. As part of interpreting and applying the quantitative findings from this study to practice, we must consider the extent to which developing leadership *confidence* should be a goal. By centering student voices, this study provides insight into women's experiences in undergraduate computing, focusing on how women conceptualize their leadership and what it means to be a leader in the field of computing. Addressing the sexism that may be rooted in these conceptualizations might be a way to reduce the gender gap in leadership confidence without assuming that it is women who need to increase their confidence to match that of men. In other words, perhaps it is not women's leadership confidence that needs to be changed, but rather sexism in how leadership and confidence are defined.

In particular, findings from this study reveal that women hold inconsistent definitions of leadership, that their conceptualizations of leadership are informed by gender essentialist thinking, and that sexism remains prevalent in computing classrooms. These inequities in undergraduate computing reflect larger gender inequities in society; contending with sexism in how undergraduates think about gender, leadership, and computing might be one important way to contend with inequity in society or at least in computing careers. That is, fostering more egalitarian understandings among college students might be one way to develop a computing workforce that rejects gender essentialist thinking and values equity in their field. Further, gender constraints in the computing classroom limit all students' ability to holistically develop their leadership and technical abilities. Removing these barriers to development is imperative in order to meet industry demands for computing graduates with a range of leadership and technical skills.

APPENDICES

Appendix A: Survey Instruments

Pretest Survey Instrument

What is your current class standing?

- ☐ First year
- ☐ Second year
- ☐ Third year
- ☐ Fourth year
- ☐ Fifth year
- ☐ Sixth year or greater
- ☐ Graduated; please specify month and year using the following format: mm/yyyy

- ☐ Other; please describe _____

Why did you enroll in an introductory computing class? Select all that apply.

- It was required for my major/minor
- Curiosity or interest in computers
- My parents encouraged me to
- A teacher or other mentor encouraged me to

Which of the following applies to you:

- I have one major
- I have more than one major
- I have not decided on a major

Which of the following applies to you:

- I have one minor
- I have more than one minor
- I do not have a minor

Conditional for “I have one major”:

What is your major?

- [See list of majors at the end of this appendix]

Indicate how much you disagree or agree with the following statement about the major you selected above:

I am very committed to my current major.

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

Conditional for “I have more than one major”:

Select one of your majors from the list below

- [See list of majors]

Indicate how much you disagree or agree with the following statement about the major you selected above:

I am very committed to my current major.

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

Select your second major from the list below

- [See list of majors]

Indicate how much you disagree or agree with the following statement about the major you selected above:

I am very committed to my current major.

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

Conditional for “I have not decided on a major”:

You indicated that your major is undecided. If you had to choose a major today, what would it be?

- [See list of majors]

Mark how much you disagree or agree with the following statement:

I am confident that this will be my major.

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

Conditional for “I have one minor”:

What is your minor

- [See list of majors]

Mark how much you disagree or agree with the following statement in relation to the minor you selected above:

I am very committed to my current minor.

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

Conditional for “I have more than one minor”:

Select one of your minors from the list below

- [see list of majors]

Mark how much you disagree or agree with the following statement in relation to the minor you selected above:

I am very committed to my current minor.

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

Select your second minor from the list below

- [see list of majors]

Mark how much you disagree or agree with the following statement in relation to the minor you selected above:

I am very committed to my current minor.

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

Conditional – If non-computing major AND non-computing minor or I don't have a minor is selected:

Please rate your agreement with the following.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am considering changing my major to computing	☐	☐	☐	☐	☐
I am considering adding a computing minor	☐	☐	☐	☐	☐

What is the highest degree you plan to attain?

- ☐ Associate's degree
- ☐ Bachelor's degree
- ☐ Master's degree
- ☐ Doctoral degree
- ☐ Professional degree (MD, JD, DDS, Ed.D, etc)
- ☐ Uncertain
- ☐ Other, please specify _____

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 major; please specify _____
- ☐ Math/Applied Math
- ☐ Business or Law
- ☐ Life/Health Sciences
- ☐ Interdisciplinary, please specify areas _____
- ☐ Arts or Humanities
- ☐ Social Science
- ☐ Education
- ☐ Interdisciplinary, please specify areas _____
- ☐ Other, please specify: _____
- ☐ Uncertain

How interested are you in having a computing job like the ones below after you finish your highest degree?

	Very Disinterested	Somewhat Disinterested	Neither disinterested nor interested	Somewhat Interested	Very Interested
College/University professor in computing field	☐	☐	☐	☐	☐
Computing researcher in industry or government lab	☐	☐	☐	☐	☐
High school computing teacher	☐	☐	☐	☐	☐
A non-research position in the computing industry	☐	☐	☐	☐	☐
Position applying computing research to another area (e.g. digital media, support of research in medicine or other sciences)	☐	☐	☐	☐	☐
Non-research position applying your computing knowledge in another area (e.g. business applications, government)	☐	☐	☐	☐	☐
Entrepreneur (computing related)	☐	☐	☐	☐	☐
Non-computing career	☐	☐	☐	☐	☐

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

How important to you is it that your future career allows you to do each of the following?

	Not at all important	Slightly important	Somewhat important	Quite a bit	Extremely important
Make a lot of money	☐	☐	☐	☐	☐
Give back to my community	☐	☐	☐	☐	☐
Bring honor to my family	☐	☐	☐	☐	☐
Be in charge	☐	☐	☐	☐	☐
Work collaboratively with others	☐	☐	☐	☐	☐
Spend a lot of time with my family	☐	☐	☐	☐	☐
Have a social impact	☐	☐	☐	☐	☐
Decide for myself what I will work on	☐	☐	☐	☐	☐
Serve humanity	☐	☐	☐	☐	☐
Take time off work to care for my family	☐	☐	☐	☐	☐
Make important decisions at work	☐	☐	☐	☐	☐
Be a role model for people in my community	☐	☐	☐	☐	☐
Become well-known in my field	☐	☐	☐	☐	☐
Help others	☐	☐	☐	☐	☐
Have a lot of responsibility at work	☐	☐	☐	☐	☐

How much do you agree or disagree that a **career in computing** would allow you to....

	Not at all	A little	Somewhat	Quite a bit	Very much
Serve humanity	☐	☐	☐	☐	☐
Be in a position of influence in society	☐	☐	☐	☐	☐
Spend time with family	☐	☐	☐	☐	☐

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 the computing community.	☐	☐	☐	☐	☐
I am interested in learning more about what I can do with computing.	☐	☐	☐	☐	☐
Computing is a big part of who I am.	☐	☐	☐	☐	☐
I feel welcomed in the computing community.	☐	☐	☐	☐	☐
Using computers to solve problems is interesting.	☐	☐	☐	☐	☐
I do not have much in common with the other students in my computing classes.	☐	☐	☐	☐	☐
I care about doing well in computing.	☐	☐	☐	☐	☐

I believe...

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
People have a certain amount of computing ability, and they really can't do much to change it.	☐	☐	☐	☐	☐
People can't really change how good they are in computing.	☐	☐	☐	☐	☐
People can learn new things, but they can't change their basic ability to do computing.	☐	☐	☐	☐	☐

What are your perceptions of people in computing? Rate how much you disagree or agree with the following statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Computing fits men's personalities better than women's.	☐	☐	☐	☐	☐
Although some women might be good at computing, women in general tend to be better at other things.	☐	☐	☐	☐	☐
Computing seems to come more naturally to women than men.	☐	☐	☐	☐	☐

How much do you agree or disagree with the following statements? I am confident that I can...

	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree	Not Applicable
find employment in an area of computing interest	☐	☐	☐	☐	☐	☐
get admitted to a graduate computing program	☐	☐	☐	☐	☐	☐
complete an undergraduate degree in computing	☐	☐	☐	☐	☐	☐
win a computing- related contest (e.g., programming contest, robotics contest, hackathon)	☐	☐	☐	☐	☐	☐
become a leader in the field of computing	☐	☐	☐	☐	☐	☐
quickly learn a new programming language on your own	☐	☐	☐	☐	☐	☐
clearly communicate technical problems and solutions to a range of audiences	☐	☐	☐	☐	☐	☐

How would you rate yourself in the following areas compared to the average student your age?
(Mark one for each item)

	Lowest 10%	Below average	Average	Above average	Highest 10%
Academic ability	☐	☐	☐	☐	☐
Artistic ability	☐	☐	☐	☐	☐
Competitiveness	☐	☐	☐	☐	☐
Computer skills	☐	☐	☐	☐	☐
Cooperativeness	☐	☐	☐	☐	☐
Creativity	☐	☐	☐	☐	☐
Drive to achieve	☐	☐	☐	☐	☐
Emotional health	☐	☐	☐	☐	☐
Leadership ability	☐	☐	☐	☐	☐
Mathematical ability	☐	☐	☐	☐	☐
Physical health	☐	☐	☐	☐	☐
Public speaking ability	☐	☐	☐	☐	☐
Self-Confidence (intellectual)	☐	☐	☐	☐	☐
Self-Confidence (social)	☐	☐	☐	☐	☐

Think about the type of support you receive from your family and rate the degree to which each of the following is true...

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
My family encourages me to pursue a computing degree.	☐	☐	☐	☐	☐
My family questions why I would pursue a computing degree.	☐	☐	☐	☐	☐
My family wonders why I invest so much time and effort into studying computing.	☐	☐	☐	☐	☐
My family emphasizes the value of earning a computing degree.	☐	☐	☐	☐	☐

During the last year, how much time did you spend during a typical week doing the following activities?

	None	Less than 1 hour	1-2 hours	3-5 hours	6-10 hours	11-15 hours	16-20 hours	Over 20
Studying/homework	☐	☐	☐	☐	☐	☐	☐	☐
Socializing with friends	☐	☐	☐	☐	☐	☐	☐	☐
Exercise or sports	☐	☐	☐	☐	☐	☐	☐	☐
Working (for pay)	☐	☐	☐	☐	☐	☐	☐	☐
Student clubs/groups	☐	☐	☐	☐	☐	☐	☐	☐
Household/childcare duties	☐	☐	☐	☐	☐	☐	☐	☐
Playing video/computer games	☐	☐	☐	☐	☐	☐	☐	☐
Online social networks (Facebook, Twitter, etc.)	☐	☐	☐	☐	☐	☐	☐	☐

During the past year, were you involved in any of the following groups or activities?

	Yes, I have participated in this group or activity.	No, I have not participated in this group or activity.
Visiting lectures related to computing	☐	☐
Computing-related student groups	☐	☐
Computing-related contests (hacking, robotics competitions, etc.)	☐	☐
Computing-related online social networking (listservs, Facebook groups, etc.)	☐	☐
Professional societies related to computing	☐	☐
Technical conferences related to computing	☐	☐
Outreach to K-12 students	☐	☐
Summer institutes or short courses related to computing (other than summer research programs)	☐	☐
Study support in computing (e.g. receiving tutoring; attending Supplemental Instruction [SI])	☐	☐

Have you participated in any of the following conferences or programs?

	Yes, I have participated in this conference or program.	No, I have not participated in this conference or program.
Grace Hopper Celebration of Women in Computing	☐	☐
Regional "Hoppers" or Celebrations of Women in Computing	☐	☐
Richard Tapia Conference	☐	☐
Discipline-Specific Workshops - if you aren't sure, click here and scroll to the bottom of the page to see list of these workshops	☐	☐

Please mark the most advanced level you completed for each subject area while in high school.

	I did not take this class	Regular	Honors	AP	IB	I'm not sure
Biology	☐	☐	☐	☐	☐	☐
Chemistry	☐	☐	☐	☐	☐	☐
Computer Science	☐	☐	☐	☐	☐	☐
Environmental Science	☐	☐	☐	☐	☐	☐
Physics	☐	☐	☐	☐	☐	☐
Psychology	☐	☐	☐	☐	☐	☐
Algebra II	☐	☐	☐	☐	☐	☐
Pre-calculus	☐	☐	☐	☐	☐	☐
Calculus	☐	☐	☐	☐	☐	☐
Statistics	☐	☐	☐	☐	☐	☐

Please tell us about your programming experience prior to the start of this academic term. Select all that apply.

I took a computer programming course in <u>high school</u> (e.g., Java, Python, HTML, etc.).
I took a computer programming course at <u>computer camp</u> .
I took a computer programming course <u>online</u> .
I took a computer programming course at <u>this college</u> .
I took a computer programming course at <u>another four-year college</u> .
I took a computer programming course at <u>community college</u> .
I did not take a specific course, but I learned to program on my own (e.g., by reading books).
I did not have programming experience prior to this course.

Thank you for answering all of those questions! You are nearly finished! The following information helps us understand the experiences of different types of students. No information will be connected to you as an individual and providing this information is completely voluntary. If you prefer not to answer a given question, simply skip that question.

What was your average grade in high school?

- A or A+
- A-
- B+
- B
- B-
- C+
- C
- C-
- D

What is your college GPA? Please indicate on a 4.0 scale.

_____ /4.0 (Overall)

_____ /4.0 (Major)

_____ /4.0 (Minor)

Please provide us with your scores for the following tests. Leave blank for tests you have not taken.

_____ What was your mathematics score on the ACT

_____ What was your reading score on the ACT

_____ What was your mathematics score on the SAT

_____ What was your reading score on the SAT

Please indicate your gender.

☐ Female

☐ Male

☐ Non-binary category or something else; please specify: _____

In what year were you born?

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 _____

Growing up, what was your family's socioeconomic status?

- Poor
- Below average
- Average
- Above average
- Wealthy

Growing up, what was your family's income bracket?

- ☐ Less than \$30,000
- ☐ \$30,000 - \$39,999
- ☐ \$40,000 - \$49,999
- ☐ \$50,000 - \$59,999
- ☐ \$60,000 - \$69,999
- ☐ \$70,000 - \$79,999
- ☐ \$80,000 - \$89,999
- ☐ \$90,000 - \$99,999
- ☐ \$100,000 to \$149,999
- ☐ \$150,000 to \$199,999
- ☐ \$200,000 to \$249,999
- ☐ \$250,000 or more

How many people do you consider to be your parent or guardian?

_____ Number of parent(s) or guardian(s)

What is the highest level of education attained by one of your parents/guardians?

- ☐ Less than high school
- ☐ High school graduate or GED
- ☐ Some college or Associate's degree
- ☐ Bachelor's degree
- ☐ Master's degree
- ☐ PhD
- ☐ Professional degree (MD, JD, Ed.D, etc.)
- ☐ Other; please specify _____

Please indicate the career of this parent.

- ☐ Computing or technology career (e.g., programmer, systems analyst, computing teacher, etc.)
- ☐ Another math or science (non-computing) career
- ☐ Other career (Not having to do with computing, math, or science)

Please indicate the gender of this parent or guardian:

- ☐ Female
- ☐ Male
- ☐ Other; please specify _____

What is the highest level of education attained by your SECOND parent/guardian?

- ☐ Less than high school
- ☐ High school graduate or GED
- ☐ Some college or Associate's degree
- ☐ Bachelor's degree
- ☐ Master's degree
- ☐ PhD
- ☐ Professional degree (MD, JD, Ed.D, etc.)
- ☐ Other; please specify _____

Please indicate the career of this parent.

- ☐ Computing or technology career (e.g., programmer, systems analyst, computing teacher, etc.)
- ☐ Another math or science (non-computing) career
- ☐ Other career (Not having to do with computing, math, or science)

Please indicate the gender of this parent or guardian:

- ☐ Female
- ☐ Male
- ☐ Other; please specify _____

[repeat questions for third and fourth parents, if applicable]

We will be contacting you in the future to follow up about your computing experiences. Additionally, if you are interested in participating in other research activities (e.g., interviews) please provide your email below.

Follow-Up Survey Instrument

Are you currently an undergraduate student?

- ☐ Yes, I am currently an undergraduate student
- ☐ No, I graduated from my undergraduate college
- ☒ No, I am not currently enrolled in college

[Current undergraduate students]

Are you currently a full-time student?

- ☐ Yes
- ☐ No

In what year do you expect to complete your current undergraduate degree? If you are not sure, pick the year that seems most likely.

- ☐ 2016
- ☐ 2017
- ☐ 2018
- ☐ 2019
- ☐ 2020
- ☐ 2021
- ☐ Later than 2021; please specify: _____

Since entering your current institution, have you done any of the following? (Mark yes or no for each item)

- Withdrawn from school temporarily
- Transferred from a 2-year college
- Transferred from a 4-year college
- Transferred from another postsecondary institution (e.g., technical, vocational, business)
- Taken courses for credit at another institution

Please indicate:

Highest degree you hold	Dropdown menu for each: None High school diploma (or equivalent) Vocational certificate
-------------------------	--

Degree you are working toward	Associate's degree (A.A., A.S., A.A.S., or equivalent) Bachelor's degree (B.A., B.S., etc.) Master's degree (M.A., M.S., etc.) Master of Business Administration (MBA)
Highest degree you plan to receive	Ph.D. or Ed.D. M.D., D.O., D.D.S., or D.V.M. LL.B., or J.D. (Law) B.D. or M.DIV. (Divinity) Other

In which field do you plan to attain your highest 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

I am currently: (Mark one)

- ☐ Employed full-time
- ☐ Employed part-time, looking for full-time work
- ☐ Employed part-time, by choice
- ☐ Unemployed, looking for work
- ☐ Unemployed, not looking for work

[If employed/looking for work]

[Are you applying to jobs/Do you work] in a computing field? "Computing field" includes any field with a focus on the following:

- **Computer Science**
- **Computer Engineering**
- **Information Systems/Science**

- **Any interdisciplinary field with a strong computing component such as computational biology or digital media**

- ☐ Yes
- ☐ No

Which of the following applies to you:

- ☐ I have one major.
- ☐ I have more than one major.
- ☐ I have not decided on a major.

Which of the following applies to you:

- ☐ I have one minor.
- ☐ I have more than one minor.
- ☐ I do not have a minor.

Answer If Which of the following applies to you: I have one major. Is Selected

What is your major?

[see list of majors]

Answer If Which of the following applies to you: I have one major. Is Selected

Indicate how much you disagree or agree with the following statement about the major you selected above, I am very committed to my current major.

- ☐ Strongly Disagree
- ☐ Disagree
- ☐ Neither Agree nor Disagree
- ☐ Agree
- ☐ Strongly Agree

****See list of additional major questions from the pretest survey***

You are receiving this survey because you were enrolled in [course name] during [semester or quarter]. Which of the following applies to you:

- ☐ I completed the course and received a(n): _____
- ☐ I dropped the course
- ☐ I was never enrolled in the course

- ☐ I received an incomplete for the course
- ☐ Other; please specify: _____

[If: student dropped course]

Why did you drop [insert course name]? Select all that apply.

- ☐ It did not meet my expectations
- ☐ It was too challenging
- ☐ It was not challenging enough
- ☐ I am no longer interested in computer science
- ☐ It was no longer a requirement for my major or minor
- ☐ I did not enjoy the professor's teaching style
- ☐ I had a scheduling conflict
- ☐ The class was too large
- ☐ I switched to a different computing class
- ☐ Other, please specify: _____

Please indicate the extent to which you disagree or agree with following statements regarding [course name]:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
It made me more interested in computer science	☐	☐	☐	☐	☐
The course was too large	☐	☐	☐	☐	☐
It was too challenging	☐	☐	☐	☐	☐
It seemed designed to "weed out" the weaker students	☐	☐	☐	☐	☐
It was not challenging enough	☐	☐	☐	☐	☐
The course made me want to pursue a computing major or minor	☐	☐	☐	☐	☐
What I learned in the course is useful to my current major	☐	☐	☐	☐	☐
What I learned in the course is useful for potential job opportunities	☐	☐	☐	☐	☐

In [course name], what percent of your classmates were women?

[Fill in text box]

Please indicate the extent to which you disagree or agree with the following statements about the skills and knowledge you gained in [course name] during [term]. The skills I gained from this course...

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not Applicable
are useful in my everyday life	☐	☐	☐	☐	☐	☐
have been useful in other computing courses	☐	☐	☐	☐	☐	☐
have allowed me to be competitive for internships	☐	☐	☐	☐	☐	☐
have been useful for a job	☐	☐	☐	☐	☐	☐
are not that useful to me today	☐	☐	☐	☐	☐	☐

If you currently applying the skills and knowledge you learned in [course name] in a way that is not mentioned above, please list it below.

NON-COMPUTING MAJOR/MINOR QUESTIONS

[If: non-computing major or minor]

"Computing" includes any field with a focus on the following:

- **Computer Science**
- **Computer Engineering**
- **Information Systems/Science**
- **Any interdisciplinary field with a strong computing component such as computational biology or digital media.**

	Yes	No
Have you ever been a computing major?	☐	☐
Have you ever been a computing minor?	☐	☐

[If: yes, been a computing major before]

How long were you a computing major?

- ☐ Less than 1 year
- ☐ 1 year
- ☐ 2 years
- ☐ 3 years
- ☐ More than 3 years

When you began your computing major, how confident were you that you would complete it?

- ☐ Not at all
- ☐ A Little
- ☐ Somewhat
- ☐ Quite a bit
- ☐ Extremely

Why did you leave the computing major? Select all that apply

- ☐ I lost interest in computing
- ☐ Computing was too technical
- ☐ Computing classes were not engaging
- ☐ Computing classes were too difficult
- ☐ I did not feel academically prepared to pursue a computing major
- ☐ I was not able to complete other computing requirements (e.g., math prerequisites)
- ☐ I did not feel like I belonged in computing
- ☐ The environment was too competitive
- ☐ I could not find the guidance I needed to succeed
- ☐ I did not feel confident about my computing abilities/knowledge
- ☐ I could not see myself pursuing a career in computing
- ☐ I decided to be a computing minor instead
- ☐ None of the above. Please specify other reason _____

[If: yes, been a computing minor before]

How long were you a computing minor?

- ☐ Less than 1 year
- ☐ 1 year
- ☐ 2 years
- ☐ 3 years
- ☐ More than 3 years

When you began your computing minor, how confident were you that you would complete it?

- ☐ Not at all
- ☐ A Little
- ☐ Somewhat
- ☐ Quite a bit
- ☐ Extremely

Why did you leave the computing minor? Select all that apply

- ☐ I decided to be a computing major instead
- ☐ I lost interest in computing
- ☐ Computing was too technical
- ☐ Computing classes were not engaging
- ☐ Computing classes were too difficult
- ☐ I did not feel academically prepared to pursue a computing minor
- ☐ I was not able to complete other computing requirements (e.g., math prerequisites)
- ☐ I did not feel like I belonged in computing
- ☐ The environment was too competitive
- ☐ I could not find the guidance I needed to succeed
- ☐ I did not feel confident about my computing abilities/knowledge
- ☐ I could not see myself pursuing a career in computing
- ☐ None of the above. Please specify other reason _____

[If: no, never been a computing major AND no, never been a computing minor]

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am considering changing my major to computing	☐	☐	☐	☐	☐
I am considering adding a computing minor	☐	☐	☐	☐	☐

Please rate your agreement with the following:

[If: strongly disagree or somewhat disagree to changing to computing major]

Why are you uninterested in obtaining a computing major? Select all that apply.

- ☐ I am not interested in computing

- ☐ I am satisfied with my current major
- ☐ Computing is too technical
- ☐ Computing classes were not engaging
- ☐ Computing classes are too difficult
- ☐ I do not feel academically prepared to pursue a computing major
- ☐ I am not able to complete other computing requirements (e.g., math prerequisites)
- ☐ I do not feel like I belong in computing
- ☐ The environment is too competitive
- ☐ I could not find the guidance I needed to succeed
- ☐ I do not feel confident about my computing abilities/knowledge
- ☐ I cannot see myself pursuing a career in computing
- ☐ Other; please specify _____

[If: strongly disagree or somewhat disagree to changing to computing minor]

Why are you uninterested in obtaining a computing minor? Select all that apply.

- ☐ I am not interested in computing
- ☐ I am satisfied with my current minor
- ☐ Computing is too technical
- ☐ Computing classes were not engaging
- ☐ Computing classes are too difficult
- ☐ I do not feel academically prepared to pursue a computing minor
- ☐ I am not able to complete other computing requirements (e.g., math prerequisites)
- ☐ I do not feel like I belong in computing
- ☐ The environment is too competitive
- ☐ I could not find the guidance I needed to succeed
- ☐ I do not feel confident about my computing abilities/knowledge
- ☐ I cannot see myself pursuing a career in computing
- ☐ Other; please specify _____

[If: computing major]

You are receiving these questions because you are a computing major. Please rate your agreement with the following.

	Yes	No
Over the past year I have seriously considered changing to a non-computing major	☐	☐
I am currently thinking about changing to a non-computing major	☐	☐

[If YES to consider changing to non-computing major]

Why did you consider leaving computing? Select all that apply. At the time...

- ☐ I lost interest in computing
- ☐ Computing was too technical for me
- ☐ Computing classes were not engaging
- ☐ Computing classes were too difficult
- ☐ I did not feel academically prepared to pursue a computing major
- ☐ I was not able to complete other computing requirements (e.g., math prerequisites)
- ☐ I did not feel like I belonged in computing
- ☐ The environment felt too competitive
- ☐ I could not find the guidance I needed to succeed
- ☐ I did not feel confident about my computing abilities/knowledge
- ☐ I could not see myself pursuing a career in computing
- ☐ None of the above. Please specify other reason _____

[If NO to currently thinking about changing]

What helped you continue in your program when you were contemplating leaving? Select all that apply.

- ☐ My desire to succeed
- ☐ I really enjoy computing
- ☐ I received extra academic help
- ☐ It was too late for me to switch majors
- ☐ Encouragement from peers
- ☐ Encouragement from faculty
- ☐ Encouragement from a mentor
- ☐ I was motivated by the idea of a well-paying, stable career
- ☐ Other; please specify: _____

Which career are you most likely to pursue? Pick one from the following dropdown list.

Computing Careers

- Business Owner/Entrepreneur (Computing related)
- Computer and information research scientists
- Computer and information analysts
 - Computer systems analysts
 - Information security analysts
- Computer support specialists
 - Computer user support specialists
 - Computer network support specialists
- Computing teacher or professor
- Database and systems administrators and network architects
 - Database administrators
 - Network and computer systems administrators
 - Computer network architects
- Game Developer
- Management role in computing
- Software developers and programmers
 - Computer programmers
 - Software developers, applications
 - Software developers, systems software
- Web developers
- Other computing related roles

Non-computing Careers

- Actor or Entertainer
- Artist
- Graphic Designer
- Musician
- Writer/Producer/Director
- Farmer or Forester
- Natural Resource Specialist/Environmentalist
- Accountant
- Administrative Assistant
- Business Manager/Executive
- Business Owner/Entrepreneur
- Retail Sales
- Sales/Marketing
- Human Resources
- Finance (e.g., Actuary, Banking, Loan Officer, Planner)
- Management Consultant
- Real Estate Agent/Realtor/Appraiser/Developer
- Sports Management
- Journalist
- Public/Media Relations
- Advertising
- College Administrator/Staff
- College Faculty
- Early Childcare Provider
- Elementary School Teacher
- Secondary School Teacher
- Librarian
- Teacher's Assistant/Paraprofessional
- K-12 Administrator
- Other K-12 Professional
- Military
- Federal/State/Local Government Official
- Protective Services (e.g., Homeland Security, Law Enforcement, Firefighter)
- Postal Worker
- Dietician/Nutritionist
- Home Health Worker
- Medical/Dental Assistant (e.g. Hygienist, Lab Tech, Nursing Asst.)
- Registered Nurse
- Therapist (e.g., Physical, Occupational, Speech)
- Lawyer/Judge
- Paralegal
- Clinical Psychologist
- Dentist/Orthodontist
- Medical Doctor/Surgeon
- Optometrist
- Pharmacist
- Veterinarian
- Engineer
- Research Scientist (e.g., Biologist, Chemist, Physicist)
- Urban Planner/Architect Custodian/Janitor/Housekeeper
- Food Service (e.g., Chef/Cook, Server)
- Hair Stylist/Aesthetician/Manicurist
- Interior Designer
- Skilled Trades (e.g., Plumber, Electrician, Construction)
- Social/Non-Profit Services
- Clergy
- Homemaker/Stay at Home Parent
- Other
- Undecided

[Only show if Other Computing or Other is selected]

You have selected 'other' for which career you are most likely to pursue. Please specify below.

[Fill in text box]

In your opinion, to what extent would a career in computing allow someone to do the following....

	Not at all	A little	Somewhat	Quite a bit	Very much
Be in a position of influence in society	☐	☐	☐	☐	☐
Make a lot of money	☐	☐	☐	☐	☐
Give back to the community	☐	☐	☐	☐	☐
Bring honor to one's family	☐	☐	☐	☐	☐
Be in charge	☐	☐	☐	☐	☐
Work collaboratively with others	☐	☐	☐	☐	☐
Spend a lot of time with family	☐	☐	☐	☐	☐
Have a social impact	☐	☐	☐	☐	☐
Decide for themselves what they will work on	☐	☐	☐	☐	☐
Serve humanity	☐	☐	☐	☐	☐
Take time off work to care for family	☐	☐	☐	☐	☐
Make important decisions at work	☐	☐	☐	☐	☐
Be a role model for people in their community	☐	☐	☐	☐	☐
Become well-known in the field	☐	☐	☐	☐	☐
Help others	☐	☐	☐	☐	☐
Have a lot of responsibility at work	☐	☐	☐	☐	☐

How important to you is it that your future career allows you to do each of the following?

	Not at all	Slightly	Somewhat	Quite a bit	Extremely
Make a lot of money	☐	☐	☐	☐	☐
Give back to my community	☐	☐	☐	☐	☐
Bring honor to my family	☐	☐	☐	☐	☐
Be in charge	☐	☐	☐	☐	☐
Work collaboratively with others	☐	☐	☐	☐	☐
Spend a lot of time with my family	☐	☐	☐	☐	☐
Have a social impact	☐	☐	☐	☐	☐
Decide for myself what I will work on	☐	☐	☐	☐	☐
Serve humanity	☐	☐	☐	☐	☐
Take time off work to care for my family	☐	☐	☐	☐	☐
Make important decisions at work	☐	☐	☐	☐	☐
Be a role model for people in my community	☐	☐	☐	☐	☐
Become well-known in my field	☐	☐	☐	☐	☐
Help others	☐	☐	☐	☐	☐
Have a lot of responsibility at work	☐	☐	☐	☐	☐

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 see myself as a leader among my peers in computing	☐	☐	☐	☐	☐
I aspire to be a leader in the field of computing	☐	☐	☐	☐	☐
I feel like an outsider in the computing community	☐	☐	☐	☐	☐
I am interested in learning more about what I can do with computing	☐	☐	☐	☐	☐
Computing is a big part of who I am	☐	☐	☐	☐	☐
I feel welcomed in the computing community	☐	☐	☐	☐	☐
I do not have much in common with the other students in my computing classes	☐	☐	☐	☐	☐
I care about doing well in computing	☐	☐	☐	☐	☐
Using computers to solve problems is interesting	☐	☐	☐	☐	☐

How would you rate yourself in the following areas as compared to the average person your age?

	Lowest 10%	Below average	Average	Above average	Highest 10%
Academic ability	☐	☐	☐	☐	☐
Artistic ability	☐	☐	☐	☐	☐
Competitiveness	☐	☐	☐	☐	☐
Computer skills	☐	☐	☐	☐	☐
Cooperativeness	☐	☐	☐	☐	☐
Creativity	☐	☐	☐	☐	☐
Drive to achieve	☐	☐	☐	☐	☐
Emotional health	☐	☐	☐	☐	☐
Leadership ability	☐	☐	☐	☐	☐
Mathematical ability	☐	☐	☐	☐	☐
Physical health	☐	☐	☐	☐	☐
Public speaking ability	☐	☐	☐	☐	☐
Self-confidence (intellectual)	☐	☐	☐	☐	☐
Self-confidence (social)	☐	☐	☐	☐	☐
Ability to use multiple programming languages	☐	☐	☐	☐	☐
Computer programming ability	☐	☐	☐	☐	☐
Ability to build a computer from scratch (i.e., use component parts to build a computer)	☐	☐	☐	☐	☐

If I pursue computing, I am confident that I can...

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
find employment in an area of computing interest	☐	☐	☐	☐	☐
get admitted to a graduate computing program	☐	☐	☐	☐	☐
complete an undergraduate degree in computing	☐	☐	☐	☐	☐
win a computing-related contest (e.g., programming contest, robotics contest, hackathon)	☐	☐	☐	☐	☐
become a leader in the field of computing	☐	☐	☐	☐	☐
quickly learn a new programming language on my own	☐	☐	☐	☐	☐
clearly communicate technical problems and solutions to a range of audiences	☐	☐	☐	☐	☐

How do you feel about the computing courses you have taken at your undergraduate 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	☐	☐	☐	☐	☐
Overall, I am satisfied with the computing program at my institution	☐	☐	☐	☐	☐
I am glad that I chose to study computing	☐	☐	☐	☐	☐

To what extent do you disagree or agree with the following statements about your undergraduate computing program?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I feel a sense of community in the computing department	☐	☐	☐	☐	☐
The department cares about its students	☐	☐	☐	☐	☐
The environment in the computing department inspires me to do the best job that I can	☐	☐	☐	☐	☐
The department is not very supportive of its students	☐	☐	☐	☐	☐
There is racial/ethnic diversity among the faculty in the computing department	☐	☐	☐	☐	☐
There is gender diversity among the faculty	☐	☐	☐	☐	☐
There is racial/ethnic diversity in the student body	☐	☐	☐	☐	☐

There is gender diversity in the student body	☐	☐	☐	☐	☐
There is a welcoming atmosphere for political differences	☐	☐	☐	☐	☐
There is a welcoming atmosphere for religious differences	☐	☐	☐	☐	☐
There is a welcoming atmosphere for differences in sexual orientation	☐	☐	☐	☐	☐
There is socioeconomic diversity	☐	☐	☐	☐	☐
There is respect for the expression of diverse beliefs	☐	☐	☐	☐	☐

On average, how frequently do you (or did you) interact with faculty in the computing department in the following ways?

	Never	Less than once per month	1-3 times per month	1-3 times per week	More than three times per week
In class	☐	☐	☐	☐	☐
At office hours	☐	☐	☐	☐	☐
Electronically (e.g., email, text)	☐	☐	☐	☐	☐

How often have professors in the computing department at your undergraduate college provided you with:

	Never	Rarely	Sometimes	Frequently
Encouragement to pursue graduate/professional study	☐	☐	☐	☐
Opportunities to work on a research project	☐	☐	☐	☐
Advice and guidance about your educational program	☐	☐	☐	☐
Emotional support and encouragement	☐	☐	☐	☐
Help to improve your study skills	☐	☐	☐	☐
Feedback about your academic work (outside of grades)	☐	☐	☐	☐
Opportunities to discuss coursework outside of class	☐	☐	☐	☐
Help in achieving your professional goals	☐	☐	☐	☐

A mentor is someone with whom you have an ongoing relationship, and who provides you with advice and assistance in advancing in your career. 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 student (e.g., graduate student, Teaching Assistant, peer)
- ☐ Someone I met at a conference or mentoring program (or other professional activity)
- ☐ Someone I have a personal relationship with (e.g., family member/partner, friend, pastor)
- ☐ Someone I have a professional relationship with (e.g., Co-worker, supervisor, etc.)
- ☐ Someone else; Please specify: _____
- ☐ I do not have a mentor

Currently, to what extent do you have a mentor who....

	Not at all	A little	Somewhat	Quite a bit	Very much
helps you improve your computing skills?	☐	☐	☐	☐	☐
shows compassion for any concerns and feelings you discussed with them?	☐	☐	☐	☐	☐
shares personal experiences as an alternative perspective to your problems?	☐	☐	☐	☐	☐
explores career options with you?	☐	☐	☐	☐	☐

To what extent is each of the following kinds of support available to you from computing students if you need it?

	Not at all	A little	Somewhat	Quite a bit	Very much
People to hang out with	☐	☐	☐	☐	☐
People to confide in or talk to about your problems	☐	☐	☐	☐	☐
People to get class assignments for you if you were sick	☐	☐	☐	☐	☐
People to help you understand difficult homework problems	☐	☐	☐	☐	☐

Think about the type of support you receive from your family and rate the degree to which each of the following is true.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Not applicable
My family encourages me to pursue a computing degree	☐	☐	☐	☐	☐	☐
My family questions why I would pursue a computing degree	☐	☐	☐	☐	☐	☐
My family wonders why I invest so much time and effort into studying computing	☐	☐	☐	☐	☐	☐
My family emphasizes the value of earning a computing degree	☐	☐	☐	☐	☐	☐
My family recognizes my accomplishments in computer science	☐	☐	☐	☐	☐	☐

Within your undergraduate computing department and/or classes, how often do/did you feel that...

	Never	A little	Sometimes	Often	All of the time
people tend to attribute your success to special treatment or luck rather than to your competence?	☐	☐	☐	☐	☐
you are "talked down to" by classmates, instructors, or advisors?	☐	☐	☐	☐	☐
your ideas or opinions are minimized or ignored?	☐	☐	☐	☐	☐

Please indicate the extent to which you disagree or agree with following statement. I believe...

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
people have a certain amount of computing ability that really can't be changed	☐	☐	☐	☐	☐
people can't really change how good they are in computing	☐	☐	☐	☐	☐
people can learn new things, but they can't change their basic ability to do computing	☐	☐	☐	☐	☐

What are your perceptions of the environment in computing careers? Rate how much you disagree or agree with the following statement.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
In general, there is a supportive environment of people in computing careers	☐	☐	☐	☐	☐
There is a supportive environment for women in computing careers	☐	☐	☐	☐	☐
There is a supportive environment for people of color in computing careers	☐	☐	☐	☐	☐
There is a supportive environment for women of color in computing careers	☐	☐	☐	☐	☐
There is a competitive environment in computing careers	☐	☐	☐	☐	☐
People who succeed in computing careers tend to fit a certain stereotype (e.g., “hacker,” “geek,” “nerd”)	☐	☐	☐	☐	☐

During this academic term, how much time did you spend during a typical week doing the following activities?

	None	Less than 1 hour	1-2 hours	3-5 hours	6-10 hours	11-15 hours	16-20 hours	Over 20 hours
Computing-related student groups	☐	☐	☐	☐	☐	☐	☐	☐
Other (non-computing) student groups or clubs	☐	☐	☐	☐	☐	☐	☐	☐
Study support in computing (e.g. Supplemental Instruction [SI])	☐	☐	☐	☐	☐	☐	☐	☐
An instructional leadership role in computing (e.g., SI leader, TA, tutor, etc.)	☐	☐	☐	☐	☐	☐	☐	☐
An organizational leadership role in computing (e.g., student org leader, etc.)	☐	☐	☐	☐	☐	☐	☐	☐
Pair programming	☐	☐	☐	☐	☐	☐	☐	☐
Studying/homework	☐	☐	☐	☐	☐	☐	☐	☐
Socializing with friends	☐	☐	☐	☐	☐	☐	☐	☐
Exercise or sports	☐	☐	☐	☐	☐	☐	☐	☐
Working (for pay)	☐	☐	☐	☐	☐	☐	☐	☐
Household/family duties	☐	☐	☐	☐	☐	☐	☐	☐
Playing video/computer games	☐	☐	☐	☐	☐	☐	☐	☐
Online social networks (Facebook, Twitter, etc.)	☐	☐	☐	☐	☐	☐	☐	☐

From the time you started college, how many times have you participated in the following?

	None	1-2 times	3-4 times	5 or more
Attended a technical conference	☐	☐	☐	☐
Presented a poster at a technical conference	☐	☐	☐	☐
Given a talk at a technical conference	☐	☐	☐	☐
Attended the Grace Hopper Celebration of Women in Computing	☐	☐	☐	☐
Attended Regional "Hoppers" or Celebrations of Women in Computing	☐	☐	☐	☐
Attended the Richard Tapia Conference	☐	☐	☐	☐

During your college career so far, have you participated in any "formal" research experiences? Formal research includes any experience you applied for, and through which you worked closely with a mentor or research advisor.

- ☐ Yes, I have participated in at least one formal research experience while I have been in college
- ☐ No, I have NEVER participated in a formal research experience while I have been in college

[If yes]

We would like to learn a little bit more about your past formal research experiences.

How many formal research experiences have you participated in during your college career so far?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4 or more

When did your [first/second/third/fourth] research experience take place? If your research experience extended over a full academic year or longer, please select the corresponding years in which your experience took place.

☐ 2010

- ☐ 2011
- ☐ 2012
- ☐ 2013
- ☐ 2014
- ☐ 2015
- ☐ 2016
- ☐ Other _____

During what time of year did your [first/second/third/fourth] research experience take place? Please select all that apply.

- ☐ Academic year
- ☐ Summer

Where did your [first/second/third/fourth] research experience take place?

- ☐ At my current college/university
- ☐ At another college/university
- ☐ At a company/organization or government institution outside of my college/university
- ☐ Somewhere else; Please describe: _____

Does your institution offer a GPA that is greater than 4.0?

- ☐ Yes
- ☐ No
- ☐ I don't know

What is your GPA? Please indicate on a 4.0 scale.

Overall

Major

Minor

Please indicate your gender.

- ☐ Woman
- ☐ Man
- ☐ Non-binary category or something else; please specify: _____

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

- ☐ African American/Black
- ☐ American Indian/Alaska Native
- ☐ Arab, Middle Eastern, or Persian
- ☐ 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 _____
- ☐ Mexican American/Chicano
- ☐ Native Hawaiian/Pacific Islander
- ☐ Puerto Rican
- ☐ Other Latino _____
- ☐ White/Caucasian
- ☐ 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 _____

[Answer If Do you have any type of disability (physical, learning, mental, etc.)? Yes Is Selected]

What type of disability do you have? Please check all that apply.

- ☐ Attention deficit hyperactivity disorder (ADHD)
- ☐ Autism Spectrum Disorder
- ☐ Intellectual Disability
- ☐ Deaf/Hard of Hearing
- ☐ Mental Illness
- ☐ Mobility or Orthopedic Disability
- ☐ Nerve Damage
- ☐ Speech or Language Disability
- ☐ Specific Learning Disability
- ☐ Traumatic Brain Injury/Head Injury
- ☐ Visual Disability (do NOT select this option if your visual impairment is wearing glasses/contacts for being far/near sighted)
- ☐ Other; please specify _____

Which of the following best describes your sexual orientation?

- ☐ Heterosexual/Straight
- ☐ Gay or Lesbian
- ☐ Bisexual
- ☐ Other; please specify _____

What is your marital status?

- ☐ Married
- ☐ In long-term committed relationship (not married)
- ☐ Single (never married)
- ☐ Single (divorced or legally separated)
- ☐ Single (widowed or life partner is deceased)

How many children, if any, do you have? Include biological, adopted, and step-children.

- ☐ No children
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4 or more

[If the participant has at least one child]

Are you the primary caregiver to any children? A primary caregiver is the person most responsible for childcare.

- ☐ Yes, I am the primary caregiver.
- ☐ 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.
- ☐ No, my children are adults.

Are you the primary caregiver to any adult family members (e.g., parents, grandparents)? A primary caregiver is the person most responsible for caregiving.

- ☐ Yes, I am the 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.

How are you paying for your education? Please select all that apply.

- ☐ Federal student loans
- ☐ Private student loans
- ☐ Personal savings
- ☐ Scholarship/fellowship you applied for
- ☐ Full-time work
- ☐ Part-time work
- ☐ Spouse or partner support
- ☐ Parent or other family support
- ☐ Other; please specify _____

Have you experienced any economic hardships during your college education that led to a leave of absence?

- ☐ Yes; please explain: _____
- ☐ No

List of Major/Minor Categories (response options for major/minor questions above)

COMPUTING and ENGINEERING

- Computer Science
- Computer Information Systems/Informatics
- Information Science/Studies
- Bioinformatics
- Computing and business (including Business Information Management and Management Information Systems)
- Information Technology
- Computer Engineering (including Computer Engineering and Software Engineering)
- Aeronautical or Astronautical Engineering
 - Civil Engineering
 - Chemical Engineering
 - Computer Engineering
 - Electrical or Electronic Engineering
 - Industrial Engineering
 - Mechanical Engineering
 - Other Engineering
 - Other Computing, please specify: _____

ARTS AND HUMANITIES

- Art, fine and applied
- English (language and literature)
- History
- Journalism
- Language and Literature (except English)
- Music
- Philosophy
- Speech
- Theater or Drama
- Theology or Religion
- Other Arts and Humanities

BIOLOGICAL SCIENCE

- Biology (general)
- Biochemistry or Biophysics
- Botany
- Environmental Science
- Marine (Life) Science
- Microbiology or Bacteriology
- Zoology
- Other Biological Science

BUSINESS

- Accounting
- Business Admin. (general)
- Finance
- International Business
- Marketing
- Management
- Secretarial Studies
- Other Business

EDUCATION

- Business Education
- Elementary Education
- Music or Art Education
- Physical Education or Recreation
- Secondary Education
- Special Education
- Other Education

PHYSICAL SCIENCE

- Astronomy
- Atmospheric Science (incl. Meteorology)
- Chemistry
- Earth Science
- Marine Science (incl. Oceanography)
- Mathematics
- Physics
- Statistics
- Other Physical Science

PROFESSIONAL

- Architecture or Urban Planning
- Home Economics
- Health Technology (medical, dental, laboratory)
- Law
- Library/Archival Science
- Medicine, Dentistry, Veterinarian
- Nursing
- Pharmacy
- Therapy (occupational, physical, speech)
- Other Professional

SOCIAL SCIENCE

- Anthropology
- Economics
- Ethnic Studies

- Geography
- Political Science (gov't. international relations)
- Psychology
- Social Work
- Sociology
- Women's Studies
- Other Social Science

OTHER FIELDS

- Agriculture
- Communications
- Forestry
- Kinesiology
- Law Enforcement
- Military Science
- Other, please specify: _____

UNDECIDED

- I am undecided

Appendix B: List of Potential Independent Variables

Variable	Factor Loading	Measurement and Coding	Source
Pretests			
Self-rated leadership ability		5-point scale: 1=Lowest 10%; 5=Highest 10%	Pretest
Self-rated leadership in computing		5-point scale: 1=Strongly Disagree; 5=Strongly Agree	Pretest
Demographic Variables			
Gender: Woman		1=Man; 2=Woman	Pretest
Race: African American/Black		0=Unselected; 1=Selected	Pretest
Race: Asian/Asian American		0=Unselected; 1=Selected	
Race: Latinx		0=Unselected; 1=Selected	
Race: White (reference group)		0=Unselected; 1=Selected	
Socioeconomic Status: Growing up, what was your family's socioeconomic status?		5-point scale: Poor to Wealthy	Pretest
Incoming Major			
Computing-related major		0=Non-Computing Major; 1=Computing Major	
Prior Achievement			
Average grade in high school		9-point scale: 1=D; 2=C-; 3=C; 4=C+; 5=B-; 6=B; 7=B+; 8=A-; 9=A or A+	Pretest
Prior programming experience (scale)			
Took high school course		0=Unselected; 1=Selected	Pretest
Took course at computing camp		0=Unselected; 1=Selected	Pretest
Took course online		0=Unselected; 1=Selected	Pretest
Took course at this college		0=Unselected; 1=Selected	Pretest
Took course at another 4-year college		0=Unselected; 1=Selected	Pretest
Took course at community college		0=Unselected; 1=Selected	Pretest
Prior programming experience: Self-taught		0=Unselected; 1=Selected	Pretest
Incoming Values			
Social good career value (factor)	Alpha=0.856		
Give back to my community	0.827	5-point scale: 1=Not at all; 5=Extremely	Pretest

Have a social impact	0.821	5-point scale: 1=Not at all; 5=Extremely	Pretest
Help others	0.845	5-point scale: 1=Not at all; 5=Extremely	Pretest
Serve humanity	0.855	5-point scale: 1=Not at all; 5=Extremely	Pretest
Family career value (scale)			Pretest
Spend a lot of time with family		5-point scale: 1=Not at all; 5=Extremely	Pretest
Take time off work to care for family for people in my community		5-point scale: 1=Not at all; 5=Extremely	Pretest
Parental and Family Socialization			
Parental education		1=Less than high school; 2=High school graduate or GED; 3= Some college or Associate's degree; 4=Bachelor's degree; 5=Master's degree; 6=PhD/Professional degree	Pretest
Parental STEM career		1=No parent has a STEM career; 2=At least one parent has a STEM career	Pretest
Family support (factor)	Alpha=0.687		
My family encourages me to pursue a computing degree	0.478	5-point scale: 1=Strongly Disagree; 5=Strongly Agree	Pretest
My family questions why I would pursue a computing degree (reverse-coded)	0.914	5-point scale: 1=Strongly Disagree; 5=Strongly Agree	Pretest
My family wonders why I invest so much time and effort into studying computing (reverse-coded)	0.906	5-point scale: 1=Strongly Disagree; 5=Strongly Agree	Pretest
Non-College References			
Gender Stereotype: Although some women may be good at computing, women in general tend to be better at other things		5-point scale: 1=Strongly Disagree; 5=Strongly Agree	Pretest
Sense of Belonging and Fit (factor)	Alpha=0.836		
I see myself as a computing person	0.873	5-point scale: 1=Strongly Disagree; 5=Strongly Agree	Follow-up
Computing is a big part of who I am	0.868	5-point scale: 1=Strongly Disagree; 5=Strongly Agree	Follow-up
I feel like I belong in computing	0.909	5-point scale: 1=Strongly Disagree; 5=Strongly Agree	Follow-up

I feel like an outsider in the computing community	0.455	5-point scale: 1=Strongly Disagree; 5=Strongly Agree	Follow-up
I feel welcomed in the computing community	0.802	5-point scale: 1=Strongly Disagree; 5=Strongly Agree	Follow-up
Time spent: Working for pay		8-point scale: 1=None; 8=Over 20 hours	Follow-up
Time spent: Household/family duties		8-point scale: 1=None; 8=Over 20 hours	Follow-up
Attended diversity conferences (scale)			
Attended the Grace Hopper Celebration of Women in Computing		0=Unselected; 1=Selected	Follow-up
Attended the Richard Tapia Celebration of Diversity in Computing		0=Unselected; 1=Selected	Follow-up
Faculty Interactions			
Frequency of interactions with computing faculty (factor)	Alpha=0.713		
Frequency of faculty interaction: in class	0.800	5-point scale: 1=Never; 5=More than three times per week	Follow-up
Frequency of faculty interaction: at office hours	0.799	5-point scale: 1=Never; 5=More than three times per week	Follow-up
Frequency of faculty interaction: electronically	0.797	5-point scale: 1=Never; 5=More than three times per week	Follow-up
Mentorship from computing faculty (factor)	Alpha=0.866		
Computing professors provided: Encouragement to pursue graduate/professional study	0.856	4-point scale: 1=Never; 4=Frequently	Follow-up
Computing professors provided: Opportunities to work on a research project	0.818	4-point scale: 1=Never; 4=Frequently	Follow-up
Computing professors provided: Emotional support and encouragement	0.839	4-point scale: 1=Never; 4=Frequently	Follow-up
Computing professors provided: Help in achieving your professional goals	0.864	4-point scale: 1=Never; 4=Frequently	Follow-up
General mentorship (i.e., not specific to computing faculty) (factor)	Alpha=0.893		
Mentorship: Helps you improve your computing skills	0.879	5-point scale: 1=Not at all; 5=Very much	Follow-up
Mentorship: Shows compassion for any concerns and feelings you discuss with them	0.924	5-point scale: 1=Not at all; 5=Very much	Follow-up

Mentorship: Explores career options with you	0.918	5-point scale: 1=Not at all; 5=Very much	Follow-up
Perceived gender diversity: There was gender diversity among the faculty		5-point scale: 1=Strongly Disagree; 5=Strongly Agree	Follow-up
Peer Interactions			
Peer support in computing (factor)	Alpha=0.905		
Computing student interactions: People to hang out with	0.891	5-point scale: 1=Not at all; 5=Very much	Follow-up
Computing student interactions: People to confide in or talk to about your problems	0.872	5-point scale: 1=Not at all; 5=Very much	Follow-up
Computing student interactions: People to get class assignments for you if you were sick	0.856	5-point scale: 1=Not at all; 5=Very much	Follow-up
Computing student interactions: People to help you understand difficult homework problems	0.881	5-point scale: 1=Not at all; 5=Very much	Follow-up
Time spent: Socializing with friends		8-point scale: 1=None; 8=Over 20 hours	Follow-up
Time spent: Computing-related student groups		8-point scale: 1=None; 8=Over 20 hours	Follow-up
Time spent: Other (non-computing) student groups or clubs		8-point scale: 1=None; 8=Over 20 hours	Follow-up
Perceived gender diversity: There was gender diversity in the student body		5-point scale: 1=Strongly Agree; 5=Strongly Disagree	Follow-up
Perceived gender diversity: What percentage of your classmates were women?		0 to 100	Follow-up
Peer and Faculty Interactions			
Contentious classroom climate (factor)	Alpha=0.877		
Classroom interactions: People tend to attribute your success to special treatment or luck rather than to your competence	0.851	5-point scale: 1=Never; 5=All of the time	Follow-up
Classroom interactions: You are talked down to by classmates, instructors, or advisors	0.918	5-point scale: 1=Never; 5=All of the time	Follow-up
Your ideas or opinions are minimized or ignored	0.920	5-point scale: 1=Never; 5=All of the time	Follow-up
Departmental support (factor)	Alpha=0.786		Follow-up
Department: I felt a sense of community in the computing department	0.846	5-point scale: 1=Strongly Agree; 5=Strongly Disagree	Follow-up
Department: The department cared about its students	0.893	5-point scale: 1=Strongly Agree; 5=Strongly Disagree	Follow-up

Department: The environment in the computing department inspired me to do the best job that I can	0.863	5-point scale: 1=Strongly Agree; 5=Strongly Disagree	Follow-up
Department: The department was not very supportive of its students (reverse-coded)	0.515	5-point scale: 1=Strongly Agree; 5=Strongly Disagree	Follow-up
Meaningful Involvement			
Leadership in computing (scale)			
Time spent: An instructional leadership role in computing (e.g., SI leader, TA, tutor, etc.)		8-point scale: 1=None; 8=Over 20 hours	Follow-up
Time spent: An organizational leadership role in computing (e.g., student org leader, etc.)		8-point scale: 1=None; 8=Over 20 hours	Follow-up
Time spent: studying/homework		8-point scale: 1=None; 8=Over 20 hours	Follow-up
Time spent: online social networks		8-point scale: 1=None; 8=Over 20 hours	Follow-up
Time spent: programming or writing code		8-point scale: 1=None; 8=Over 20 hours	Follow-up
Outreach to K-12 students related to computing		8-point scale: 1=None; 8=Over 20 hours	Follow-up
Time spent: Playing video/computer games		8-point scale: 1=None; 8=Over 20 hours	Follow-up
<i>Note.</i> All variables labeled “scale” were created by adding items together. Measures labelled “factor” were created using Principal Axis Factoring.			

Appendix C. Interview protocol

Part I: Background

1. Introductions – share background; establish a pseudonym; informed consent and permission to record (start recording)
2. Can you tell me about your background? What year are you in school? What led you to study computing at [insert institution name]?

Part II: Perceptions of Leadership

3. How do you define leadership? What terms come to mind?
 - a. Is there a difference between a leader and a manager? If yes, how are they different?
4. When you think about leaders in computing and technology, who do you think about?
 - a. Are there specific people who come to mind? Explain.
 - b. What traits do leaders have? To what extent do you see those traits in yourself?
5. What aspects of leadership in computing are appealing to you? What aspects are unappealing?
6. Do you think your gender shapes your perceptions about leadership in computing? If yes, how?
 - a. Do you think that it is easier for men to be leaders in computing? Why or why not?
 - b. Do you think that leadership is defined around masculine attributes? Why or why not? If yes, do you think that is true for leadership in all fields, or is computing different? How?
7. Are there other factors beyond gender that shape your perceptions? Describe.

8. Do you think that your perceptions about leadership in computing have changed since you entered college? If yes, can you describe how?

Part III: Leadership Experiences

1. Can you describe any experiences you have had in college where you were a leader?
 - a. Some probes:
 - i. Student groups? Experiences in class?
 - b. How did you feel about those experiences?
2. Can you think of specific experiences (positive or negative) in college that have shaped how you think about leadership in computing and tech? Please describe.
 - a. Some probes:
 - i. Experiences with faculty and staff? A mentor?
 - ii. Experiences with other students?
 - iii. What about off-campus? Employment experiences? Family?

Part IV: Aspirations

3. Do you think you will continue to pursue computing? In what capacity (e.g., a computing career, major, etc.)? Why or why not?
4. In what ways do you aspire to leadership in computing?
5. In what ways do you aspire to leadership more generally?

Part V: Wrap-up

6. Is there anything that I didn't ask about that you think is important for this research?
7. Would it be ok for me to call or email you to follow up and get your feedback on how I'm interpreting the findings from this interview (i.e., member check)?

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