UNIVERSITY OF CALIFORNIA

Los Angeles

Courting the Uncommitted: A Mixed-Methods Study of Undecided Students in Introductory Computer Science Courses

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

Doctor of Philosophy in Education

by

Kathleen Joelle Lehman

2017

ABSTRACT OF THE DISSERTATION

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University of California, Los Angeles, 2017

Professor Linda J. Sax, Chair

In the United States, there has been an increased focus on attracting and retaining more and diverse college students to computing majors to ensure that there is a trained workforce to fulfill jobs in the growing tech sector as well as to increase the representation of women and people of color in the computing industry. Some have suggested that computer science departments might recruit more diverse students to computing majors from the pool of undecided students on their campuses, particularly those who may be enrolled in introductory CS courses.

The purpose of this study was to examine the experiences of undecided students enrolled in an introductory CS course that might encourage or dissuade them from pursuing a computing major. Drawing from career theory, science identity theory, and the extant literature, this study took a mixed-methods approach to develop a holistic picture of the experiences of undecided students who enroll in introductory CS courses. Specifically, this study used a national sample of students surveyed as part of the BRAID Research Project to conduct descriptive analyses and a blocked logistic regression. These analyses explored the characteristics of undecided students enrolled in introductory CS, their perceptions of the climate in the course, and the factors that predicted their decision to choose a computing major at the end of the course. Across all analyses, differences were examined by race and gender. Additionally, the study relied on interview data from undecided students who enrolled in introductory computing courses. Taking a phenomenological approach, the qualitative aspect of this study considers why undecided students enroll in introductory CS and how their experiences in the course inform their major choice decision.

The findings from this study suggest that many undecided students who enroll in an introductory CS course will choose a computing major by the end of that course. Some aspects of their course experiences, particularly the extent to which undecided students feel supported by computing peers, play a role in their decision to pursue a computing major. Further, the findings from this study suggest that undecided students are more likely to be women than CS majors who enroll in introductory CS courses, making undecided students a good pool from which to recruit women to computing. However, once enrolled in the course, undecided students' gender and racial/ethnic backgrounds play a minimal role in their decision to pursue computing. In light of these findings, the study provides implications for theory, CS departments, and CS introductory course instructors, as well as suggestions for future research.

The dissertation of Kathleen Joelle Lehman is approved.

M. Kevin Eagan

Jane Margolis

Cecilia Rios-Aguilar

Sharon Traweek

Linda J. Sax, Committee Chair

To my parents, Rob and Julie Guiler.

and

To my husband and daughters, Zach, Sophia, and Elizabeth.

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Acknowledgements

Since I was a small child, I wanted to be a doctor. Granted, I was thinking more about becoming a medical doctor than earning my PhD, but as I hit this milestone, I cannot help but acknowledge that earning my PhD is a childhood dream realized. Along the way, there have been many people who have supported me and provided me with life-changing opportunities that made not only this project, but this moment in my life, possible. Though there are more people than I could possibly list who are deserving of my gratitude, I wish to acknowledge a few of the key players for the particular ways they have encouraged me.

I am forever indebted to Linda Sax, who has served not only as my advisor but as my dear mentor and role model. It has been my great privilege to be your student and work alongside you, and I am so grateful that our work together continues with the BRAID Research project. Not only have you shaped me as a scholar, but you have shaped me as a mother, as I navigated the "balance" of becoming a new mom in the midst of this dissertation process. Thank you so much for choosing me to be your student and supporting and encouraging me at every turn.

I am so grateful to my dissertation committee, Kevin Eagan, Jane Margolis, Cecilia Rios-Aguilar, and Sharon Traweek. Thank you for your investment in me and my work. Additionally, I owe a debt of gratitude to the BRAID Initiative co-founders, Maria Klawe and Telle Whitney, for creating BRAID, and in the process, handing me the perfect dataset for my dissertation. I would not be able to do this work without the support of staff at the Anita Borg Institute (particularly Roshni Kasad and Cait Rogan), as well as the support of the many BRAID Research funders, including the National Science Foundation, the Computing Research Association, Google, Microsoft, Intel, and Facebook. To the BRAID Research team, Jennie, Hilary, Brit,

Kari, Christina, Connie, and Kaitlin: thank you for your dedication to this research and for the many ways you supported me in this project.

There have been many fellow students who have been central to my educational experience in HEOC. Tiff, my dear friend, your friendship is one of the best gifts of my time at UCLA. Thank you for being an amazing mentor, supervisor, and advisor in this process and for sharing in my successes and challenges, both personal and professional, every step of the way. Christos, thank you for being my cohort and my person. You have had my back more times than I can count and have been such an ally to me. Jennie, thank you for agreeing to join our crazy research project and for enhancing my work in so many ways, from helping me conceptualize what it meant to be "undecided" to helping me merge my data. You are going to do great things, and I am honored to be part of your journey. Hilary, from the moment I saw your application, I knew we would be good friends. Thank you for your positivity and humor in all things!

There is a long list of teachers and mentors who entered my life long before I arrived in Los Angeles but whose impact shaped my doctoral experience and dissertation. Ellen Adams, Sarah Stitzlein, Brian and Kristyn Tomlinson, Anne Cavett, and Michael Denton: thank you for guiding me to a career in higher education. I am grateful for the time and energy you invested in me as a student and/or employee and your encouragement of my scholarly interests. Most of all, thank you for being role models of what a life in academia might be like.

I would like to acknowledge my family and friends-who-are-family for their unwavering support through this process. First and foremost, thank you, Mom and Dad. Thank you for being my first teachers and my biggest cheerleaders, and most of all, thank you for your continual love.

I am so grateful for the way you always show up and help, doing whatever you can to make life easier and better for me (and Zach and Soph). To "The Panel," Cari, Heather, Beth, and Tara: it is a true gift to have friends like you—your unwavering belief in me has made all the difference. Laur, my chosen sister, thanks for standing beside me in the tough moments and celebrating the great ones. And, thank you for listening when I rambled about data cleaning, interview protocols, and theoretical frameworks and for copy editing this monster!

Finally, to my sweet little family, Zach, Sophie, and Libby: thank you for doing this day-in and day-out with me. Zach, I have been so fortunate to have you as my constant companion on this journey since we were sixteen years old. Thank you for always believing in my goals and making them your own. I am especially grateful for the many ways you have picked up the slack for me in the past few months as I scrambled toward the finish line. To our girls, Sophie and Libby, it is my greatest honor in life to be your mama. You each did part of this program with me (in-utero), and I have no doubt that your little kicks of encouragement helped me keep going. Soph, thank you for understanding when I had to work and for bringing immeasurable joy and laughter to our lives. Libby, you are my sweet surprise, and I cannot wait to meet you! Know that every moment I am away from you working on this research is spent in service to my profound hope that this work will improve the landscape of your (and every child's) educational opportunities.

Vita

2006	Miami University Department of French Research Scholarship Recipient Miami University, Oxford, Ohio
2007	Miami University Student Leadership Award Miami University, Oxford, Ohio
2007	Teaching Assistant, Introduction to Women's Studies Miami University, Oxford, Ohio
2007	B.A., French Miami University, Oxford, Ohio
2007-2009	Assistant Hall Director The Ohio State University, Columbus, Ohio
2008	The Ohio State University Student Life Recognition Award for Outstanding Achievement The Ohio State University, Columbus, Ohio
2009	M.A., Higher Education and Student Affairs The Ohio State University, Columbus, Ohio
2009-2012	Residence Education Coordinator University of North Carolina, Charlotte, Charlotte, North Carolina
2009-2010	Instructor, Transition to First Year University of North Carolina, Charlotte, Charlotte, North Carolina
2010-2011	Instructor, Gender in College University of North Carolina, Charlotte, Charlotte, North Carolina
2012-2017	Research Assistant, Various Projects University of California, Los Angeles, Los Angeles, California
2012	Helen S. Astin Fellowship Recipient University of California, Los Angeles, Los Angeles, California
2013	Graduate Summer Research Mentorship Award University of California, Los Angeles, Los Angeles, California
2014, 2015	Teaching Assistant, Research and Evaluation in Higher Education University of California, Los Angeles, Los Angeles, California
2015	Miami University Outstanding Young Alumni Award Recipient Miami University, Oxford, Ohio
2015, 2016	Ellen Schalk-Field Memorial Scholarship Recipient University of California, Los Angeles, Los Angeles, California
2016	Teaching Assistant, Why Research Matters to Student Affairs Practice University of California, Los Angeles, Los Angeles, California
2017	Guest Instructor, Student Affairs Practice and Theory University of California, Los Angeles, Los Angeles, California

Publications and Select Presentations

Lehman, K.J. (2015). *Understanding the role of faculty in the computer science gender gap*. Presented at the 2015 UCLA GSE&IS Research & Inquiry Conference, Los Angeles, CA.

__________& Riggers-Piehl, T.A. *STEM students' soft skills: Differences in men's and women's views on leadership, politics, and spirituality.* Paper Presentation at the 2017 Annual Meeting, American Educational Research Association, San Antonio, TX.

__________& Sax, L. J. (2015). *Who are female CS majors? Identifying their unique characteristics and long-term trends*. Paper Presentation at the 2015 Annual Meeting, American Educational Research Association, Chicago, IL.

__________Sax, L.J., & Zimmerman, H.B. (2017). Women planning to major in computer science: Who are they and what makes them unique?. *Computer Science Education*, *26*(4).

Riggers-Piehl, T. A., & Lehman, K. (2016). Modeling the relationship between campus spiritual climate and the sense of belonging for Christian, Muslim, and Jewish students. *Religion & Education*. http://doi.org/10.1080/15507394.2016.1175843

Sax, L. & Lehman, K. (2013). *Navigating information overload: Data visualization as a tool for advancing scholarship.* Feature presidential presentation at the 2013 Annual Meeting, Association for the Study of Higher Education, St. Louis, MO.

Sax, L. J., Lehman, K., Barthelemy , R., & Lim, K. (2016). Women in Physics: A Comparison to STEM Over Four Decades. *Physical Review Special Topics: Physics Education Research*, 12(2). doi: 10.1103/PhysRevPhysEducRes.12.020108.

Sax, L. J., Lehman, K. J., Jacobs, J.A., Kanny, M.A., Lim, K., Monje-Paulson, L. & Zimmerman, H. (2017). Anatomy of an Enduring Gender Gap: The Evolution of Women's Participation in Computer Science. *The Journal of Higher Education, 88*(2).

Sax, L. J., Lehman, K. J., & Zavala, C. (2017). Examining the enrollment growth: Non-CS majors in CS1 courses. In SIGCSE '17: Proceedings of the 48th ACM Technical Symposium on Computing Science Education. New York, NY, USA: ACM.

Sax, L. J., Lim, K., Jacobs, J., Lehman, K., Paulson, L. & Maclennan, A. (2016). *Reversal of the gender gap: The biological sciences as a unique case within STEM.* Presented at the 2016 Annual Meeting, Association for the Study of Higher Education, Denver, CO.

Sax, L. J., Zimmerman, H., Blaney, J. M., Toven-Lindsey, B., & Lehman, K. (2015). *Diversifying computer science departments: How department chairs become change agents for women and underrepresented minority students.* Presented at the 2015 Annual Meeting, Association for the Study of Higher Education, Denver, CO.

Zimmerman, H., Toven-Lindsey, B., Sax, L. J., Lehman, K.J. & Blaney, J. M. (2016). Building momentum: How department chairs lead initiatives to broaden participation in computer science. Presented at the 2016 Annual Meeting, Association for the Study of Higher Education, Columbus, OH.

Chapter One: Introduction

I know the struggles that can hinder women when they are working in a predominantly male field. I also know firsthand how computer science and technology make for a great career, offering a good income, work-life balance and opportunities to travel. They also offer a chance to make significant contributions to the world, by working on important societal problems. I want young women to have these opportunities.…We also need more African Americans, Latinos/Latinas, poets, football players and artists involved in creating technology. Right now there is unfilled demand for computer science grads and not just in the tech industry. I want computer science and technology to be a world that embraces everyone who has passion, ability and interest, whether they look like the dominant group or not.

-Dr. Maria Klawe (2015)

Dr. Maria Klawe, president of Harvey Mudd College, is a mathematician and computer scientist, but she is best known for her passion for diversifying the computing field. To that end, in July of 2014, she gave a talk at the Computer Research Association's (CRA) biennial conference where she outlined strategies that computer science (CS) departments might employ to increase the representation of women and underrepresented minority (URM) students in the major. Her talk gave rise to the Building, Recruiting, and Inclusion for Diversity (BRAID) Initiative, a collaborative effort between Harvey Mudd College, the Anita Borg Institute (ABI), University of California, Los Angeles (UCLA), 15 CS departments across the United States, and private and public funders. The BRAID Initiative seeks to jump start CS departments' efforts to diversify their undergraduate CS majors and then to document the results so as to identify best practices. At the heart of this initiative is a key belief: The United States needs more individuals, particularly women and people of color, with a computing background.

The need for more computer scientists is well documented. In January of 2016, President Obama announced the "CS for All" initiative to encourage all American students to learn computer science and understand computational thinking skills as a "new basic skill necessary for economic opportunity and social mobility" (The White House, 2016, ¶1). Beyond a general need for more individuals with a computing background, there is a specific need for individuals to fill jobs in the growing computing and information technology sector. The Bureau of Labor Statistics (BLS, 2015) predicts that there will be over 186,600 new positions for software developers created by 2024, for a total of over 1.3 million software developer positions (BLS, 2015). This represents a 17% growth over the next ten years, compared to an expected 7% growth for all careers. Further, technology and computing jobs will be among the highest paying in the next decade (BLS, 2015). The median annual wage for jobs in the computer and information technology sector is more than double the median annual wage for all occupations (BLS, 2015).

Not only does the United States need more computer scientists in general, but also there is a specific need for more women and people of color to pursue this field. Women earn about 18% of all CS degrees (National Center for Education Statistics (NCES), 2013), and URM students, including Black or African American, Latino/a, and Native American students, earn around 19% of all CS degrees (National Science Foundation (NSF), 2015). Women now make up the majority of bachelor's degree recipients (NCES, 2014), and the proportion of American college students from underrepresented racial/ethnic groups is increasing, while the proportion who are White is declining (NCES, 2015). Hence, it will be difficult to meet the demand for individuals with CS backgrounds if CS departments do not begin to attract more women and URM students. Further, computer scientists are designing the technology that drives society; in order for technology to serve our diverse society, we need diverse people making that technology. Finally, as explained above, those with CS degrees are at a distinct economic advantage, as they will have access to high salaries and ample job opportunities. Women and people of color often earn less than their male and White counterparts after graduating college. Hence, recruiting more women and URM students to fields like CS may help to address wage gaps (St. Rose, 2010).

In order to recruit more and diverse individuals to computing, CS departments need to recruit more students, particularly women and URM students into the CS major in college. CS degrees serve as a major pipeline to the computing field, as the majority of computing jobs require a CS or related degree (e.g., computer engineering). Previous research has shown that prior computing experience is a key predictor of students' interest and success in CS in college (Badagliacco, 1990; Beyer, Rynes, Perrault, Hay & Haller, 2003; Margolis & Fisher, 2002). However, many students may not have had access to CS in high school and may be unaware of the opportunities available to them in computing (Margolis, Estrella, Goode, Holme & Nao, 2008). Further, women and URM students tend to come to college with limited computing experience (Beyer et al., 2003; Margolis, Fisher, & Miller, 2000). Therefore, as CS departments seek to grow and diversify, they must specifically recruit women and URM students (Cohoon, 2002; Margolis & Fisher, 2002). At the same time, CS department chairs are not usually part of university admissions processes, so it may be difficult for them to recruit women and URM students to the major from high school (Sax, Zimmerman, Blaney, Toven-Lindsey & Lehman, 2015). Hence, leading scholars and computing organizations have suggested that CS departments recruit from *within* their institutions, such as by recruiting undecided students, particularly those who have already shown interest in the CS major by enrolling in an introductory CS course (Cohoon, 2002; National Center for Women and Information Technology (NCWIT), 2015).

Why Undecided Students Matter

As discussed above, undecided students represent an important opportunity for CS departments, as they may serve as a pool of students who could be recruited to the CS major. Nearly 10% of students enter college undecided about their major (Eagan, Stolzenberg, Bates, Aragon, Ramirez Suchard & Rios-Aguilar, 2015), and many more may come to college with some degree of indecision about their major (Kelly & Lee, 2002). Research on undecided students has focused primarily on outcomes related to major indecision, such as the impact of being undecided on students' academic and personal development (Gordon & Steele, 2003; Hartman & Fuqua, 1983; Hu & Kuh, 2002; John, Hu, Simmons, Carter & Weber, 2004; Leppel, 2001). However, little is known about the pathways for undecided students to select a STEM or CS major. The research that does exist suggests that undecided students with strong high school grades, high standardized test scores, and advanced math backgrounds are more likely to select a STEM major (Green & Sanderson, 2014; Hurtado, Hughes, Figueroa, Eagan & Wilkins, 2015). However, these predictors are similar to those that attract all students to STEM fields (see Sax et al., 2017). Hence, more research is needed to clarify the extent to which factors that predict undecided students' STEM major choice may be different from those that predict all students' STEM major choice. Further, no research has investigated the specific pathway for undecided students to choose a CS major. Given that the types of students who pursue CS have a unique set of characteristics from students who pursue other STEM fields (e.g., compared to students in all other STEM fields, students in CS rate themselves the lowest in terms of their academic ability)

(Lehman, Sax & Zimmerman, 2017; Sax et al., 2017), one cannot assume that the factors that might attract undecided students to STEM fields in the aggregate are the same as those that might attract them to CS specifically.

Why Introductory CS Courses Matter

Introductory CS courses often serve as students' first academic experience with the CS major. Research has shown that students' experiences in introductory STEM courses are key to their success and retention in STEM disciplines, including CS (Gasiewski, Eagan, Garcia, Hurtado & Chang, 2011; Seymour & Hewitt, 1997; Tobias, 1990). While there are many studies that focus on introductory CS courses, much of the research centers on efforts to improve these courses through pedagogical and curricular means, such as adding homework help sessions and incorporating pair programming (Newhall, Meeden, Danner, Soni, Ruiz & Wicentowski, 2014; Rich, Perry & Guzdial, 2004; Wilson, 2002). However, despite calls for CS departments to use their introductory CS courses as a tool to recruit more students to the major (Cohoon, 2002; NCWIT, 2015), very little research has investigated the role introductory courses may play in bringing more students into CS. Of the research that does exist, one study found that introductory CS courses may be detrimental to undecided or non-major students' perceptions of computing (Farkas & Murthy, 2005). Another study investigated the role of taking an introductory CS course on community college students' plans to complete a CS major at a four-year institution and found that the factors that contributed to students' plans to major in CS included having a pre-existing interest in CS and playing video games (Denner, Werner, O'Connor & Glassman, 2014). However, it is not well understood how students' experiences in introductory computing courses play into their major choice selection or how these experiences might differ by gender and/or race/ethnicity. Little is known about the characteristics of undecided students who choose to take an introductory CS course or why they choose to enroll in such courses. In order for CS departments to utilize introductory CS courses as an effective recruiting tool, more research is needed to determine the types of undecided students who might enroll in a CS courses, why they take the courses, and how students' experiences in these courses might encourage or dissuade them to choose a CS major.

Purpose of the Study

This study examined the experiences of undecided students enrolled in introductory CS courses at BRAID institutions as a means to understand how CS can recruit more and diverse students to the major. As discussed above, there is a need for more individuals, particularly women and people of color, with computing backgrounds. CS departments are seeking to increase the representation of women and URM students in the CS major. Undecided students make up a sizeable number of incoming college students (Eagan et al., 2015), and these students, especially those who express interest in CS by enrolling in an introductory course, represent a prime opportunity to recruit diverse students to the major (Cohoon, 2002; NCWIT, 2015). However, the literature base on undecided students' pathways from taking an introductory CS course to choosing a CS major is limited. Furthermore, few studies have examined the experiences of undecided students in introductory CS courses and how these experiences may play into their major selection choice. Finally, prior research has not investigated how these experiences may vary by students' gender and/or racial/ethnic identities. To address these gaps in the literature, the following research questions guided this study:

Quantitative questions:

1. What are the demographic and family traits, academic and computing backgrounds, and self-ratings of undecided students who choose to take an introductory CS course? Do these characteristics differ significantly by gender? By race/ethnicity? Between undecided students and declared CS majors?
2. What are undecided students' perceptions of the climate in their introductory CS courses, particularly in terms of their experiences with the course instructor and their peers? Do their perceptions vary by gender? By race/ethnicity? Between undecided students and declared CS majors?
3. To what extent is there a relationship between undecided students' experiences in introductory CS courses (e.g., teaching and evaluation practices, faculty attitudes toward students, and experiences with peers) and their intention to major in CS? What is the magnitude of the relationship? Does the relationship vary by the students' gender and race/ethnicity?

Qualitative questions:

4. Why do undecided students choose to take an introductory CS course?
5. How do undecided students make the decision to major or not major in CS? How do their experiences in the introductory course factor into their decision-making process?

This study took a convergent mixed-methods approach to answer these questions. Using mixed methodology allowed for an investigation of complexities about undecided students' experiences in introductory CS courses that a single mode of inquiry would not have allowed (Creswell & Plano Clark, 2011). To address the first three research questions, quantitative survey data collected as part of the BRAID Initiative was used, specifically the fall 2015, spring 2016, and fall 2016 administrations of the BRAID introductory course pre- and post-test surveys.

These survey instruments were created by the BRAID research team at UCLA under the direction of Dr. Linda Sax in collaboration with the CRA's Center for Evaluating the Research Pipeline (CERP). Across the 2015-2016 and fall 2016 survey administrations BRAID institutions 535 undecided students took the pre-test survey, and 214 of those students went on to also take the post-test survey. The BRAID introductory course student survey data are the most appropriate to explore questions related to students' introductory CS course experiences. The surveys gathered information on students' background characteristics, perceptions and values, experiences in the introductory computer science course, and major and career aspirations, and therefore provided rich data to draw from in terms of independent and dependent variables.

Student interview data were used to address the last two research questions related to why undecided students take introductory computing courses and how their experiences in the courses may help them select a major. The scope of the qualitative aspect of the study involved interviews with nine undecided students enrolled in introductory CS courses at institutions participating in the BRAID Initiative: Two 60-minute interviews were conducted with each participant, once while students are enrolled in the introductory CS course and once during the term following their enrollment. Maximum variation sampling was used to select participants who are diverse in terms of their gender and racial/ethnic identities. Semi-structured interview protocols were utilized with the goal of understanding how undecided students make meaning of their introductory CS course experiences and use those experiences to inform their major choice.

The quantitative and qualitative data were brought together for analysis using two complementary theoretical frameworks, Holland's Theory of Career Choice (1997) and Carlone and Johnson's (2007) science identity theory. Holland's theory postulates that people make vocational choices, including their college major choice, based upon their personalities; in turn, these choices are reinforced by the characteristics of their chosen major. Hence, Holland's theory helped explain how students make choices about a major in light of the socialization forces they experience in their introductory CS course. Carlone and Johnson's (2007) science identity theory considers the dynamics of race/ethnicity and gender in students' experiences in scientific disciplines. Therefore, Carlone and Johnson provided an identity lens to understand how undecided students view their experiences in CS introductory courses and the extent to which they do or do not believe they could succeed as computer scientists.

Significance of the Study

Significance for Research

This study sought to expand the literature on participation in computer science in a number of ways. There is little research on pathways for undecided students who take an introductory course to pursue a STEM major, and there is no research on pathways for undecided students who take introductory CS courses to pursue a CS major. This study provides important information on the characteristics of undecided students who enroll in introductory CS courses, their experiences in the course, and the relationships between course experiences and their plans to pursue a computing (or non-computing) major. Additionally, a great deal of literature has focused on reasons for the gender gap, and to a lesser extent, the racial/ethnic gap in computing. However, little research has explored how introductory CS courses may serve as a tool for recruiting diverse students to the CS major. Hence, as this study considered how undecided students' experiences vary by gender and race/ethnicity, the findings fill a gap in the knowledge about how introductory CS courses may impact women's and URM students' participation in the major. Finally, this study used Holland's Theory of Career Choice (1997) and Carlone and Johnson's (2007) science identity theory to understand undecided students' experiences in introductory CS courses. Previous research has not applied these frameworks to this population; consequently, this study provides new insights on their application to the undecided student experience.

Significance for Practice

As faculty, staff, administrators, public policy makers, and others seek to bring more individuals, especially women and people of color, into computing, more knowledge is needed about how to recruit individuals who may have the desire and aptitude to succeed in computing but are unaware of the opportunities in CS. This study helps colleges and universities learn more about one such population, undecided students who enroll in CS courses, and helps clarify the types of introductory course experiences that may encourage or deter these students from pursuing a computing major. Further, this study reports on the characteristics of undecided students who enroll in an introductory CS course. This knowledge may help CS departments design effective recruitment strategies to encourage women and URM students who have not yet declared a major to try a computing course.

Outline of the Study

This study aimed to address the gaps in the literature related to undecided students' experiences in introductory CS courses. Hence, this study examined the characteristics of undecided students who take introductory CS courses, the experiences these students have in those courses, the role these experiences play in the students' ultimate major choice, and how these experiences may vary by students' gender and race/ethnicity. Chapter one introduced and provided a justification for this study, and chapter two will build on this foundation in a thorough review of the extant literature on gaps in participation in computing, undecided students, and the role of introductory courses. Chapter two will also provide further detail on the theoretical basis for the study. Chapter three will discuss in detail the methodology employed, including the hypotheses associated with each research question, the means for data collection, and plans for analysis. Later, chapters four and five will outline results of the study, and chapter six will discuss the implications of the study's findings for research and practice.

Chapter Two: Literature Review and Theoretical Frameworks

The primary goal of this chapter is to establish a framework for understanding the gender and racial/ethnic gaps in computing and how undecided students who take introductory CS courses may represent an opportunity to recruit and retain more students, particularly women and URM students, to the major. Over the past several decades, scholars have been investigating the gender and racial/ethnic gaps in STEM fields (e.g., Blickenstaff, 2005; Seymour & Hewitt, 1997). Recently, more attention has been paid to gaps in participation in computing (Cohoon & Aspray, 2008), yet compared to the larger body of literature that focuses on STEM fields in the aggregate, relatively little is known about causes of the dearth of women in specific sub-fields, like CS (Kanny, Sax & Riggers-Piehl., 2014). At the same time, scholars have suggested that outreach efforts are key to recruiting more women and students of color to computing (Cohoon, 2002; Margolis et al., 2008; Margolis & Fisher, 2002). Further, Cohoon (2002) argued specifically that CS departments should recruit first and second year students from within their institutions to take introductory CS courses precisely because many college students are open to changing their majors. However, little is known about the experiences of undecided students who take introductory CS courses or how their experiences may differ by gender and/or race/ethnicity. To make recruitment efforts effective, is necessary to understand more about the characteristics of undecided students who take introductory CS courses, the process by which these students make major choices, and the role that their CS course experience plays in their ultimate major choice.

This study draws upon the extant literature as well as two theoretical frameworks. Hence, the first half of this chapter will begin with a literature review, including discussions of what is known about the gender and racial/ethnic gaps in CS, undecided students and the factors that might lead an undecided student to select a STEM major like CS, and the role of introductory CS courses in students' decision to pursue and persist in the field. The second half of this chapter will describe two complementary theoretical frameworks, Holland's Theory of Career Choice (1997) and Carlone and Johnson's (2007) science identity theory, that were used in this study to understand how undecided students' experiences in introductory CS courses may play a role in the major choice as well as how undecided students might make sense of their experiences. Finally, the chapter will conclude with a summary of the literature and a preview of how the literature and theoretical frameworks will inform the study's methodology.

Literature Review

Women's Participation in the CS Major

The literature on gaps in participation in computing reveals a variety of explanations for women's underrepresentation in the field, including the culture of computing, varying levels computing experience, barriers to entering the field, a lack of role models and mentors, issues related to student-faculty interaction, inadequate peer support, concerns with curricula and pedagogy, and student characteristics (Cohoon & Aspray, 2008). In general, these explanations for gaps in women's participation can be grouped into two umbrella categories: individual-level differences between students and structural issues that may facilitate inequality (Blickenstaff, 2005). The following sections will summarize what is known about women's participation in CS by first exploring their numerical representation in the field and then summarizing the literature on the individual differences and structural inequalities.

Representation in CS major. In considering women's representation in the CS major, it is useful to examine both the proportion and number of CS degrees that are awarded to women and how their representation has evolved over time. Women make up about 18% of all CS degree recipients (NCES, 2013). However, women's representation in the major has waxed and waned over the past five decades. When degree attainment data first became available in 1971, women constituted about 14% of CS degree recipients. However, women's participation in the major significantly increased such that in the mid-1980s, women earned as much as 37% of CS degrees (the peak of women's participation in the field since degree attainment data became available). Beginning in 1985, women's participation gradually declined before hitting a recent low point in 2011, when women earned fewer than 18% of all CS degrees.

It is important to point out that the gender gap in CS persists even as the number of computing degrees awarded to men *and* women has been increasing in recent years (NCES, 2012). In 2004, the number of computer science bachelor's degrees awarded reached a historical peak at nearly 60,000, with 14,903 degrees awarded to women and 44,585 degrees awarded to men. From 2004 until 2009, the number of degrees awarded in CS decreased somewhat, such that in 2009 the number of degrees awarded hit a recent low. That year, women earned 6,779 CS degrees and men earned 31,215, for a total of 37,994 CS degrees awarded. Since that time, the number of degrees awarded to both men and women has increased by about 25%; in 2012, 38,773 CS degrees were awarded to men, and 8,611 CS degrees were awarded to women. In order for the gender gap to close, however, women's interest in the field will have to increase at a *faster* rate than men's interest.

At a numerical level, the source of women's underrepresentation in CS is clear: even as more individuals have completed CS degrees, much of the increase is due to men's bourgeoning interest in the field, leading to a persistent gender gap. However, it is less apparent *why* fewer women are entering CS than men; many scholars attribute women's underrepresentation to individual-level differences between men and women, as discussed in the following sections.

Individual-level factors. A number of differences in students' personal characteristics may play a role in the gender gap in CS. Cohoon and Aspray (2008) point out that while these differences may be inherent or socialized, they leave certain students lacking "some ingredient necessary for participation in CSE as it is currently constructed" (p. 164). In particular, students' academic backgrounds, confidence in their abilities, values and personality traits, and computing experience are important to their decision to pursue and succeed in CS.

Academic backgrounds. Generally, studies have found that high-achieving students are more likely to pursue CS (Beyer et al., 2003; Cohoon and Aspray, 2008). However, in a nationwide study of the characteristics of male and female CS students, Lehman and colleagues (2017) found that students in CS tend to earn lower high school grades than students in other STEM fields. Several studies found that having a strong mathematics background, including having high math test scores and taking advanced math coursework, is key to students' success in CS (e.g., Herling, 2011; Margolis & Fisher, 2002; Wilson & Shrock, 2001). On average, women and men perform equally well in mathematics (Hyde & Mertz, 2009); however, several studies have found that men outnumber women at the extremes of the math achievement distribution, so men are more likely than women to attain higher levels of achievement in math (Hyde & Mertz, 2009; Penner & Paret, 2008; Wai, Cacchio, Putallaz & Makel, 2010). Further, women are less likely to take advanced science and mathematics coursework in high school (Blickenstaff, 2005). For instance, in 2014, nearly 20,000 fewer women took the Advanced Placement BC Calculus exam than men (College Board, 2014). Given the importance of mathematics in CS curricula, the fact that fewer women than men score at the highest end of the math achievement scale and take advanced mathematics at high school may contribute to women's underrepresentation in the field.

Confidence. Students' confidence in their abilities may also play an important role in their pursuit of the major. Sax et al. (2017) found that math self-concept is an important predictor of students' intention to pursue a CS major in college and is the most important variable for explaining the gender gap in undergraduate CS participation. Similarly, men's and women's varying levels of confidence in their computing abilities may also contribute to the gender gap in CS. One study found that female CS majors had *less* confidence in their computer skills than male *non*-majors (Beyer et al., 2003). Given that women are less likely than men to be confident in their abilities to succeed in areas key to a CS degree, such as math and computing, they may be deterred from pursuing or persisting in the CS major.

Values and personality traits. Research has found that students who pursue CS value the career opportunities that stem from a degree in computing. Extrinsic motivations, such as getting a job and making a high salary, are shown to be important to students who pursue CS majors, particularly men (Sax et al., 2017; Beyer et al., 2003). Studies also suggest that students in CS are less concerned with helping others than students in other STEM fields. In fact, research indicates that women’s prioritization of values related to helping others contributes to explaining why women are less likely to pursue STEM in general and CS in particular (Sax et al., 2017). Work by Diekman, Brown, Johnston, and Clark (2010) suggests that women are more likely to place a high importance on a career that values others, and women tend not to view careers in STEM as altruistic (Diekman et al., 2010). Hence, some women may not find computing attractive because they do not believe it aligns with their goals of helping others (Beyer, Rynes & Haller, 2004).

Experience. Women come to college with less advanced computing experience than their male peers, and their relative inexperience may be part of the reason that women are less likely than men to pursue a CS degree. Prior studies have shown that women may be exposed to computers later than men (Badagliacco, 1990; Margolis & Fisher, 2002), and women's interest in CS may come later and more gradually than men's (Margolis et al., 2000). Further, one study found that men come to college having done more complex computing tasks, such as installing RAM on their own computer (Beyer et al., 2003). Women are also less likely to have taken Advanced Placement CS courses in high school, as only 20% of the computer science AP exam takers were women in 2014 (College Board, 2014). Some research has shown that taking AP CS courses in high school is key to students’ interest and success in CS in college (Margolis et al., 2000; Margolis et al., 2008). Because women are less likely to have experience with computers and exposure to advanced computing knowledge, they may be less likely to pursue CS in college.

External Factors. As explained in the paragraphs above, women differ from their male counterparts in a number of key ways that impact their interest and success in computing. One might view these as inherent differences between the genders. However, Margolis and Fisher (2002) argue that many individual-level differences are closely tied with larger, structural inequalities. They suggest that structural disparities amount to "weighty influences that steal women's interest in CS away from them" (Margolis & Fisher, 2002, p. 6). The following sections will summarize the literature on structural inequalities, such as the culture of computing, role models and mentoring, peer support, and curriculum and pedagogy, that may shape women's participation in the field.

Culture of computing. Academic disciplines, such as computing, develop their own cultures. Becher (1981) noted that academic disciplines are "cultural phenomena: they are embodied in collections of like-minded people, each with their own codes of conduct, sets of values and distinctive intellectual tasks" (p. 109). The culture of computing, in particular, has become increasingly masculinized (Ensmenger, 2010), such that computer scientists' approach to work, stereotypes about the field, and sexual harassment incidents may make it more difficult for CS departments to recruit and retain women.

Approach to work. There are some aspects of the way computer scientists tend to work that may make the field less attractive to women. Research has shown that CS students have a preference for working alone, often procrastinate on assignments, have a penchant for experimentation, tend to disregard the process (and are instead focused the outcome), may be combative in group settings, and tend towards an unwillingness to support others (Waite, Jackson, Diwan & Leonardi, 2004). Although Waite and colleagues (2004) examined how CS students' approach to work might vary by gender and did not find any differences between male and female CS students' work preferences, it may be that the type of women (and men) who enter CS majors conform to these work preferences, while women who are off-put by this work culture avoid the field altogether. For instance, some research suggests that fields like CS and engineering tend to be narrowly focused, so students are often encouraged to limit thinking to the technical aspects of the problem and not focus on the wider implications of a problem (Cech, 2014). This "culture of disengagement" (Cech, 2014) could be discouraging to women, who tend to value work with clear social purposes (Diekman et al., 2010).

Stereotypes. Stereotypes are one way in which the culture of the field is expressed and may discourage women from entering and persisting in the field. The stereotypes about computer scientists, suggesting they are anti-social, geeks, and/or hackers, might dissuade women from entering the field (Margolis & Fisher, 2002). One study found that women who hold negative stereotypes of computing find the field less appealing (Beyer et al., 2004). Another study found that students who were exposed to a newspaper article with stereotypical descriptions of computer scientists were less likely to be interested in CS than students who read an article with neutral descriptions (Cheryan, Drury & Vichayapai, 2013). Hence, as the culture of the field is communicated to potential students through these stereotypes, women may have difficulty seeing themselves as computer scientists, and thus, be deterred from pursuing a CS degree.

Sexual harassment. Sexual harassment is widespread in engineering and computing fields (Servon & Visser, 2011); one study suggests that the majority of women working in the technology sector experience some form of sexual harassment (Hewlett, Sherbin, Dieudonne, Fargnoli & Fredman, 2014). Further, there have been a number of well-publicized cases of sexual harassment in the computing industry (see, for example, Carroll, 2014). As women hear about instances of sexual harassment in the tech sector, they may decide to pursue another field, rather than enter or continue in a field where they believe they are likely to experience such discrimination (Lemons & Parzinger, 2007; Orser, Riding & Stanley, 2012).

Role models and mentoring. Role models and mentors play an important role in attracting women to CS. Mentoring may increase students' interest in CS and promotes student learning (Tashakkori, Wilkes & Pekarek, 2005). Further, Cohoon's (2001) study of departmental factors that increase women's retention in the CS major found that departments with higher proportions of female faculty as well as those with faculty who were committed to mentorship were more successful in retaining women students in the major. The role model's manner appears to be important. Cheryan, Siy, Vichayapai, Drury, and Kim (2011) found that when women interact with role models who conform to stereotypes about computer scientists (such as the anti-social geek stereotypes discussed previously) their belief that they will succeed in CS decreases. However, when men interact with stereotypical role models, there is no impact on their belief in their ability to succeed in CS. Hence, while role models and mentors are likely important for all CS students, they may be even more important for female students, particularly as they may corroborate or disconfirm stereotypes about the field.

Peer support. Just as students get cues from role models and mentors, students also get cues about the extent to which they belong and can succeed in CS from their peers. In fact, other students may serve as role models, such as through teaching assistant or peer instructor positions.

One study found that using peer instructors in CS courses reduced the fail rate in the courses by more than 60% (Porter, Bailey, & Simon, 2013). Some campuses have found that groups for women in CS provide women with peer role models and a community of support (Frieze & Blum, 2002). Further, women are often encouraged to participate in national networking opportunities like the Grace Hopper Celebration of Women in Computing (GHC). One study found that attending GHC had a positive effect on attendees' commitment to a degree or career in CS. Further, many attendees felt their participation in the conference decreased their feelings of isolation as women in CS and increased their sense of community in the field (Alvarado & Judson, 2014). Peer connections also play an important role in students' success in the field after college. Yet, women are less likely to have social networks that will yield jobs in the technology field than men are (Koput & Gutek, 2010). Therefore, while strong peer support can help women navigate challenges of being CS students, women's peer networks may be smaller and/or less useful than their male counterparts.

Curriculum and pedagogy. Some scholars have argued that course content and teaching practices common in CS may be better suited for men's learning styles than for women's (Cohoon & Aspray, 2008). However, much of the research in this area suggests that "good" pedagogical practices tend to benefit all students in CS, regardless of students' gender and/or racial/ethnic backgrounds. For instance, students who participate in pair programming, a technique in which two programmers work together at one computer to write and review code, in their introductory CS course are more successful in that course and more likely to major in CS (Werner, Hanks, McDowell, Bullock & Fernald, 2005). Pair programming seems to be especially beneficial for students who are struggling in their CS courses (Radermacher & Walia, 2011).

Additionally, other studies have shown that adopting a behaviorist approach to teaching, such as by encouraging students to ask questions and collaborate and creating a more casual, familiar classroom environment can lead to improved student learning and engagement in their first CS course (Settle, 2012). Further, the literature shows that teaching practices in CS matter to student retention given that certain teaching practices, like assigning relevant and meaningful assignments and encouraging students to collaborate, are stronger predictors of student retention in CS that other teaching practices (Barker, O'Neill & Kazim, 2014).

Still, student-centered curriculum and pedagogy seems to be particularly important for women. For example, one study found that CS departments with faculty who espoused student-centered attitudes and employed inclusive teaching practices (e.g., exhibiting a willingness to help students master difficult concepts) had lower rates of attrition among their female students (Cohoon, 2001). Further, faculty seem to play a key role in women's success: one study reported that faculty in CS may treat women differently than men, making women feeling isolated and lacking in support (Hewlett et al., 2014). With the goal of making CS departments and faculty more inclusive of women, Barker and Cohoon (2009) proposed a collection of key pedagogical practices. Among their many recommendations, they argue that faculty should create classroom environments that are inclusive and collaborative, provide early and consistent feedback to students, make assignments relevant to student interests and goals, and foster student-faculty and student-student interactions in and out of class. When describing "inclusive" learning environments, Barker and Cohoon (2009) suggest that CS faculty and departments should make sure that the curriculum fosters collaboration (not competition) by using techniques such as class discussion, student-led learning, and group projects.

URM Students' Participation in the CS Major

More attention has been paid to the gender gaps in computing than the racial/ethnic gaps. The body of literature that does exist suggests that structural issues, particularly issues related to curriculum and pedagogy, stereotypes, and role models, contribute to the dearth of students of color in computing. Further, a few studies have focused on the experiences of students from specific racial/ethnic groups, while others have centered on the experiences of women of color in computing. The following sections will begin with a discussion of what is known about URM students' numerical representation in the field before turning to a review of explanations for their underrepresentation in CS and a summary of the literature describing the experiences of students from specific racial/ethnic groups and women of color in computing.

Representation in the CS major. Understanding the racial/ethnic diversity of the CS major is complex, for a variety of reasons, including how various racial/ethnic groups are defined. This study is particularly concerned with underrepresented minority students. In CS, the National Science Foundation (NSF, 2014) designates African American/Black, Latino/a, and Native American students as URM students.

Over the past two decades, URM students' participation has increased in CS (NSF, 2014). The NSF report *Women, Minorities, and Persons with Disabilities in Science and Engineering* (2015) shows that in 1993 (the first year for which the NSF report provides degree attainment data), URM students earned 13.9% of CS degrees. The proportion of CS degrees awarded to URM students has increased steadily since that time; in 2012, URM students earned 19.4% of CS degrees, representing a 5.5% increase (NSF, 2015). Among science and engineering fields, CS experienced the greatest increase in the proportion of degrees awarded to

URM students from 1993 to 2012, as the biological sciences increased by 4.9%, physical sciences increased by 4.0%, engineering increased by 3.8%, and mathematics and statistics increased by 1.6% (NSF, 2015). However, the increase in degrees awarded to URM students in CS is still modest, particularly when compared to a field like psychology, where the proportion of degrees awarded to URM students increased by 11.7% between 1993 and 2012 (NSF, 2015). Hence, while CS has fared better in recent years in terms of increasing its racial/ethnic diversity compared to other science and engineering fields, it is still concerning that so few students of color are completing CS degrees.

Further, it is important to consider race *and* gender, given that research on gender and racial inequality in STEM fields tends to focus on the participation of women *or* URM students and fails to capture how women of color are represented in STEM fields (Ong, Wright, Espinosa & Orfield, 2011). Compared to other STEM fields, CS is particularly diverse among women (Lehman et al., 2017). In a study of incoming students who planned to major in CS, Lehman et al. (2017) found that CS had the lowest proportion of White women of any STEM field and that CS women were significantly more diverse than CS men, due to the fact that a relatively large proportion of women who planned to major in CS were African American. However, because the overall number of CS degrees awarded to women is relatively small, the number of CS degrees awarded to women of color is very small, even as they make up a higher proportion of CS degree recipients than women in other STEM fields. For example, Black women earned 17.7% of the CS degrees awarded to women in 2012 (NSF & NCES, 2012). Yet, as shown in Table 2.1, only 3.2% of CS degrees were awarded to Black women. Therefore, while female URM students make-up a relatively large proportion of *women* who earn CS degrees, they earn a very small proportion of *all* CS degrees awarded, while White men received the majority of CS degrees.

Table 2.1. Proportion of Bachelor's Degrees Awarded in 2012, by Race and Gender

	N for All Majors			N for CS Majors			% among race/ethnicity		% among gender		% among all CS majors	
	All	Women	Men	All	Women	Men	Women	Men	Women	Men	Women	Men
White	1,132,689	635,766	496,923	27,067	3,986	23,081	56.1	43.9	63.0	66.9	8.7	50.6
Asian or Pacific Islander	118,261	64,348	53,913	3,964	874	3,090	54.4	45.6	6.4	7.3	1.9	8.3
Black	172,868	113,601	59,267	4,847	1,460	3,387	65.7	34.3	11.3	8.0	3.2	9.1
Hispanic	176,699	107,568	69,131	4,210	791	3,419	60.9	39.1	10.7	9.3	1.7	9.2
American Indian/ Alaska Native	10,743	6,561	4,182	231	50	181	61.1	38.9	0.7	0.6	0.1	0.5
Other/ unknown	139,777	80,734	59,043	5,276	1,082	4,194	57.8	42.2	8.0	8.0	2.4	11.2

Source: National Science Foundation, National Center for Science and Engineering Statistics, Special tabulations of U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, 2012.

Explanations for the racial/ethnic gap. Margolis and colleagues' 2008 book titled *Stuck in the Shallow End* is the most complete treatment of issues of race, education, and computing. The study investigated the interplay between school structures and factors that affect students' pathways into CS. Although the book focuses on students in high school settings, many of the findings may also apply to collegiate settings. Margolis and her colleagues found that high schools reinforce inequality through various aspects of their structure, including factors related to curriculum and pedagogy, stereotypes, and role models. Their findings have been corroborated by other studies that focus on race and computing, as summarized in the sections that follow.

Curriculum and pedagogy. Margolis et al. (2008) found that facets of the curriculum at the high schools in their study negatively impacted students of color's intentions to pursue CS. For instance, they found limited CS course offerings at more racially diverse schools. Further, the authors reported that URM students tended to be "tracked" into lower level computing courses, while White students were more likely to be encouraged to take advanced CS courses (e.g., AP CS). Hence, a number of studies have found that URM students are less likely to pursue the CS major in college, in large part because they lack the necessary computing experience (Charleston, 2012; Kodaseet & Varma, 2012; Varma, 2006). However, URM students' inexperience may be traced back to curricular obstacles at the high school level.

Faculty members may be able to help students of color in CS overcome their relative inexperience through their teaching and interactions with URM students. Varma (2006) interviewed URM CS students at minority-serving institutions and found that faculty who made courses relevant to diverse populations and expressed care for students were particularly important to students of color. Further, she argued that faculty should help students of color become more confident in their mathematical and computing abilities in order to help URM students succeed in the major. Studies that have focused on CS at the high school level have found that when CS teachers receive ample professional support to make their classrooms more inclusive and to improve their pedagogical practices, overall enrollment in CS courses increased, and the number of URM students who took the CS courses also significantly increased (Goode, 2007; Margolis et al., 2008). Hence, it seems that instructors teaching CS courses are in an important position to encourage URM students' interest in computing and provide support to facilitate their success in CS.

Stereotypes. While faculty can help URM students overcome obstacles, they may also hold stereotypes about URM students that are harmful to their participation and success in computing. Margolis et al. (2008) explain, "images of who belongs where lie deep within our psyche" (p. 13). As such, instructors may have deficit views of students from different groups and tend to associate intelligence with White and Asian students. Margolis et al. (2008) reason that teachers may associate hand labor, rather than brain work, with immigrants and people of color. This may be part of the reason why African American and Latino/a students are more likely to be tracked to remedial/vocation classes and not given access to higher status knowledge, such as CS courses, regardless of their aptitudes. Further, even those URM students who do end up in higher-level CS courses face stereotypes that make it more challenging for them to succeed in computing. Margolis and her colleagues argue, "in CS classes, White and Asian students (and males in particular) simply do not have the experience of having their intellectual abilities in the subject doubted solely because of their race and gender" (Margolis et al., 2008, p. 86). Therefore, stereotypes can decrease opportunities for URM students in CS and diminish their interest in computing.

Role models. For students of color who desire to pursue CS, the lack of racially diverse role models makes their plight even more challenging (Margolis et al., 2008). Given the paucity of their numbers, URM students are less likely to be in CS courses with other students of color or in a course taught by a person of color. Varma (2006) argues that opportunities to connect with other minority students in CS are important in mitigating URM students' feelings of anxiety in the classroom. Hence, helping URM students find role models, such as by encouraging URM students to attend the Tapia Conference, a national conference focused on race and computing, or through programmatic efforts like student organizations and mentorship programs, may be important to URM students' recruitment and retention in CS.

Experiences of students from specific racial/ethnic groups. A few scholars have looked at the experiences of students from specific racial/ethnic groups in CS. Charleston (2012) investigated African American students' decision to pursue CS and developed a model of Computing Career Choice for African Americans. Charleston found that factors such as early engagement with advanced aspects of computing and computers, a strong background in mathematics and science, mentorship, a cohort of peers in computing, and awareness of the interdisciplinary nature of CS all contributed to African American students' decision to pursue CS. Herling (2011) looked specifically at the experiences of Hispanic women in CS. Much like Charleston (2012), Herling found that having prior computing experience, understanding the interdisciplinary nature of CS, and accessing social support in the form of verbal encouragement as well as role models were important factors in Hispanic women's decision to choose and persist in CS. Kodaseet and Varma (2012) considered the experiences of American Indian students who pursue CS degrees. They argue that there are few Native Americans in CS because of Native American students' unequal access to technological resources (e.g., lack of computers at home and a lack of qualified computing teachers in local schools), socialization biases, including a lack of encouragement to pursue higher education in general and CS in particular, a dearth of role models, and conflicting cultural values between CS and tribal cultures.

These studies provide important context on the experiences of African American students, Hispanic women, and American Indian students and give voice to their particular perspectives. However, as may be evident from the above summaries, there is a great deal of overlap between the factors that are important to these students' pursuit and persistence in computing and the factors that are important to all URM students, other marginalized groups, such as women, or any person who wants to pursue CS. Hence, more research, particularly national research that examines the experiences of CS students by race and gender, is needed to help clarify which predictors of students' interest and success in computing might be universal and which may be specific to a particular group of students. By having a more granular understanding of students' experiences, faculty, staff, and administrators will be in a better position to adapt recruitment and retention efforts.

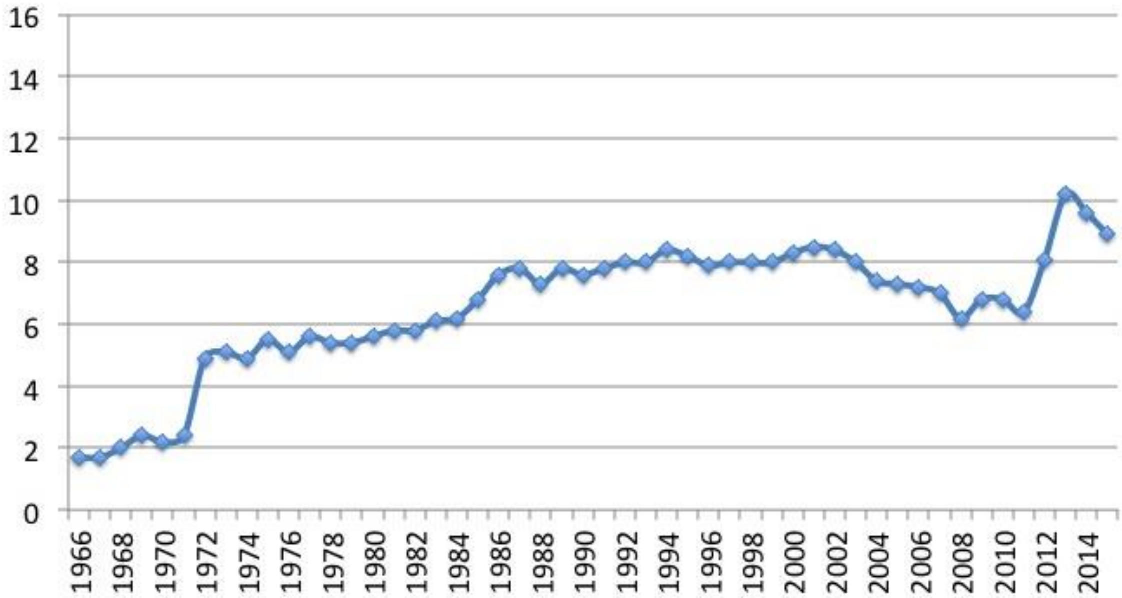
Women of color in CS. As mentioned previously, much of the literature on gender and racial inequality in STEM fields has focused on the participation of women *or* URM students. Therefore, many of the efforts to broaden participation in these fields have served White women and men of color (Ong et al., 2011). It is important to study race and gender together because of "the way in which race/ethnicity and gender function simultaneously to produce distinct experiences for women in color in STEM" (Ong et al., 2011, p. 176). That is, the intersectional nature of gender and racial identities create interdependent systems of disadvantage such that women of color face multiple levels of marginalization (Crenshaw, 1991). Unfortunately, few studies have considered the experiences of women of color in CS. Varma (2010) has focused specifically on issues of gender and race/ethnicity in understanding participation gaps in CS. She found that women from all racial/ethnic groups, except for Native Americans, attribute the gaps in participation in CS to gender socialization and technical anxiety. Native American women mostly attribute the gaps in participation to "other reasons." Charleston, George, Jackson, Berhanu, and Amechi (2014) focused on the experiences of Black women in CS undergraduate and graduate programs. The participants in their study faced stereotypes about their gender and racial identities while pursuing their CS degrees. They felt isolated in their programs and identified faculty as a main contributor to their isolation, as faculty were perceived as holding stereotypes about Black women and sometimes acting in discriminatory ways (e.g., making racist/sexist remarks). These studies are a good starting point to clarify how women of color may experience the CS major. However, more research is needed to understand factors that are important to recruiting women of color to CS, providing appropriate support to help them persist in the major, and retaining them in computing after graduation.

Undecided Students

As discussed in the above sections, students' lack of prior coding experience poses a significant challenge to CS departments seeking to diversify their student populations. Hence, the literature argues that a key to bringing more and diverse students to the field is to recruit students to the major from within the institution (Cohoon, 2002; Margolis & Fisher, 2002). However, many CS department chairs lament that it is difficult for them to address the gender and racial/ethnic gaps in the CS major because recruitment processes are often relegated to admissions offices (Sax et al., 2015). That is, department chairs may understand that their department lacks in diversity, yet because the department is not an active participant in admissions, department chairs do not feel that they have the power to recruit more women or URM students to their major. Undecided students who take introductory CS courses represent a key opportunity. They are easily accessible and, by virtue of enrolling in a CS course, have already expressed some level of interest in the field. For instance, the National Center for Women and Information Technology's 2015 report *Recruit Strategically: A "High Yield in the Short Term" Workbook for Attracting Women to Undergraduate Computing and Engineering* outlines a recruitment strategy for CS departments to increase the number of women in their CS major. Among the reports' primary suggestions is that departments should identify undecided students and non-majors, particularly those enrolled in introductory CS courses, and target these students for recruitment. By identifying and targeting undecided students, departments may be able to recruit students who have the aptitude to succeed in computing but may not have been exposed to programming in high school and/or be aware of the opportunities available in CS.

Defining decidedness. Many students come to college with some degree of ambiguity about their choice of major. In 2015, the Higher Education Research Institute's (HERI) reported that 8.9% of incoming college students were undecided about their major choice (Eagan et al., 2015). As shown in Figure 2.1, the proportion of undecided students grew steadily from 1966 to 2015. In 1966, the first year students were surveyed, less than 2% of entering college students identified as an undecided major, while in 2001, 8.5% were undecided. Then, the proportion of students who were undecided declined somewhat, dropping to about 6% in 2008. Recently, the proportion of undecided college students has been increasing again, hovering around 10% for the past three years.

Figure 2.1. Proportion of Incoming College Students with Undecided Major, 1966-2015.



Source: Higher Education Research Institute

It is important to make the distinction between students who are *undecided* and students who are *undeclared*. Each college and university has their own policies about who can declare a major and when a student is expected to make a major choice. At some institutions, students are required to declare a major in their application, and therefore, all incoming students have made some sort of major choice. However, students may still have some degree of indecision about that choice. Alternatively, at other institutions, students are admitted to a school (e.g., College of Computing Sciences) as pre-majors or intended majors but do not declare a specific major until later in the academic career (usually by the end for the first or second year). Hence, some students may have a declared major but are undecided, while others may have no declared major but may be certain of their major choice.

The literature on career and major indecision has defined "undecided" in a variety of ways (Nauta, 2012). In some studies, students who are undecided are defined simply as those who do not have a major listed with the registrar's office (Leppel, 2001). Holland & Holland (1977) first conceptualized career indecision, and at the time they defined it as a dichotomous variable (decided or not). Much of the research on undecided students conceptualizes the term in this way. However, over time, many scholars have advocated for a continuous conceptualization that captures the degree of an individual's indecision (Guay, Senécal, Gauthier, & Fernet, 2003; Guerra & Braungart-Rieker, 1999). Kelly and Lee (2002) argue for a multidimensional approach to measuring career indecision. Further, they suggest that many students with declared majors may have prematurely declared a major due to family pressure and/or still have a significant amount of uncertainty in their decision even after selecting a major. Therefore, indecision may also be measured among students with declared majors (Kelly & Lee, 2002).

Outcomes for undecided students. The extent to which being undecided is either positive or negative for students has been a topic of debate among higher education scholars. Some scholars have argued that coming to college as an undecided major may be the "healthiest" decision incoming college students can make, as this allows students to be open to a variety of opportunities (Grites, 1981). However, the research that considers outcomes for students who enter college as undecided majors demonstrates that they face many obstacles. Undecided majors are less likely to be engaged in their university communities compared to students who have declared majors or are in pre-professional programs (Hu and Kuh, 2002). Further, both men and women who entered college without a major were less likely to persist to the second year than students who declared arts and sciences majors (Leppel, 2001). The impact of undecidedness on student persistence may vary by race. One study found that White students who were undecided majors were less likely to persist in college than other White students but found no statistical difference in persistence between African American students who were undecided and had a declared major (John et al., 2004). Additionally, undecided students have been found to perform worse academically than their peers with declared majors (Leppel, 2001).

In addition to having consequences for students' academic careers, being undecided may also have effects on students' personal development and mental health. Some scholars have argued that undecided students tend to have high levels of anxiety and may be forestalled in their identity development (Hartman and Fuqua, 1983). Gordon and Steele's (2003) research supports this, as undecided students in their study reported a great deal of anxiety. Over half of the students who said they were completely undecided reported high levels of anxiety, and 84% of students with any level of indecision said they had some degree of anxiety about choosing their major (Gordon & Steele, 2003). Of course, it is impossible to know if the students in Gordon and Steele's study experienced anxiety *because* they were undecided, or if students with anxiety are also more likely to be undecided in their major choice. Still, students who are undecided may face additional obstacles in college that could negatively impact their academic and personal development. Hence, resources for college counselors often advise faculty and staff to assist undecided students in making a major choice as quickly as possible upon matriculation (Gordon, 2007).

Undecided students and STEM fields. Little is known about how many undecided students ultimately select any STEM field or CS. This review identified only a few studies that considered students' pathways from entering college as an undecided major to selecting a STEM major. Astin and Astin (1992) examined changes in students' major choice from the freshmen to senior year, focusing specifically on students' pathways to earning science, mathematics, and engineering degrees. Approximately 7.6% of the students in their study entered college as an undecided major; among the undecided students, 4.3% earned a degree in the biological sciences, 4.2% earned a degree in the physical sciences, and 1.1% earned a degree in engineering, and the remaining students earned a psychology, social science, or non-science degree. Astin and Astin (1992) included CS among the physical sciences, along with fields like mathematics, physics, and chemistry. Though useful, this study is dated, as the students surveyed began their college careers in 1985. Further, because of the way in which STEM sub-fields were defined, it is unknown how many of the students who entered college as undecided students went on to earn a CS degree.

Green and Sanderson (2014) used data on undergraduate students from 2003 to 2009 to study what factors motivated students who entered college without a major to declare a STEM major, including a variety of computing majors, and complete a STEM degree. In this study, about 20% of the students who began college with no major went on to complete a STEM degree. Undecided students who scored higher on standardized test scores, had strong high school grades, and took advanced high school mathematics coursework, were more likely to complete a STEM degree. The authors noted that taking calculus in high school was especially important, and those who completed a STEM degree had SAT scores approximately one hundred points higher than those who went on to earn non-STEM degrees. Gender and race were also important predictors of students completing a STEM degree, as women were less likely to go on to earn a STEM degree and Asian students were more likely. Further, the study found that the Carnegie classification of the students' school was important, as students attending bachelors-level institutions were more likely to complete a STEM degree than students at master's or doctoral institutions, "implying that institutions that are more focused on teaching than research may better nurture students who are not initially interested in STEM" (Green & Sanderson, 2014, p. 22). Hence, it is not only students' individual characteristics that shape undecided students' decision to complete a STEM degree like CS but also the academic environment that they experience in college.

A study by Hurtado et al. (2015) also examined factors that predicted undecided students' ultimate choice of a STEM major using data from a variety of sources to follow students who entered college in 2004 up until graduation. Much like Green & Sanderson (2014), Hurtado and her colleagues (2015) found that undecided students' high school academic preparation and achievement was particularly important. Further, institutional characteristics were significant predictors of undecided students' choice of a STEM degree. For example, attending an institution where a high proportion of STEM students were pre-med had a negative association with the likelihood that an undecided student would go on to earn a STEM degree. Additionally, students who had higher degree aspirations, particularly undecided students who entered college with plans to earn a doctorate or medical, dental, or veterinary degree were more likely to earn a STEM degree.

The findings from Green and Sanderson's (2014) and Hurtado et al.'s (2015) studies are important because they provided specific information on factors that predict undecided students' ultimate choice of a STEM major. However, in both studies, only undecided students were included in the models that predicted students' STEM major choice. Hence, these studies do not differentiate which of the predictors are unique to undecided students and which may be universal to any student who majors in a STEM field. More research is needed to understand the extent to which predictors of undecided STEM major choice may be similar to or different from those factors that predict a STEM major choice for all students.

Introductory CS Courses

Some of the first academic environments that college students interested in pursuing a STEM field encounter are introductory STEM courses. Introductory STEM courses are crucial to students' retention and success in pursuing and completing a STEM degree, particularly for women and URM students (Seymour & Hewitt, 1997). These courses often serve as "gatekeepers" that filter students out of STEM majors such that only the most successful students continue in the major (Tobias, 1990). Further, the content, structure, and approach to teaching introductory STEM courses plays an important role in shaping outcomes for students, such as students' level of engagement in the introductory course (Gasiewski et al., 2011). This study focuses specifically on students' experiences in introductory CS courses. Though there are many studies that examine introductory CS courses (sometimes called CS1 courses), the literature base is descriptive in nature (e.g., Rich et al., 2004) and emphasizes the particular efforts of a single institution to improve their introductory CS course (e.g., Newhall et al., 2014; Wilson, 2002). Still, the literature on introductory CS courses has found that developing student support initiatives (e.g., homework help sessions), integrating best pedagogical practices (e.g., pair programming), and making courses more engaging improve introductory CS courses, particularly for women and URM students (Newhall et al., 2014; Rich et al., 2004; Wilson, 2002).

Despite their importance for retaining students, few studies have considered the role of introductory courses in *recruiting* students to STEM or CS majors. This review identified only one study on recruiting students to a STEM major from introductory courses. The study focused on the geology major and found that approximately 7% of students enrolled in the classes were candidates for recruitment into the major (Hoisch & Bowie, 2010). The authors argued that reinforcing positive perceptions of geologists/geology and addressing negative perceptions of field are key to recruiting students from the introductory course into the major (Hoisch & Bowie, 2010)

Prominent scholars and computing-organizations focused on broadening participation in CS have argued that CS departments should recruit students from within their institutions (Cohoon, 2002; NCWIT, 2015), yet this review located only two studies that focused on non-majors and undecided majors in introductory computing courses. Farkas and Murthy (2005) studied changes in non-major and undecided students' perceptions of computing over the course of taking an introductory computing class. They found that students' perceptions became increasingly negative. Therefore, the authors hypothesized that taking an introductory course might discourage students from choosing a computing major; however, the study did not examine the impact of taking the course on the likelihood of students' choosing a computing major. Further, the introductory computing course in this study was a computing literacy course, not a programming course.

Denner et al., (2014) studied students at California community colleges who were enrolled in introductory programming courses to see what factors predicted students' plans to pursue a CS major at a four-year university. This study found that for women, having an interest in CS, playing video games, having peer support, expecting success in computing, and being interested in solving problems were significant predictors of planning to pursue a CS major. For men, important predictors included having an interest in CS, playing video games, having prior programming experience, and reporting positive interactions with instructors and peers in computing classes. Hence, this study suggests that experiences in entry-level computer courses were more important for men than for women in their ultimate decision to pursue CS. This study provides important information on factors that might contribute to students in introductory computing courses going on to pursue computing degrees based on data from institutions in the state of California. It provides a foundation for studying these factors at four-year institutions across the United States.

Summary of Literature

The above-sections have summarized what is known about the gender and racial/ethnic gaps in CS, undecided students and their decision to pursue a STEM field, and introductory CS courses and the role they play in recruiting undecided majors to the computing field. Significant gaps in the literature exist, particularly studies that address gender *and* race/ethnicity in diversifying CS, factors that lead to undecided students choosing a CS major, and the role of introductory CS courses in recruiting students to the major. Further, much of what is known on these topics is based on single-institution studies. To make knowledge generalizable across institutional contexts, more multi-institutional research is needed.

Theoretical Frameworks

At the heart of this project are two central areas of inquiry: (1) how do undecided students in introductory CS classes use their experiences in that course to inform their ultimate major choice? (2) how do these experiences and decision making processes vary by gender and race/ethnicity? To explore these questions, this study makes use of two complementary theoretical frameworks, Holland's Theory of Career Choice (1997) and Carlone and Johnson's (2007) science identity theory. Though Holland's theory is one of vocational choice, Holland states explicitly that it can also be used to understand how students make choices in educational setting. It is particularly useful for this study because it examines the relationship between an individual and the environment. Therefore, it helps to clarify the role students' experiences in the introductory CS course may play in a students' major selection process. Carlone & Johnson (2007) developed a theory of science identity development that has been specifically used to understand how women and people of color in STEM fields make sense of their experiences within STEM majors and the impact these experiences have on their persistence in STEM fields. Their framework provides a lens to understand how undecided students integrate experiences they have in introductory CS courses into their own science identity and how these experiences play into undecided students' major selection process. The following sections summarize each theory and discuss their application to this study.

Holland's Theory of Career Choice

Holland posits that people make vocational choices based upon their personalities and, in turn, their career choices are reinforced by the characteristics of their chosen vocation. Smart, Feldman, and Ethington (2000) applied Holland's theory specifically to college students making choices about their academic major. They summarize the three main assumptions of Holland's theory as it pertains to college environments as follows: "1) students choose academic environments compatible with their personality types, 2) academic environments reinforce and reward different patterns of student abilities and interests, and 3) students flourish in environments that are congruent with their dominant personality types" (Smart et al., 2000, p.

33). Hence, students' major choices are shaped both by their individual characteristics as well as the characteristics of the academic environment.

Individuals and environments. In Holland's theory, most people can be classified as one of six model personality types: realistic, investigative, artistic, social, enterprising, and conventional. Holland explains that these personality types come from heredity and social experiences. According to Holland, a person's race/ethnicity and gender shape his/her social experiences, which in turn, help shape personalities. Similarly, there are six model environments that are analogous to the personality types. Holland (1997) defines a model environment as "the situation or atmosphere created by the people who dominate a given environment" (p. 41). Model environments require, reinforce, and reward the characteristics of the analogous personality types who dominate them.

Environments are inextricably linked with the people who are a part of said environment. That is, environments are conveyed through people. Hence, the collective traits of the people in an environment, including their demographic (e.g., gender, race/ethnicity, age) and psychological characteristics (e.g., personality or learning styles), predict the prevailing features of that environment (Strange & Banning, 2001). In a collegiate environment, students' interactions with their academic environments cue them about whether or not a specific environment is a good "fit" for them. Holland calls the degree of fit between persons and environments congruence. The more congruent an individual and an environment are, the more likely a person will be attracted to and satisfied by that environment. Environments that are inhabited by individuals who are very homogeneous in terms of personality types are said to be highly differentiated.

Differentiated environments actively reinforce their own characteristics (Holland, 1973), while undifferentiated environments are more flexible and open (Strange & Banning, 2001).

Once an individual is part of an environment, the person goes through a socialization process. As part of socialization, members of the environment will reward new members for acting in ways preferred by the environment, developing the competency areas required by the environment, and adopting the values of the environment (Smart et al., 2000). In educational settings, socialization is a particularly important process. Smart, Feldman, and Ethington (2006) argue that students who select academic environments with which they are not congruent are not necessarily “doomed to some degree of failure or unhappiness in their vocational or academic careers” (pg. 18). Rather, research demonstrates that academic environments (e.g., academic departments) have a similar impact on students’ growth in the abilities and interests related to that specific academic environment, regardless of whether or not students’ Holland type was congruent or incongruent with that academic environment (Smart et al., 2000; Feldman, Ethington & Smart, 2001; Feldman, Smart & Ethington, 2004). Hence, the socialization aspect of Holland’s theory is a powerful force that allows individuals to develop characteristics that were not initially strong.

Application to present study. A number of scholars have explored the relationship between individuals, environments, and the groups of individuals that make up these environments within collegiate settings (e.g., Astin,1968, 1993; Clark and Trow, 1966). However, Holland focuses specifically on how people, including college students, make vocational choices. Further, this study looks at students who have not yet made a choice about their academic major. As mentioned previously, Holland was among the first to conceptualize major indecision (Holland & Holland, 1977), and he continued to advocate for the use of his theory in studying undecided majors (Gordon, 2007). Additionally, undecided students are already being exposed to a variety of academic environments, including CS, through their introductory courses. Therefore, Holland's theory helps clarify how students make choices about a major in light of the socialization forces they experience in their introductory CS course. As Smart et al. (2000) discuss, the role of academic disciplines is often examined in studies of faculty but is less frequently examined in studies of students. However, given the extent to which academic disciplines can shape students' development in college (Smart et al., 2000; Feldman et al., 2001, 2004), it is clear that academic disciplines are central to understanding students.

Holland's theory also provides important information on CS as an academic environment. Originally, Holland and his colleagues classified CS as an enterprising environment (Rosen, Holmberg & Holland, 1987). Enterprising environments focus on enterprising activities, like selling products or managing people, and tend to value money, power, and status. More recently, college career services offices tend to categorize the CS major as an investigative environment (e.g., Salisbury University, 2014; University of North Florida, 2015), which center around analytical and scientific activities and value scholarship, intellectualism, and scientific rigor. Though no discussion of how or why CS was reclassified could be found, it is likely that the changing nature of the field from one that was more vocational to one that is more scientific led to its reclassification. Interestingly, investigative environments tend to be male dominated. In their study of how students' personality types predicted their initial and ultimate college major choice, Smart et al. (2000) found that the largest group of students who selected a field congruent with their personality were men with investigative personalities who selected investigative environments. Women, on the other hand, were more likely to choose social environments. Hence, Holland's theory not only provides a frame by which to understand the students' decision making process, but it also provides a lens by which to understand CS as an academic environment, including the ways in which it may be a gendered space.

Carlone and Johnson

Carlone and Johnson (2007) present a science identity theory that takes into account the dynamics of race and gender in students' experiences in scientific disciplines. Carlone and Johnson developed their framework because they identified a need for lens that "takes into consideration the complex interplay between structure and agency and the ways these tensions play out over time" (p. 1188). In other words, they sought to explain how students' experiences in scientific disciplines affected the ways in which students formulated their identity as scientists. The authors borrow Brickhouse's (2001) definition of identity, arguing that identity is "individual agency plus societal structures that constrain individual possibilities" (Brickhouse, 2001, p. 286).

In developing their theory, Carlone and Johnson conducted ethnographic interviews with of women of color in science to ascertain how they make meaning of their science experiences, develop and sustain a science identity, and understand the relationship between their science identity and gender and racial identities. Out of these interviews, Carlone and Johnson model science identity in terms of individuals' competence, performance, and recognition. The authors explain that "a science identity is accessible when, as a result of an individual's competence and performance, she is recognized by meaningful others, people whose acceptance of her matters to her, as a science person" (p. 1192). Hence, in establishing a science identity, an individual's knowledge and understanding of science intersects with one's ability to perform relevant science activities and be recognized as a scientist (see Figure 2.2). Further, one's science identity and gender, racial, and ethnic identities mutually inform and reinforce each other.

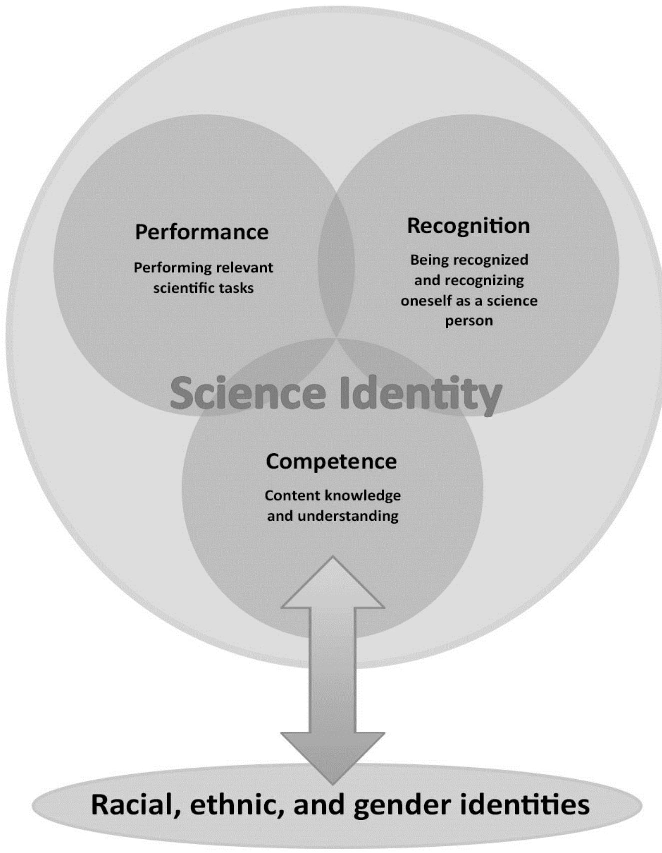


Figure 2.2. Science Identity Model, Adapted from Carlone and Johnson (2007)

Application to present study. While Holland helps to clarify how and why students make major choices, Carlone and Johnson provides an identity lens to understand how undecided students make sense of their experiences in CS introductory courses, specifically as it pertains the extent to which they do or do not see themselves as (computer) scientists. Carlone and

Johnson (2007) explain the need for an identity lens in approaching research on underrepresented populations in STEM:

> The identity lens allows us to ask questions about the kinds of people promoted and marginalized by science teaching and learning practices, the ways students come to see science as a set of experiences, skills, knowledge, and beliefs worthy (or unworthy) of their engagement; and the possible ways that students' emerging identities in science might eventually involve changes in their more enduring sense of why they are and who they want to become (Carlone & Johnson, 2007, p. 1189).

This study explored undecided students' experiences in introductory CS courses, paying particular attention to how these experiences vary by gender and race. Carlone and Johnson's model helps to forefront how students' gender, racial, and ethnic identities influence their introductory course experience and ultimately their major choice. Further, as discussed previously, students in introductory STEM courses take part in an intense socialization process by which they are expected to adopt the norms and values of that discipline (Cech, Rubineau, Silbey & Seron, 2011). As students in this study are socialized into CS through their introductory course, an identity lens provides a framework for understanding how new students "affiliate with, become alienated from, and/or negotiate the culture norms within these communities" (Carlone & Johnson, 2007, p. 1189).

Summary and Conclusion

This chapter reviewed the literature on gender and racial/ethnic gaps in CS, undecided students, and introductory CS courses. Research on broadening participation in the sciences has generally focused on STEM fields in the aggregate, while relatively little literature has focused on CS specifically. Research has paid more attention to the gender disparities in the field, while less research focuses on the URM students and even fewer studies have focused specifically on women of color in CS. The literature that does exist attributes the lack of women and students of color, particularly African American, Latino, and Native American students, in CS to a number of factors related to the culture of computing, prior computing experience, barriers to entry, an absence of role models and mentors, insufficient and poor faculty-student and peer interactions, unsupportive curricula and pedagogy, and student characteristics. More multi-institutional research is needed to explore how these factors play out across institutional contexts, as well as research that considers the role of gender *and* race/ethnicity in diversifying CS.

The literature on undecided students suggests that many students, regardless of whether or not they have officially declared a major, come to college with some level of indecision. However, very little research has investigated the predictors of undecided majors going on to choose a STEM and/or CS major. Therefore, more research is needed to understand the pathway for undecided majors to choose a CS major.

Introductory STEM and CS courses play an important role in retaining students, particularly women and URM students; however, very few studies have investigated the role that these courses play in recruiting undecided or non-major students to STEM fields generally or CS specifically. The little research that does exist has focused on introductory courses at a single institution or the pathways for students who take an introductory programming course at a community college and plan to go on to major in CS at a four-year university. Hence, more multi-institutional research is needed about the role of introductory courses in recruiting students to STEM and CS majors.

This study addresses these important gaps by studying undecided students who take an introductory CS course at fifteen colleges and universities across the United States and how their experiences in these courses vary by gender and race. As described above, this study uses Holland's Theory of Career Choice (1997) and Carlone and Johnson's (2007) science identity theory to understand how students who take introductory CS courses make a major selection and what aspects of their experiences in the introductory CS course might propel or discourage them from choosing a CS major. The chapter that follows outlines the study's methodology. In order to capture a more complete picture of the role introductory CS courses plays in undecided students' major choice selection and how their experiences vary by gender and race, a mixed-methods approach is employed. Chapter three outlines detailed information on the sample, data collection, and data analysis.

Chapter Three: Methods

The analyses for this study seek to identify the characteristics of undecided students who enroll in introductory CS courses, explore the experiences these students have in the course, and understand how undecided students' introductory computing course experiences may influence their decision to choose a CS major. The means by which students choose a college major is complex and highly individual (Gordon, 2007). In order to thoroughly examine the major selection process for undecided students, this study used both quantitative and qualitative methods. Taken together, the two research streams allow for the exploration of different facets of the data and develop a more complete picture of the undecided student experience in introductory computing courses (Creswell & Plano Clark, 2011).

This study employed a convergent design to address research questions across quantitative and qualitative research streams, utilizing multiple modes of analysis. To address the first of the quantitative questions, descriptive analyses were run to identify undecided students' traits and perceptions of course climate as a group and determine if differences exist between men and women, students from different racial/ethnic groups, and undecided students and CS majors. Second, a logistic regression analysis was conducted to test the relationship between undecided students' introductory course experiences and their intent to major in CS. Interaction terms were incorporated into the regression analysis to determine if and how the predictive power of students' course experiences differs by students' gender and/or racial/ethnic identity. Qualitative questions give voice to the undecided students in the study and provide a rich description of what it means to be an undecided student in an introductory computing course. A phenomenological approach was utilized to answer questions related to why undecided students take an introductory course and how they make a major choice, particularly in light of their introductory CS course experiences. Finally, data from both research streams were brought together for discussion (Creswell & Plano Clark, 2011). This study addresses five main research questions.

Research Questions

Quantitative questions:

1. What are the demographic and family traits, academic and computing backgrounds, and self-ratings of undecided students who choose to take an introductory CS course? Do these characteristics differ significantly by gender? By race/ethnicity? Between undecided students and declared CS majors?
2. What are undecided students' perceptions of the climate in their introductory CS courses, particularly in terms of their experiences with the course instructor and their peers? Do their perceptions vary by gender? By race/ethnicity? Between undecided students and declared CS majors?
3. To what extent is there a relationship between undecided students' experiences in introductory CS courses (e.g., teaching and evaluation practices, faculty attitudes toward students, and experiences with peers) and their intention to major in CS? What is the magnitude of the relationship? Does the relationship differ by the students' gender and race/ethnicity?

Qualitative questions:

4. Why do undecided students choose to take an introductory CS course?

   a. How do their gender and/or racial/ethnic identities play into their decision to take an introductory CS course?

   b. How do their career aspirations play into their decision to take an introductory CS course?

5. How do undecided students make the decision to major or not major in CS?

   a. How do their experiences in the introductory course factor into their decision-making process?

   b. How do their gender and/or racial/ethnic identities play into their major choice?

This chapter will discuss the research questions and accompanying hypotheses and propositions. Then this chapter will describe the overarching mixed-methodology before discussing the specific approaches for both the quantitative and qualitative research streams, including the samples, data sets, and analytical approaches.

Hypotheses

The following section reiterates the research questions guiding the study. The first three questions stem from the quantitative stream and are accompanied by hypotheses and rationales. The last two questions are qualitative in nature. Because I wanted to approach the qualitative aspects with an open mind and did not want bias my interpretation to fit with any pre-conceived beliefs, I do not provided specific hypotheses for questions associated with the qualitative stream. Instead, I will discuss some general propositions that I brought to the qualitative components of the project.

Quantitative Stream

Research question one. What are the demographic and family traits, academic and computing backgrounds, and self-ratings of undecided students who choose to take an introductory CS course? Do these characteristics differ significantly by gender? By race/ethnicity? Between undecided students and declared CS majors?

Hypothesis. I hypothesized that most of the undecided students who enrolled in introductory CS courses would be male, White or Asian, and from higher income families. Further, I predicted that they would have taken advanced math, science, and computing coursework in high school. I expected to find some differences between men and women, students from different racial/ethnic groups, and between undecided students and declared CS majors. Specifically, I predicted that women would have higher grades than the men but less computing experience and less confidence in their intellectual, mathematical, and computing abilities than their male counterparts. Similarly, I anticipated the URM students would have less science, math, and computing experience than majority students and would also tend to have lower self-ratings. Though I predicted the group would include mostly men and majority students, I anticipated that the undecided students would be more diverse in terms of race and gender than declared CS majors. Finally, I expected that the undecided students would have less computing experience than students who had already decided on a CS major.

Rationale. Previous studies have found that undecided students who go on to pursue a STEM major tend to reflect similar demographics and backgrounds as STEM students in general, such that undecided students who are male, White or Asian, and with strong math and science backgrounds are more likely to go on to complete STEM degrees (Green & Sanderson, 2014; Hurtado et al., 2015). Additionally, a previous study compared the background traits and self-ratings of men and women who reported intent to major in CS (Lehman et al., 2017). This study found that women had higher grades but less confidence in their intellectual, mathematical, and computing abilities. It seemed likely that similar patterns would emerge among men and women who are undecided in their major but enroll in a computing course. Further, literature on URM students' participation in the computing field suggests that underrepresented students may not have been afforded a strong math/science background or computing experience, and these obstacles may keep them from pursuing a computing degree (Charleston, 2012; Kodaseet & Varma, 2012; Margolis et al., 2008; Varma, 2006). Hence, it followed that undecided students from underrepresented groups might have less experience and/or confidence in math, science, and computing than majority students. Finally, CS students are disproportionately male and White or Asian (NSF & NCES, 2012), so I anticipated that declared CS majors would reflect those traits, while undeclared students might be more diverse. Further, having a strong background in math and science (Herling, 2011; Margolis & Fisher, 2002; Wilson & Shrock, 2001), having prior computing experience (Margolis et al., 2000; Margolis et al., 2008), and being confident in one's computing and math abilities (Sax et al., 2017) are important factors in students' participation in computing. I thought it likely that students who entered college certain they wanted to major in CS would more closely reflect those characteristics than students who came to college unsure about their major choice.

Research question two. What are undecided students' perceptions of the climate in their introductory CS courses, particularly in terms of their experiences with the course instructor and their peers? Do their perceptions vary by gender? By race/ethnicity? Between undecided students and declared CS majors?

Hypothesis. I hypothesized that the undecided students would generally have positive perceptions of the climate in their introductory CS course and would find their instructors and classmates to be supportive and accessible. However, I expected that students in majority groups, including men and White and Asian students, would have more positive perceptions of the climate than women or minority students. Further, I expected that students who had declared a CS major would view the climate in their introductory CS courses more favorably than undecided students.

Rationale. The institutions in this study are all part of the BRAID initiative, and a key component of the BRAID initiative is to address issues of climate, particularly within the context of introductory courses. Further, each of the BRAID institutions have publicly and explicitly pledged to work to improve the experience for women and URM students in the CS major. Hence, it is likely that the students in this study encountered introductory CS courses taught by instructors who share in the BRAID's commitment to diversity and may also have undergone training about how to create a supportive classroom. Similarly, I expected that the departmental commitment to diversity and creating a positive climate would be reflected in the student body; hence, I believed that students would generally find their instructors and peers to be supportive. However, given the literature that demonstrates that women and URM students face challenging climates in CS departments (e.g., Cech, 2014; Cohoon & Aspray, 2008; Margolis et al., 2008), I predicted that women and URM students would view the climate in their introductory CS courses less favorably than men or majority students. Further, given my prediction that declared CS majors would come to college with more computing experience (see hypotheses and rationale for research question one), I anticipated that these students would be more accustomed to the climate of CS and would therefore view the climate more favorably than undecided students.

Research question three. To what extent is there a relationship between undecided students' experiences in introductory CS courses (e.g., teaching and evaluation practices, faculty attitudes toward students, and experiences with peers) and their intention to major in CS? What is the magnitude of the relationship? Does the relationship differ by the students' gender and race/ethnicity?

Hypothesis. I hypothesized that there would be a positive relationship between undecided students' experiences in the CS course and their intent to major in CS, such that students who reported favorable experiences in the course would have a higher likelihood of reporting an intent to major in CS at the end of the course. I further hypothesized that students' course experience will be more important for women than for men and for URM students than majority students.

Rationale. Previous research has found that student-centered pedagogical and curricular practices are important for all students' continued interest and success in CS (Radermacher & Walia, 2011; Settle, 2012; Werner et al., 2005). Additionally, studies have shown that a student-centered approach may be more important for women than men (Cohoon, 2001; Hewlett et al., 2014). Varma (2006) suggested that positive course experiences are key to URM students' interest and success in CS. Further, studies have shown that when CS teachers receive professional development around issues of diversity and engaged pedagogy, the number of women and URM students who take CS courses significantly increases (Goode, 2007; Margolis et al., 2008).

Qualitative Stream

While the quantitative components of this study provides big picture information about the characteristics and experiences of undecided students in introductory CS courses, the qualitative aspect of this study allows for greater understanding of the nuances of students' lived experiences in those courses. Specifically, the qualitative stream of this study investigates *why* undecided students might choose to take an introductory CS course and *how* their experiences in the course may or may not inform their decision-making around selecting a college major. Some basic propositions prompted my interest in the experiences of undecided students who take introductory CS courses and led me to expect the following:

- Undecided students, particularly women and URM students, would take an introductory CS course because they a) had a talent for math and science and b) had been encouraged by a family member or teacher that CS might be a worthwhile application of that talent.
- Undecided students would utilize their experiences in their courses, including the introductory CS course, to inform their decision-making as they seek to choose a major.
- Undecided students with introductory CS course instructors who utilized traditional methods, particularly lectures, and evaluated students mainly through examinations would find that the CS courses did not meet their expectations. That is, the students would find the programming aspects foreign, difficult, and uninteresting and would be dissuaded from pursuing the CS major.
- Students enrolled in introductory courses with professors who are engaging, utilized student-centered pedagogy, and emphasized the real-world application of CS would be excited about computing and would consider CS as a major.

- Undecided students enrolled in introductory CS courses who felt that they "fit in" with their peers in the class would feel more engaged in the course and be more interested in pursuing CS as a major.

Mixed Methodology

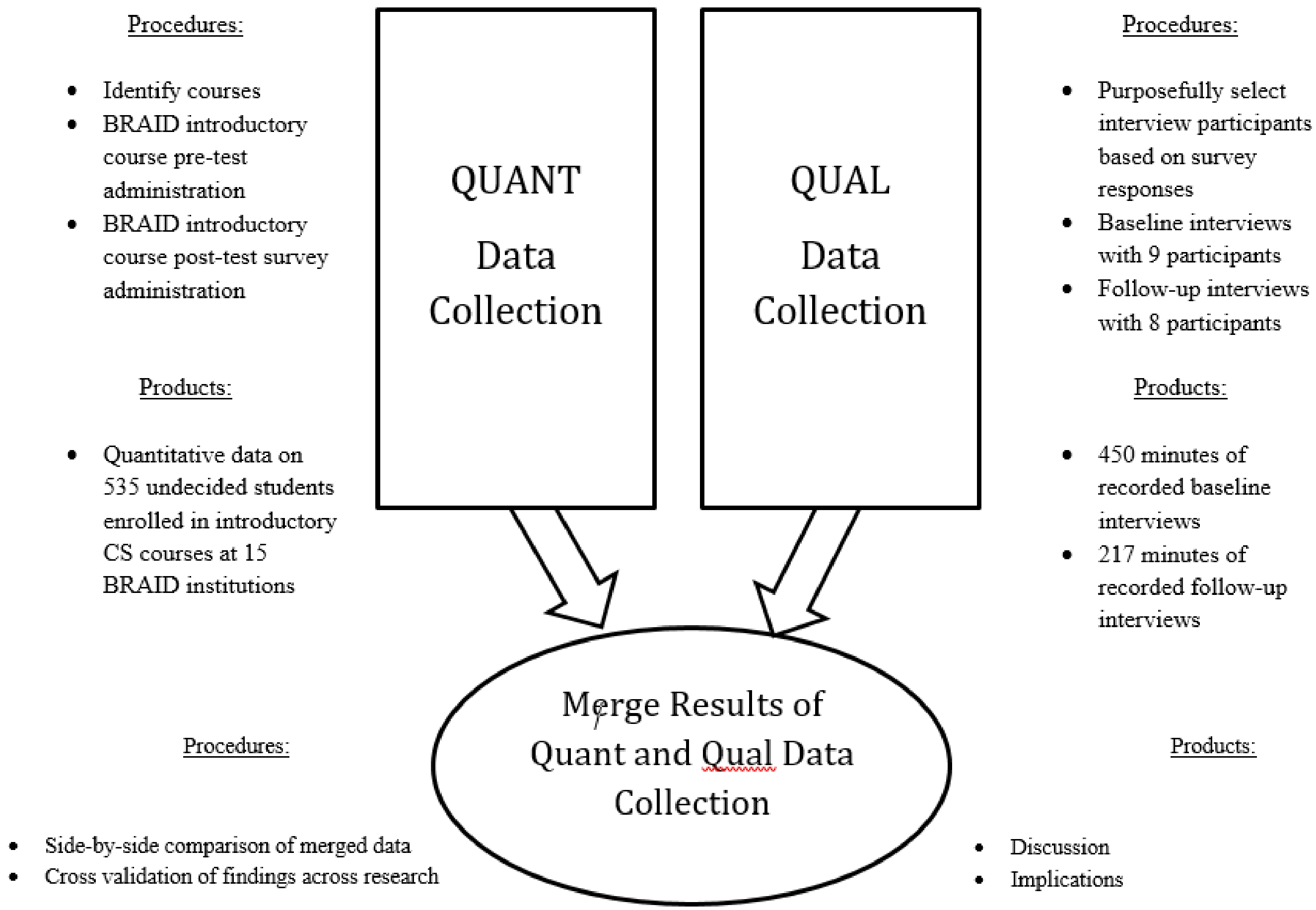
This study utilized a convergent, mixed-methods design. A convergent design involves collecting, analyzing, and merging quantitative and qualitative data and results simultaneously. That is, for both the data collection and analysis phases, quantitative and qualitative data are collected separately but at the same time. Then, the data from both streams are merged together for interpretation. This approach is useful in developing a holistic understanding of a topic (Creswell & Plano Clark, 2011). This study used the "parallel-databases variant" of the convergent design process in which the researcher employs the qualitative and quantitative data to study different facets of the phenomenon in question (i.e., the experience of undecided students who enroll in introductory CS courses). Then, the two sets of independent results are brought together and compared in the discussion (Creswell & Plano Clark, 2011). Hence, in the sections that follow, the details of quantitative and qualitative methodologies are discussed separately; however, in chapter six, the results are discussed together to allow for side-by-side comparison of the merged data (Creswell & Plano Clark, 2011). Figure 3.1 is a procedural diagram depicting the mixed-methods design for this study. As shown in Figure 3.1, the participants for both the quantitative and qualitative streams were enrolled in introductory CS courses at institutions involved in the BRAID initiative. Therefore, the following section will summarize the BRAID initiative before moving to detailed discussions of the quantitative and qualitative methodologies.

BRAID Initiative

The BRAID initiative is a joint effort led by Dr. Maria Klawe, president of Harvey Mudd College, and Telle Whitney, CEO of the Anita Borg Institute. In the summer of 2014, Dr. Klawe selected 15 institutions to participate in BRAID, an initiative to increase the representation of women and underrepresented minority students in computer science departments. BRAID schools were selected on a first-come, first-serve basis following the announcement of the initiative at a conference for computer science department chairs. Although the institutions selected to participate in BRAID are a convenience sample, analyses of the BRAID schools' computer science degree attainment data reveal that BRAID institutions closely resemble national trends in computer science degree production for women and men (Sax & Lehman, 2015). Further, the institutions represent a mix of public and private institutions located in regions across the United States. Each BRAID school was provided $30,000 a year for three years to support diversity efforts in return for their commitment to increase the representation of women and URM students in the CS major by developing initiatives related to least three of the four following areas: 1) improve introductory CS courses; 2) address issues of the climate in the CS major and department; 3) develop or expand their outreach efforts to recruit more women and URM students to the major; 4) incorporate interdisciplinary approaches into the CS curriculum (e.g., dual-degrees in CS and business or interdisciplinary classes that incorporate art and programming).

Alongside the departmental efforts, Dr. Linda Sax of UCLA and her team of graduate students (including the author of this study) are conducting a longitudinal, mixed-methods research study to document the BRAID initiative and identify best practices. For a summary of the research design of the larger BRAID research project, see Sax, Lehman, and Blaney (2016). While the BRAID research project is interested in the experiences of all types of computer science students at BRAID institutions, this study focused specifically on the experience of undecided students who take an introductory computer science class. Hence, this study drew upon some of the survey data collected by the UCLA BRAID research team, as discussed in more detail below, but the analyses and qualitative data collection were independent of the larger research project.

Figure 3.1. Procedural Diagram for Convergent Design Mixed-Method Procedures



Quantitative Methodology

Data Source and Sample

The quantitative data in this study was drawn from the UCLA BRAID research team's student surveys. Specifically, the data was obtained from student responses to pre- and post-test surveys that were administered to all students enrolled in introductory courses at BRAID institutions during the 2015-2016 and 2016-2017 academic years. The BRAID research team allows the department chair of each institution to determine what constitutes an introductory CS course; however, the department chairs were encouraged to select courses that a) represented the first course that would allow a student to complete a CS major and b) involved programming as a central component of the course content. The BRAID department chairs provided the research team with the names, titles, and course numbers for the introductory courses to be surveyed as well as the names and email addresses of the students enrolled in those courses. The BRAID research team then administered the BRAID introductory course surveys to students online through the survey administration software Qualtrics. BRAID departments participated in recruitment efforts by posting flyers and making in-class announcements related to the survey. Further, students were incentivized to complete the survey in two ways: 1) the first 400 students to complete each survey receive a $15 electronic Amazon gift-card and 2) during both the pre- and post-test administrations, all participants were entered in a drawing to receive one of two $125 electronic Amazon gift-cards.

Survey instruments. The BRAID introductory course instruments were developed by the BRAID research team in consultation with the staff of the Computing Research Association's

(CRA) Center for Evaluating the Research Pipeline (CERP) which is responsible for the Data Buddies Survey (DBS). The DBS is administered each fall at approximately 100 institutions to computing students across the United States. In order to allow data from BRAID institutions to be compared with data from non-BRAID schools, the BRAID research team incorporated many items on the DBS into the BRAID survey instruments. More details about the survey instruments are discussed in the following paragraphs; the full pre- and post-test instruments are located in Appendix A.

The analyses for this study were based upon samples derived from the pre-test and the matched sample from the pre- and post-test during the fall 2015, spring 2016, and fall 2016 administrations of the surveys (see Table 3.2 below for a summary of the samples and data sources used to address each research question). The pre-test survey is administered to students within the first month of class in order to obtain baseline information on students' background characteristics, pre-course experiences, and pre-course academic and career plans and aspirations, including their major choice. During the 2015-2016 and fall 2016 survey administrations, 21,988 students were enrolled in introductory CS courses at the participating BRAID institutions, and 6,854 of those students completed the pre-test, resulting in a 31% response rate.

All students enrolled in the courses receive the post-test survey during the last two weeks of their introductory course. This survey is composed of two parts: the DBS and the post-test module. The DBS asks questions relevant to students' departmental and extracurricular computing experiences and gathers information related to students' demographic traits, selfperceptions, and views about computing. The post-test module focuses specifically on students' experiences within their introductory CS course. Across the 2015-2016 academic year and fall 2016 administrations, 40% (n=2,589) of the students who took the pre-test also took the post-test.

Undecided student sample. For most of the analyses in this study, the samples were restricted to students who were undecided in their major choice. Students were coded as either decided or undecided based on their responses to several questions on the pre-test related to their major and degree of confidence in that choice (Guay et al., 2003; Guerra & Braungart-Rieker, 1999). Specifically, students were asked to select one of the following: 1) "I have one major;" 2) "I have more than one major;" or 3) "I have not decided on a major." Students who have at least one major are then asked to determine the extent to which they agree with the statement "I am very committed to my major" on a five-point scale from strongly disagree to strongly agree. Students who say they have not decided on a major are asked to propose a major if they "had to choose one today." These students are also asked to state the extent to which they agree with the statement "I am confident that this will be my major" on a five-point scale from strongly disagree to strongly agree.

As discussed in chapter two, the definition of "undecided" extends beyond those students who simply do not have a declared major. This study aims to capture the concept of being undecided in several ways. First, students who say that they have not decided on a major (CS or otherwise) were counted as undecided. However, in order to have a more conservative estimate, those students who strongly agree that they are confident in a particular proposed major were coded as decided students.

Additionally, as suggested by Kelly and Lee (2002), some students who indicated that they do have a major were counted as undecided. This is done in order to account for the fact that some students may have declared a major but may not actually be committed to that major choice. This is particularly important given that declaring a major is required as part of admission at several of the institutions in the BRAID sample. Among the 15 BRAID institutions, six require students to declare a major as part of the admissions process. At the remaining institutions, students are required to apply to a particular school or college and are categorized as "intended majors" or "pre-majors." Therefore, students may have declared a major but may feel significant indecision about that choice. Hence, students who indicated that they have a major (CS or otherwise) but disagreed or strongly disagreed that they were committed to that major were also included as undecided. Across the fall 2015, spring 2016, and fall 2016 survey administrations 535 of the students who took the pre-test met this definition of "undecided" and 214 of these students also took the post-test. Table 3.1 summarizes the samples and data sources to be used to address the various research questions.

Table 3.1. Data Sources and Samples, by Research Question

Research Question	Data Source	Sample	Total N[1]
RQ1: What are the demographic and family traits, academic and computing backgrounds, and self-ratings of undecided students who choose to take an introductory CS course?	Pre-test	Undecided students	535
Do these characteristics differ significantly by gender?	Pre-test	Undecided students	535
Do these characteristics differ significantly by race/ethnicity?	Pre-test	Undecided students	535
Do these characteristics differ significantly between undecided and declared CS majors?	Pre-test	All students	6,854
RQ2: What are undecided students' perceptions of the climate in their introductory CS courses, particularly in terms of their experiences with the course instructor and their peers?	Matched Sample	Undecided students	214
Do these characteristics differ significantly by gender?	Matched Sample	Undecided students	214
Do these characteristics differ significantly by race/ethnicity?	Matched Sample	Undecided students	214
Do these characteristics differ significantly between undecided and declared CS majors?	Matched Sample	All students	2,589
RQ3: To what extent is there a relationship between undecided students' experiences in introductory CS and their intention to major in CS? What is the magnitude of the relationship? Does the relationship differ by the students' gender and race/ethnicity?	Matched Sample	Undecided students	214

A summary of selected demographic characteristics of the undecided student samples is provided in Table 3.2. Though there are some variations between the two samples, the majority of respondents in both the pre-test sample (used to address research question one) and the matched sample (used to address research questions two and three) were men. White students

[1] The total sample includes students from the fall 2015, spring 2016, and fall 2016 survey administrations.

make up the largest group of respondents in both samples, followed by Asian or Asian American students. Further, most of the students in both samples were in their first year, although about a quarter of respondents were second-year students.

Table 3.2. Selected Demographic Characteristics

	Pre-test Sample (N=535)		Matched Sample (N=214)	
	%	N	%	N
Students' Gender				
Men	62.1	332	58.5	125
Women	37.9	203	41.5	89
Students' Race/Ethnicity				
White	45.0	241	46.4	97
Asian or Asian American	29.5	158	30.6	64
Two or more: White and Asian	2.1	11	2.9	6
Black or African American	6.0	32	3.8	8
Hispanic or Latina/o	9.3	50	9.1	19
Native American	0.6	3	0.0	0
Native Hawaiian	0.4	2	0.5	1
Middle Eastern	0.7	4	0.5	1
Two or more: URM	6.4	34	6.2	13
Students' Class Standing				
First year	59.0	323	63.8	134
Second year	23.4	128	24.8	52
Third year	11.5	63	8.1	17
Fourth year or beyond	6.0	33	3.3	7

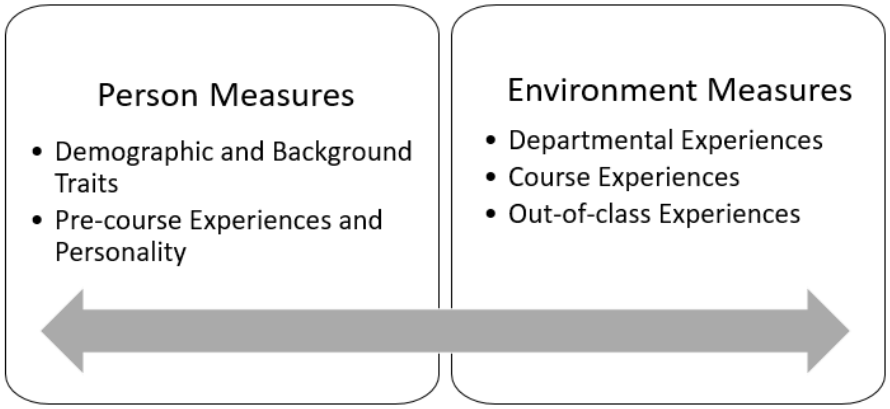
Conceptual Model

I relied heavily on Holland's Theory of Career Choice to drive variable selection and guide the blocking scheme for the quantitative analyses in this study. In its essence, Holland's theory is a person-environment fit theory; Holland suggests that students are first attracted to specific academic environments (i.e., the introductory CS course) due to their individual traits.

As shown in Figure 3.2, the first group of variables included “person” measures that help explain why students may have chosen to enroll in an introductory CS course, including demographic and background traits and student pre-course experiences and personality measures.

The second group of variables centered on the environment. Holland (1997) posited that there are six environment types that are analogous to the personality types, which he called model environments. The model environment attracts, reinforces, and rewards the characteristics of the personality types who make-up that environment. Once a person is part of an environment, the individual undergoes a socialization process in which members of that environment reward new members for behaving in ways that reflect the environmental norms and for developing skill sets important to that environment. Past research indicates that the socialization process is particularly powerful in academic environments (i.e., academic departments) such that students whose personality type is incongruent with their academic environment will experience similar growth in their abilities and interests as students with a Holland type congruent with the environment (Smart et al., 2000; Feldman et al., 2001, 2004). Hence, the environmental variables in this study did not focus on the typology of the environment but rather the impact of the environment on students. The environmental measures included in this study represent the different aspects of the collegiate environment likely to affect students’ major aspirations, including departmental experiences, course experiences, and out-of-class experiences.

Figure 3.2. Application of Holland's Theory to Present Study



Measures

Dependent measures. As discussed in chapter two, prominent scholars and computing organizations have argued that CS departments hoping to diversify the CS major should recruit undecided students into the major, particularly those who have enrolled in an introductory CS course (Cohoon, 2002; NCWIT, 2015). Therefore, one of this study's goals was to identify the factors that contribute to an undecided student's decision to pursue the CS major by the end of the introductory CS course. In light of this, the main dependent measure in this study was the students' intent to major in computer science at the completion of the introductory CS course. A dichotomous variable derived from the post-test determined if a student plans to pursue a CS major or not. A similar coding scheme as the one used determine if students are undecided majors (described above) was used to determine if a student was coded as a prospective CS major. Specifically, students who selected any of the computing major options, including Computer Science, Computer Information Systems/Informatics, Computing and Business, Information Technology, Computer Engineering, and Other Computing, were coded as prospective CS majors. Further, those students who remained undecided but selected a computing major as their proposed major and strongly agreed with the statement "I am confident that this will be my major" were coded as a prospective CS major. Finally, those students who had chosen a non-computing major or who remained undecided and did not display a high-level of confidence that they would choose a CS major were coded as non-CS majors.

As mentioned, this study included a variety of computing majors under the umbrella-term "computer science." For the larger UCLA BRAID research study, BRAID institutions were asked to identify the majors that fall under the scope of CS at their college or university. While all BRAID institutions have a CS major, many also have other computing majors that closely align with CS. In order to capture all of these students, this study broadly defined CS and uses the terms "computer science" and "computing" interchangeably. For a list of majors that encompass CS at BRAID institutions, see Table 3.3.

Table 3.3. Computer Science Majors offered at BRAID Institutions

Major	Number of Institutions
Computer Science	15
Computer Engineering	7
Data Science	3
Software Engineering	2
Computer Systems Engineering	1
Informatics	2
Computer Science and Information Systems	1
Applied Mathematics and Computer Science	1
Computer Information Systems	1
Information Systems	1
Business Information Management	1
Computer Game Science	1
Computer Science and Engineering	1
Information Technology	1
Management Information Systems	1

Independent variables. As discussed above variables were initially selected for the multivariate analysis were determined using Holland's (1997) Theory of Career Choice, as well as relevant literature outlined in chapter two. The list of variables for the descriptive and inferential analyses, including their measurement and coding schemes, is presented in Appendix B. The preliminary list of variables was reduced for the final multivariate analysis through the use of case analysis, missing values analysis, and factor analysis. First, the number of variables such that there were at least 10 cases per variable. The 10 case per variable is in keeping with recommendations for logistic regression analysis (Peduzzi, Concato, Kemper, Holford, & Feinstein, 1996), and a recent study found that the 10 case rule is quite conservative when applied to logistic analyses, such that Type I errors are unlikely to occur (Vittinghoff &

McCulloch, 2007). Additionally, variables for which more than 15% of the cases are missing were eliminated. Finally, exploratory and confirmatory factor analysis were used to create composite measures. This reduced the quantity of independent measures included in the model, thereby making it more parsimonious. More details about specific measures to be included in each block of the model are provided in the following paragraphs.

Demographics and background. The demographic and background variables included students' gender, racial/ethnic background, socioeconomic status, and parents' careers. All of these measures were drawn from the pre-test. Including demographic and background measures in the model is important for theoretical reasons. In Holland's (1997) theory, an individual's background characteristics are central to career and academic decisions. That is, individuals select academic environments that are compatible with their personalities. One's personality is determined both by heredity as well as social experiences, and Holland argues that social experiences are shaped by traits like gender and race/ethnicity. Further, as discussed in chapter two, the literature suggests that demographic and background traits have important implications for a student's decision to choose and succeed in a CS major (e.g., Beyer et al., 2003; Cohoon and Aspray, 2008; Margolis et al., 2008; Sax et al., 2017).

The measurement and coding schemes for all the variables included this block can be found in Table B2 in Appendix B. The composition of a several items in this block warrants further explanation. Although students' gender was primarily drawn from the pre-test survey, if a respondent did *not* respond to the gender item on the pre-test but *did* respond to the gender item on the post-test, their post-test response for gender was imputed for the regression analysis. The gender variable was coded toward women (i.e., 1=male and 2=female).[2] When creating the variables for race/ethnicity, I had hoped to disaggregate groups as much as possible, but the small samples available for some racial/ethnic groups necessitated that I create a dichotomous variable comparing URM students (Black/African American, Hispanic/Latino/a, Native American, Native Hawaiian, Middle Eastern, and Two or more races (URM) against majority students (White and Asian/Asian American students). URM students were coded as the higher value (1=White and Asian students and 2=URM students).

As mentioned, a measure of students' socioeconomic status was included in this block. To capture the multiple dimensions of students' socioeconomic backgrounds, I created a scale that incorporated students' self-reported level of wealth in qualitative terms (e.g., "poor," "average," and "wealthy") as well as their self-reported family annual income. Then, I examined the distribution of the scale across all students who took the survey and recoded the scale to make the resulting measure more meaningful categories (i.e., "high," "medium," and "low"). Additionally, the parents' career variable included in this block captures the extent to which any of the students' parents have a career in computing. On the pre-test survey, students may provide information on up to four parents. Therefore, students who reported that at least one parent has a career in computing were coded as "yes," whereas students who reported that none of their parents has a computing career were coded as "no."

[2] Students are asked to indicate their gender on the pre- and post-tests and are given three response options (1=male; 2=female; 3=non-binary category or something else, please specify). Four respondents indicated a non-binary gender. These cases were excluded from the analyses.

Student pre-course experiences and personality. The pre-course experiences and traits block incorporated measures derived from the pre-test that are related to students' high school grade point average (GPA), prior programming experiences, sense of belonging in CS, and student personality. The variables included as pre-course experiences represent social experiences that Holland (1997) suggests help shape a person's personality, which in turn, influences the choices one makes about selecting an academic major. The inclusion of pre-course experiences is further justified by the literature on participation in the computing major. Research has found that students' computing and math confidence, career orientation, beliefs about computing, and prior computing experience are central to their pursuit and success in computing (Badagliacco, 1990; Beyer et al., 2003; Cheryan et al., 2013; Margolis & Fisher, 2002; Margolis et al., 2008; Sax et al., 2017).

The measurement and coding schemes for the items in this block are located in Appendix B. The measure for computing identity is a factor developed using Carlone and Johnson's (2007) theory of science identity. It includes items representing the three spheres of science identity: performance, competence, and recognition. For example, the performance dimension is captured through variables that measure students' level of agreement with statements like "I care about doing well in computing," and items such as students' self-rated computing ability and their level of confidence in their ability to learn a new programming language were included to incorporate their competence in computing. The recognition dimension is represented by items asking students the extent to which they agree with statements like "I see myself as a computing person" and "computing is a big part of who I am." A full list of items included in this factor, along with factor loadings and reliabilities is included in Table 3.4.

Table 3.4 Factor Loadings for Computing Identity

Item	Factor Loadings
Fit in CS: I feel like I "belong" in computing.	0.87
Fit in CS: I see myself as a "computing person."	0.82
Fit in CS: Computing is a big part of who I am.	0.77
Fit in CS: I care about doing well in computing.	0.70
Fit in CS: Using computers to solve problems is interesting.	0.67
Fit in CS: I am interested in learning more about what I can do with computing	0.66
Self-Efficacy: I am confident that I can complete an undergraduate degree in computing.	0.62
Fit in CS: I feel welcomed in the computing community.	0.55
Fit in CS: I feel like an outsider in the computing community.	0.55
Self-rating: Computer skills	0.53
Self-Efficacy: I am confident that I can quickly learn a new programming language on your own.	0.53
Cronbach's Alpha	0.89

This block also included composite measures of students' personalities. As discussed previously, Holland (1997) argues that one's personality drives career decisions, such as major choice. Hence, the model incorporated measures that represent four of the six different personality types, as described by Holland, including investigative, artistic, social, and enterprising[3]. In Smart and colleagues' (2000) study of Holland's theory applied college

[3] Conventional and realistic personality types were excluded because the vocations and skill sets accompanying these personalities are not represented in four-year universities, according to Smart et al. (2000). Further, variables related to these personality types were not available on the student surveys.

students' major choice, they created factors to represent each personality. To the extent that variables were available, I created similar composite measures, using Smart et al.'s (2000) measures as a guide (see Table 3.5). Note that only two items (i.e., self-rated artistic ability and creativity) were available to capture the artistic personality, thus they were added together as a scale. The personality measures were examined to ensure appropriate factor loadings and reliabilities, following the procedures outlined in the analysis section of this chapter.

Table 3.5 Factor Loadings for Holland Types

Item	Factor Loadings
Enterprising Personality (α =.82)	
Career Orientation: Make important decisions at work	0.84
Career Orientation: Have a lot of responsibility at work	0.79
Career Orientation: Become well-known in my field	0.66
Career Orientation: Be in charge	0.64
Career Orientation: Decide for myself what I will work on	0.57
Self-rating: Competitiveness	0.51
Self-rating: Leadership ability	0.51
Investigative Personality (α =.75)	
Self-rating: Academic ability	0.79
Self-rating: Mathematical ability	0.76
Self-rating: Intellectual self-confidence	0.64
Self-rating: Drive to achieve	0.48
Social Value Orientation (α =.88)	
Career Orientation: Serve humanity	0.81
Career Orientation: Help others	0.80
Career Orientation: Have a social impact	0.78
Career Orientation: Be a role model for people in my community	0.77
Career Orientation: Give back to my community	0.75
Career Orientation: Work collaboratively with others	0.60

Departmental Experiences. The students' perceptions of the CS department, as measured by their responses on the post-test, were included in the model. Specifically, as shown in Table 3.6, a factor representing students' satisfaction with the CS department and sense of community and support in the department was included. Previous research has found that department characteristics are important to students' success in computing majors, specifically students' sense that CS is a supportive community (Cohoon, 2001). Further, scholars focused on improving the recruitment and retention of underrepresented students have argued that improving the departmental climate is key to diversifying the CS major (Barker & Cohoon, 2009).

Table 3.6 Factor Loadings for Departmental Support

Item	Factor Loadings
Satisfaction: Overall, I am satisfied with the computing program at my institution	0.71
Support: I feel a sense of community in the computing department	0.77
Support: The department cares about its students	0.78
Support: The environment in the computing department inspires me to do the best job that I can	0.87
Support: Computer science administrators (e.g., the department chair) care about diversity	0.50
Cronbach's Alpha	0.85

Course experiences. As discussed in chapter two, pedagogical practices as well as faculty views toward students are important factors in students' choice of and success in CS, particularly for women and URM students (e.g., Barker et al, 2014; Barker & Cohoon, 2009; Goode, 2007; Margolis et al., 2008; Varma, 2006). Drawing from this body of research, this study included a number of composite measures related to the introductory CS course, including the instructors' pedagogical approaches, students' perceptions of the instructor's responsiveness, and students' experiences with peers. In addition to the factors outlined in Table 3.7 below, this block also included a scale for traditional pedagogy which incorporated the frequency that introductory CS course instructors used lecturing or grading on a curve. All the measures pertaining to students' course experiences were drawn from the post-test.

Table 3.7 Factor Loadings for Introductory Course

Experiences

Item	Factor Loadings
Inclusive Pedagogy (α =.86)	
Use of examples involving people of color	0.83
Use of examples involving women	0.82
Discussions addressing misconceptions about the field of CS	0.69
Interdisciplinary connections to CS	0.65
Student choice in activities and assignments	0.63
Student presentations	0.60
Use of real world problems involving relevant social issues	0.54
Grouping students by level of CS experience	0.54
Collaborative Pedagogy (α =.72)	
Pair programming	0.80
Group work	0.74
Peer instruction	0.48
Class discussion	0.47
Instructor Responsiveness (α =.86)	
Perceptions: Introductory course faculty are interested in helping me when I come to them with questions	0.93
Perceptions: Introductory course faculty are responsive to questions in class	0.79
Perceptions: Introductory course faculty are responsive to email communication	0.74
Peer Support (α =.90)	
Peer Support: Someone to hang out with	0.89
Peer Support: Someone to confide in	0.84
Peer Support: Someone to get class assignments from	0.80
Peer Support: Someone to help you understand assignments	0.80

Out-of-class experiences. The last block included variables related to students' experiences outside of the classroom that may impact their decision to pursue a CS major.

Specifically, variables related to how much time they spend on outside activities (i.e., participating in student organizations, studying or doing homework, and playing video games) were included. All of these measures are found on the post-test. The literature supports inclusion of such variables given that students' out-of-class experiences is important to students' pathway from an introductory CS course to a computing major (Denner et al., 2014).

Missing values. This study used the expectation-maximization (EM) algorithm to address missing cases. The EM algorithm uses maximum likelihood estimates in place of missing values (McLachlan & Krishnan, 2007), making it superior to other approaches to missing values. For example, mean replacement, which replaces missing values with the grand mean value for the variable in question, is not as accurate as the EM algorithm (McLachlan & Krishnan, 2007). To maximize the effectiveness of this approach, variables that had more than 15% missing cases were removed; hence, the EM algorithm was only used to address missing values on variables for which less than 15% cases were missing. Additionally, the EM algorithm was not used to replace missing values on students' demographic characteristics, including their gender and race/ethnicity. Students who did not answer the questions pertaining to their gender or race/ethnicity were removed from the analysis.

Factor analyses. As discussed previously, exploratory and confirmatory factor analyses were conducted to reduce the variables present in the model. Factors were created using principle axis factoring with promax rotations, as this approach has been shown to be the most accurate, while also maximizing each factor's strength and uniqueness (Russell, 2002). Factors with an eigenvalue ≥ 1 were retained, and variables were only included in a factor if they load at .40 or higher. Further, the threshold for reliability was set at a Cronbach's *alpha* of .65. Factor analysis procedures were guided by the extant literature on students' experiences in computing and introductory courses, as discussed in the preceding paragraphs. Additionally, I relied on previously constructed factors, particularly those factors created by CERP for analysis of DBS data (Nyame-Mensah, Tamer, & Stout, 2015), as well as the factors created by Smart and colleagues (2000) to identify students' Holland types.

Analytical Approaches

The quantitative analyses were conducted in two parts. To address the first two research questions, descriptive analyses were conducted to understand the key characteristics of undecided students who enroll in an introductory CS course (research question 1) and their perceptions of the climate of the course (research question 2). Additional analyses were conducted to compare differences between men and women, majority (i.e., White and Asian) and URM students, and undecided students and declared CS majors. The second phase utilized logistic regression to identify relationships between undecided students' experiences in introductory CS courses and then choosing a CS major by the end of the course. The following paragraphs will describe the descriptive and multivariate analytical approaches in more detail.

Descriptive analyses. Initially, frequency distributions, means, and standard deviations were employed to explore the dataset, establish basic statistics on the population of the study (e.g., gender and racial/ethnic make-up), and examine variables for normality. Additionally, bivariate correlations were run to identify variables that are highly correlated with each other.

However, as no variables had an inter-correlation greater than .51, no items were eliminated for this reason.

Next, cross-tabs, z-tests, and t-tests were run to understand the characteristics and perceptions of undecided students and examine differences between groups of students (i.e., by gender, race/ethnicity, and major status). Specifically, the first set of crosstabs, z-tests, and t-tests were used to test the first hypothesis by identifying the demographic and family traits, academic and computing backgrounds, and self-ratings of undecided students enrolled in an introductory CS course and comparing how these characteristics differ between men and women, students of different racial/ethnic groups, and undecided students and declared CS majors. The second set of analyses tested the second hypothesis by providing an understanding of undecided students' perceptions of the course climate, particularly as it relates to their experiences with course instructors and peers, and comparing how these perceptions differ between men and women, students of different racial/ethnic groups, and undecided students and declared CS majors. The specific variables that were included in these analyses addressing research questions one and two are identified in the list of variables in Table B1 in Appendix B.

Multivariate analysis. The third research question examined the predictors of an undecided student selecting a CS major and explored if the salience of those predictors depends on gender and/or race/ethnicity. To accomplish this, a logistic regression analysis was conducted on the matched pre-test and post-test dataset to predict the likelihood of undecided students enrolled in an introductory CS course selecting CS as their major (versus all other majors) at the end of their course experience.

Regression model. As described above, the independent variables for this study were selected and blocked in accordance with Holland's (1997) Theory of Career Choice. As such, the variables were blocked per his person-environment fit approach by first incorporating "person" variables, including demographic and background traits and student pre-course experiences and personality (see Figure 3.2). After entering variables related to students' background and pre-course experiences, then variables related to their experience in the environment were added to the model. Environmental variables comprised departmental experiences, course experiences, and out-of-class experiences.

For the main effects model, I ran a blocked logistic regression, entering each of the five blocks (i.e., demographics and background traits, pre-course experiences and personality, departmental experiences, introductory CS course experiences, and out-of-class experiences) so that each model built upon the previous one. This approach allowed me to explore how the addition of blocks impacted the predictors that emerged as significant in previous models and the overall fit of the model. Finally, interaction terms were added to the model to explore how the salience of introductory CS course experiences depended on students' gender and race/ethnicity. Hence, two-way and three-way interaction terms were added to the model, as described in more detail below.

Interaction terms. Research suggests that students' course experiences, including teaching and learning factors and interactions with instructors and peers, may be important for women's and URM students' participation in CS (Barker & Cohoon, 2009; Cohoon, 2001; Cohoon & Aspray, 2008; Hewlett et al., 2014; Margolis et al., 2008; Varma, 2006). Further, scholarship has suggested that it is important to consider race *and* gender, as women of color may face multiple levels of marginalization (Crenshaw, 1991; Ong et al., 2011). Taking this research into consideration, this study examines how the relationship between undecided students' course experiences and their intent to major in CS may differ by their gender and race/ethnicity by including the following interaction terms: Gender*Course Experiences; Race/Ethnicity*Course Experiences; and Gender*Race/Ethnicity*Course Experience. The course experience variables included those described in the course experiences block above. To make the interpretation of multiple sets of interactions easier, I ran three separate interaction effects models that incorporated the main effects and interactions between undecided students' introductory course experiences and a) their gender, b) their URM status and c) their gender *and* URM status.

Qualitative Methodology

The qualitative component of this study seeks to understand *why* an undecided student might decide to enroll in a CS course and *how* the student's experiences in the course might factor into his/her major choice process. Because the goal of the qualitative component of this study was to understand the experience of being an undecided student enrolled in an introductory CS course, a phenomenological approach was used. Phenomenology is useful for describing what all participants have in common with respect to the phenomenon of interest (i.e., the experience of being an undecided student in an introductory CS course) and is appropriate when one is looking to understand a phenomenon from multiple viewpoints, particularly to develop practices or policies (Creswell, 2013). Hence, this study used interviews to generate a rich a description of what it means to be an undecided student taking an introductory CS course and the structures of the course that influence their experience.

Sample

The sample for this study was purposefully chosen to identify participants who could provide the most useful data on the experience of undecided students taking an introductory CS course. More specifically, this study utilized maximal variation sampling in which diverse participants were chosen to capture different viewpoints on the experience of being undecided student in a computing course (Patton, 2002). This approach helps create a more complete understanding of this phenomenon. Table 3.8 provides a list of participants and a summary of their backgrounds.

Table 3.8. Interview Participants

Participant[4]	Gender	Race	Class Standing[5]	Prior Programming Experience	Major at 1st Interview	Major at 2nd Interview
Abdel	Man	Asian/Asian American	First Year	Self-Taught	Computer Science	Undecided
Klahan	Man	Asian/Asian American	Second Year	None	Computing-Undecided	Computing-Undecided
Carmen	Woman	Hispanic/Latino/a	First Year	HS Course	Computing-Undecided	Computing-Undecided
Adam	Man	White, Caucasian or European American	First Year	None	Computer Science	Computer Science
Julie	Woman	White, Caucasian or European American	First Year	College Course	Undecided	Chemical Engineering
Robert	Man	White, Caucasian or European American	First Year	None	Spanish	Spanish & Media Studies
Devin	Man	Black/African American	Second Year	Computer Camp	Nuclear Engineering	Nuclear Engineering
Ning	Woman	Asian/Asian American	First Year	Self-Taught	Undecided	Undecided
Alana	Woman	Black/African American	First Year	None	Undecided	N/A[6]

[4] All participant names listed are pseudonyms.

[5] Class standing is listed as of spring 2016, when the first interview was conducted.

[6] Alana did not complete the second interview; therefore, no major choice is listed.

Individual participants were selected from the undecided sample of students who took the pre-test during the spring 2016 administration. First, undecided students (as defined in the quantitative section above) were identified in the dataset. Only those students who gave their express permission for the UCLA BRAID research team to contact them for follow-up interviews were retained. Then, descriptive analyses were conducted to identify a diverse mix of potential interview participants, including men and women, as well as students from different racial/ethnic backgrounds, and a variety of BRAID institutions[7]. These students were then contacted via email and invited to participate in interviews. Ultimately, 9 undecided students from 7 BRAID institutions participated in the first round of interviews during the spring of 2016, and 8 of those participants went on to complete a second interview in the fall of 2016. This sample size falls within the recommendation to interview 5 to 25 individuals for phenomenological studies (Polkinghorne, 1989). Among the nine interview participants, five identified as men and four identified as women. Six participants identified with a majority racial/ethnic group (White or Asian), while three participants reported that they were from an underrepresented racial/ethnic group (i.e., African American/Black or Hispanic/Latino/a).

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[7] It is important to note that while institutional affiliation was considered when identifying participants, this was done to ensure diversity in participants' experiences. However, institutional and departmental analyses were not a focus of the study, so as to protect the anonymity of participants, given that there may only be a small number of undecided students who are women or students of color at a given institution.

Data Collection

As mentioned previously, semi-structured interviews with participants served as the data source for the qualitative stream of this study. Selected participants were invited (via email) to participate in the interviews. Participants were asked to commit to participating in two, sixty-minute interviews which were conducted over the phone. The baseline interview was conducted near the end of the spring 2016 term, during the time that participants were enrolled in the introductory CS course. The follow-up interview was conducted during the fall of 2016, after students had completed the course. The longitudinal interview design is modified from the in-depth phenomenological interviewing technique described by Seidman (2013). Seidman (2013) suggests a three-interview structure during which the first interview is dedicated to gathering a focused life history of the participant, the second is focused on the details of the experience in question, and the third is spent on how the participant makes meaning of that experience. In this study, the three-interview structure was collapsed into two interviews but included the basic elements of Seidman's technique. Students who participated in the baseline received a $10 Amazon e-gift card, and students who participated in the follow-up interview received a $15 Amazon e-gift card (so, students who participated in both interviews received a total of $25 in Amazon e-gift cards). Prior to each interview, participants were asked to read the consent form and verbally consent to participate in the study. Participants' anonymity was carefully protected through the use of pseudonyms. Additionally, any direct quotes reported in results do not contain identifying information, given that faculty, department chairs, and other administrators at the research sites may read the students' statements. With the permission of participants, each interview was audio recorded and transcribed.

Protocol. As indicated, the interviews were semi-structured to allow for natural flow in the conversation as well as exploration of topics that the participants themselves deem relevant. The full protocol is included in Appendix C. Generally, participants were asked about their backgrounds and prior experiences, talents and interests, plans for the future, major choice decision-making process, experiences in the introductory CS course, and the role those experiences play in their major choice. Prior to beginning interviews, the interview protocol was be pilot tested with three students and revisions were made to the protocol as necessary.

Data Analysis

Data analysis was an on-going process conducted in conjunction with the data collection. The primary source of data for this study included interview transcriptions. In accordance with the phenomenological approach, interview transcriptions were read several times and statements that seemed to be of significance were noted. Then, these statements were examined for similarities and grouped into themes (Moustakas, 1994; Polkinghorne, 1989). Hence, transcripts were coded through an inductive process at the end of which the data was distilled into smaller units of analysis (i.e., themes). Finally, the themes were used to generate textual descriptions (what undecided students experienced) and structural descriptions (structures that influenced their experience) and merged so that the "essence" of the phenomenon could be reported (Creswell, 2013). Transcriptions were done by the third-party transcription service, J Bryant Creative, and the qualitative software Quirkos was used to assist with coding.

While conducting the analysis, I relied on Carlone and Johnson's (2007) theory of science identity as a lens to understand the dynamics at play within the introductory CS course. Carlone and Johnson posit that some students are promoted while others are marginalized by teaching and learning practices common in science classrooms. Further, they argue that students' can see themselves as scientists when they are able to perform relevant scientific tasks, demonstrate competency in the content area, and be recognized as well as recognize themselves as scientists. Hence, in the analysis of undecided students' experiences, the science identity lens was used to understand how undecided students engage or distance themselves from the CS major as they negotiated their introductory CS course.

Validity. In qualitative research, there are many ways to understand what it means to present "valid" research. For the purposes of this study, validity refered to the extent that the data and findings are accurate reflections of the phenomena of interest (Creswell, 2013). Hence, validation is the process by which accuracy is ensured. First, in designing the qualitative component of this study, I endeavored to interview participants across a variety of contexts and backgrounds to help ensure that the themes that emerged are reflective of the unique experience of undecided students in introductory courses. Further, as outlined in the above sections, data was analyzed in a systematic manner to help prevent personal biases from coloring my interpretations of the data. Finally, in an attempt to clarify my biases as a researcher (Creswell, 2013), I identified aspects of my background and orientation to this project that may shape my interpretation of the data, as discussed in more detail in the following section.

Positionality

I come to this study with a variety of life experiences, perspectives, and interests that may influence the way I interpret the data. I am not a computer scientist—I have limited coding experience, and I have never even taking a computing course. Yet, my father had a 30-year career working for Hewlett-Packard, so my family always had a personal computer in our home (which was uncommon when I was born in 1985). Additionally, my husband has a degree in computer science and works in the video game industry. Hence, my world has always intersected with the world of computing. Probably because of my life experiences, I have a long-standing interest in women's representation in STEM fields and in increasing opportunities for women in computing, in particular. I have held multiple professional roles related to increasing women's representation in STEM fields. I ran living-learning program for women in engineering at the University of North Carolina-Charlotte, and more recently, I have been the project manager for two different research studies, both focused on women's underrepresentation in STEM. In short, I am personally and professionally invested in this topic and diversifying the computing field.

Chapter Summary

Drawing on a multi-institutional dataset, this study reports on the profile of undecided students who enroll in introductory CS courses and their perceptions of the course climate. It examines the relationship between students' course experiences and their intention to pursue a computing major. In addition to the quantitative analyses, this study provides a depth of understanding about the unique experience of undecided students who take introductory courses, with the goal of understanding how students use those experiences to make decisions about a major choice. Further, this study addresses the role gender and race play across all dimensions of the study. Taken together, the quantitative and qualitative streams converge to provide a more complete picture of the undecided student experience in computing in hopes of informing CS department policies and practices around recruitment and retention of diverse students. In the following two chapters, I will present the findings of the quantitative and qualitative analyses. Then, the findings from both data sets will be brought together for discussion in chapter six.

Chapter Four: Quantitative Results

This chapter presents the findings from the quantitative analyses employed to investigate the characteristics and backgrounds of undecided students who enroll in an introductory computing course and the experiences in the introductory course that might encourage or dissuade them from choosing a CS major. The first two sections present the results of descriptive analyses related to the characteristics of undecided students enrolled in an introductory CS courses and their perceptions of the climate of the course, as well as how these factors may vary by gender, race/ethnicity, and major status (i.e., undecided students vs. computing majors). Next, I discuss the results from the multivariate analysis which explores the relationship between undecided students' experiences in their introductory CS course and their plans to major in computing and how the relationship may depend upon a students' gender or race/ethnicity.

Profile of Undecided Students Enrolled in Introductory CS Courses

The first research question guiding this study seeks to explore the characteristics of undecided students who enroll in an introductory computing course. To do so, I analyzed frequencies on measures of undecided students' demographic and family traits, academic and computing backgrounds, and self-ratings (Tables 4.1, 4.2, and 4.3). A full list of variables used in the descriptive analyses is included in Appendix B.

Frequency Analyses

Demographic and family traits. As I hypothesized, the majority of undecided students who enroll in introductory computer courses are White or Asian and are men (refer to Table 4.1). Further, I predicted that undecided students would tend to come from higher income families. As discussed in chapter three, the scale for socioeconomic status includes measures of students' self-reported socioeconomic background (e.g., "poor," "average," and "wealthy") as well as their self-reported family annual income. This scale was then recoded such that the top third of all students who took the introductory course pre-test survey fell into the "high" category, while the lowest third of the sample fell into the "low" category. While undecided students who fall into the "high" category for socioeconomic status (SES) represent the largest group at 39.6%, undecided students were fairly evenly distributed in terms of their families' SES. In addition to these findings, a few unexpected findings emerged from this analysis. The students in this study came from a variety of income backgrounds, but the vast majority of them came from homes where at least one parent had earned a bachelor's degree or higher. Additionally, nearly a fifth of the undecided students enrolled in an introductory CS course have at least one parent with a computing-related career (e.g., programmer, systems analyst, computing teacher, etc.). While this finding is similar to the 20% of all students enrolled in introductory CS courses at BRAID schools who have at least one parent in a computer career (Sax, Lehman & Zavala, 2017), the result is still noteworthy given that nationwide data show that only about 2% of all college students report having a parent who is a computer programmer (Eagan et al., 2015).

Table 4.1. Frequencies on Demographic and Family Items

	Percent	Number
Students' Gender		
Men	62.1	332
Women	37.9	203
Students' Race/Ethnicity		
White	45.0	241
Asian or Asian American	29.5	158
Two or more: White and Asian	2.1	11
Black or African American	6.0	32
Hispanic or Latina/o	9.3	50
Native American	0.6	3
Native Hawaiian	0.4	2
Middle Eastern	0.7	4
Two or more: URM	6.4	34
Students' Class Standing		
First year	59.0	323
Second year	23.4	128
Third year	11.5	63
Fourth year or beyond	6.0	33
Socioeconomic Status		
Low	31.6	162
Medium	28.7	147
High	39.6	203
Parents' Education		
High school or less	16.6	88
Some college/Associate's degree	17.2	91
Bachelor's degree	29.6	157
Graduate/Professional degree	36.6	194
Parents' Career: Computing		
No parent with a computing career	81.8	472
At least one parent with a computing career	18.2	105

Academic and computing backgrounds. In terms of their academic and computing backgrounds, the results of the frequency analyses reveal that undecided students who enroll in introductory CS courses are high-achieving, as nearly two-thirds of them reported having average high school GPAs of A- or higher (see Table 4.2). I hypothesized that the students in this study would come to their introductory CS course with previous math, science and computing coursework from high school. The results of this analysis show that while most of the students in this sample had taken certain types of math and science courses, including calculus (and lower level math courses), physics, chemistry, and biology, there were several subject areas, most notably computer science, that most students had *not* taken in high school. However, the majority did report having some sort of prior programming experience (i.e., taking a previous computing course, attending a summer camp, or teaching themselves). Few undecided students in introductory computing courses were involved in a computing-related activity, such as attending a conference like the Grace Hopper Celebration or the Tapia Celebration of Diversity in Computing.

Table 4.2. Frequencies on Academic and Computing Background Items

	Percent	Number
HS GPA		
A or A+	37.5	204
A-	26.3	143
B-, B or B+	32.0	174
C+ or below	4.2	23
HS Coursework: Biology		
Regular	40.2	212
Honors	31.1	164
AP/IB	23.9	126
I did not take this class	4.7	25
HS Coursework: Chemistry		
Regular	35.3	186
Honors	33.2	175
AP/IB	24.9	131
I did not take this class	6.6	35
HS Coursework: Computer Science		
Regular	20.3	106
Honors	6.5	34
AP/IB	15.9	83
I did not take this class	57.3	299
HS Coursework: Environmental Science		
Regular	17.7	92
Honors	5.8	30
AP/IB	14.6	76
I did not take this class	62.0	323
HS Coursework: Physics		
Regular	28.5	151
Honors	20.8	110
AP/IB	29.2	155
I did not take this class	21.5	114
HS Coursework: Psychology		
Regular	18.1	95

Table 4.2 Continued

	Percent	Number
Honors	3.6	19
AP/IB	22.8	120
I did not take this class	55.5	292
HS Coursework: Algebra II		
Regular	35.0	185
Honors	51.7	273
AP/IB	7.2	38
I did not take this class	6.1	32
HS Coursework: Pre-Calculus		
Regular	31.8	168
Honors	45.3	239
AP/IB	10.6	56
I did not take this class	12.3	65
HS Coursework: Calculus		
Regular	10.4	55
Honors	9.1	48
AP/IB	49.9	264
I did not take this class	30.6	162
HS Coursework: Statistics		
Regular	9.3	49
Honors	2.7	14
AP/IB	24.1	127
I did not take this class	64.0	338
Prior Programming Experience		
No	41.1	237
Yes	58.9	340
Computing Conference Attendance		
No	89.6	517
Yes	10.4	60
Average SAT Composite Score (2400 scale)		
Mean	1845.7	300

Self-ratings. As seen in Table 4.3, most undecided students in this study tended to rate themselves as at least average on all self-ratings measures. They were particularly confident in areas related to academics, as more than half of them rated themselves as "Above Average" or "Highest 10%" in terms of their academic ability, drive to achieve, mathematical ability, and intellectual self-confidence. Most of them also felt that they were at least above average in terms of their cooperativeness and creativity. Despite their relative confidence in their creative abilities, they rated themselves much lower on their artistic abilities than creative abilities. The students in this study also rated themselves lower on the social self-confidence and competitiveness than they did on other measures. Interestingly, on their computing skills, a large proportion (about 40%) of the participants rated themselves as average.

Table 4.3. Frequencies on Self-Rating Items

	Percent	Number
Academic Ability		
Highest 10%	18.5	101
Above Average	49.7	271
Average	27.7	151
Below Average	3.7	20
Lowest 10%	0.4	2
Artistic Ability		
Highest 10%	7.3	40
Above Average	24.2	132
Average	37.4	204
Below Average	23.5	128
Lowest 10%	7.5	41
Competitiveness		
Highest 10%	13.7	74
Above Average	35.1	190
Average	34.3	186
Below Average	13.8	75
Lowest 10%	3.1	17
Computer Skills		
Highest 10%	10.1	55
Above Average	38.4	209
Average	40.8	222
Below Average	9.2	50
Lowest 10%	1.5	8
Cooperativeness		
Highest 10%	18.9	103
Above Average	41.7	227
Average	34.2	186
Below Average	4.6	25
Lowest 10%	0.6	3
Creativity		
Highest 10%	12.3	67
Above Average	37.6	205
Average	36.9	201
Below Average	12.1	66
Lowest 10%	1.1	6

Table 4.3 Continued

	Percent	Number
Drive to Achieve		
Highest 10%	24.6	134
Above Average	36.6	199
Average	29.6	161
Below Average	7.9	43
Lowest 10%	1.3	7
Leadership Ability		
Highest 10%	13.1	71
Above Average	36.8	200
Average	34.2	186
Below Average	14.5	79
Lowest 10%	1.5	8
Mathematical Ability		
Highest 10%	17.1	93
Above Average	40.9	223
Average	31.0	169
Below Average	8.8	48
Lowest 10%	2.2	12
Intellectual Self-Confidence		
Highest 10%	16.9	92
Above Average	39.8	217
Average	32.5	177
Below Average	8.1	44
Lowest 10%	2.8	15
Social Self-Confidence		
Highest 10%	10.8	59
Above Average	26.1	142
Average	33.8	184
Below Average	22.6	123
Lowest 10%	6.8	37

Group Differences

Next I ran cross-tabulations on the measures related to demographic and family traits, academic and computing backgrounds, and self-ratings to compare differences among undecided students by gender and URM status and between undecided students and declared CS majors. When running the cross-tabulations, I conducted z-tests with Bonferroni corrections to determine if differences found between groups were significant ($p < .05$). Additionally, for ordinal variables, I conducted independent paired sample t-tests to determine if there were significant differences between the groups' mean scores. The following sections explore the results of these analyses by variable category, beginning with the students' demographic and family traits (Table 4.4).

Differences in demographic and family traits. As shown in Table 4.4 below, the analyses revealed no significant differences between women and men in terms of demographic or family variables. However, the analyses did reveal significant differences between URM and majority students, as well as between undecided students and CS majors.

Differences by URM status. There were a few significant differences between URM students and White and Asian students, as seen in Table 4.4. URM students were more likely than White and Asian students to take the introductory course later in their academic careers. Further, approximately 57% of URM students fall into the "low" SES group, while 46% of White and Asian students fall into the "high" SES category, resulting in a significant difference between the two groups' mean SES scores. There was also a significant difference between their parents' average level of education. More specifically, URM students tended to have a parent who, at most, attended some college or earned an associate's degree, and White and Asian students were more likely than URM students to report that at least one parent attended graduate school. These findings are not surprising given prior research that has shown that college students from underrepresented groups tend to come from families with lower income and education levels than their majority peers (Allen, Jayakumar, Griffin, Korn & Hurtado, 2005; Hurtado, Saenz, Santos & Cabrera, 2008). Previous research has shown that these types of disparities create barriers for students of color in computing and limit their participation in the field (Margolis et al., 2008).

Differences by major status. There were also some notable differences between the undecided students and CS majors enrolled in the introductory CS course (see Table 4.4). As I expected, women made up a larger proportion of undecided students than they did CS majors. However, while I predicted that the group of undecided students would also be more racially diverse than CS majors, in fact 23.4% of undecided students were URM students, whereas 29.1% of CS majors reported being from an underrepresented racial/ethnic group. This finding is important to departmental recruitment efforts, as undecided students may be a promising pool from which to recruit women but may not aid in efforts to increase the number of URM students in computing majors. Undecided students were more likely than CS majors to take the introductory course as second-year students. This finding is not surprising, given that most CS programs require CS majors to take the introductory course in the first year.

Table 4.4. Differences in Background Characteristics and Family Traits

	Percent Among Undecided Students				Percent Among Intro CS Students	
	Women	Men	Majority	URM	Undecided	CS Major
Gender						
Men			76.6	23.4	62.1	**75.4**
Women			76.5	23.5	**37.9**	24.6
Race/Ethnicity						
White or Asian	76.5	76.6			**76.6**	70.9
URM	23.5	23.4			23.4	**29.1**
Class Standing						
First year	63.9	57.5	**63.1**	50.0	59.0	63.3
Second year	19.9	26.0	23.6	25.0	**23.4**	18.0
Third year	11.0	10.5	8.7	**16.4**	11.5	13.8
Fourth year or beyond	5.2	6.0	4.6	8.6	6.0	4.9
Mean	1.6	1.7	1.6	**1.8**	1.6	1.6
Socioeconomic Status Scale						
Low	31.6	31.6	23.1	**57.3**	31.6	32.8
Medium	29.5	28.4	**30.9**	21.4	28.7	26.6
High	38.9	39.9	**46.0**	21.4	39.6	40.6
Mean	2.1	2.1	**2.2**	1.6	2.1	2.1
Parents' Education						
High school or less	16.1	17.1	13.2	**27.7**	16.6	17.7
Some college/Associate's degree	16.1	18.3	14.7	**24.4**	17.2	17.7
Bachelor's degree	26.6	31.4	29.7	27.7	29.6	30.7
Graduate/Professional degree	41.2	33.2	**42.4**	20.2	36.6	34.0
Mean	2.9	2.8	**3.0**	2.4	2.9	2.8
Parents' Career: Computing						
Non-computing career	78.8	81.9	78.7	86.4	81.8	79.5
Computing	21.2	18.1	21.3	13.6	18.2	20.5

Bold indicates significant differences among groups $p<.05$; the higher value on each of the measures has been bolded.

Differences in academic and computing backgrounds. Table 4.5 displays the differences between groups on measures of their academic and computing backgrounds.

Differences by gender. In terms of gender differences, the findings align with previous research on gender differences among college students, as well as differences between men and women in computing. For instance, women reported a higher mean high school grade point average than men and were more likely to report earning top grades in high school than men, a finding consistent with prior research on college students (Sax, 2008). Further, as I predicted, women were less likely to come to the introductory CS course with prior programming experience than their male counterparts. However, there was no significant difference between their average SAT composite scores. There were few but notable differences between men's and women's high school coursework. Women were more likely than men to have taken the highest levels of biology, a finding not surprising given that women make up more than half of biological sciences majors in college (Sax, Lim, Jacobs, Lehman, Paulson & MacLennan, 2016). On the other hand, women were less likely than men to have taken any form of computer science course in high school, though there were not significant differences in the proportion of undecided men and women in this study who took the AP CS course. Given the large gender disparities that exist in that course (College Board, 2014), it is somewhat unexpected that no significant difference is present in the AP CS participation among men and women who are undecided about their major.

Differences by URM status. The z-test and t-test analyses reveal that White and Asian students in this study were more likely to report earing higher high school grades than URM students (refer to Table 4.5). Further, URM students' mean SAT composite score was lower than White and Asian students' scores. URM students were also less likely to take certain math and science coursework than their White and Asian peers, notably chemistry, physics, and psychology. However, among the undecided students who took an introductory CS course, there were no significant differences found between URM students' and White and Asian students' high school coursework in computer science, prior programming experience, or computing conference attendance. This finding is contrary to my expectations and surprising, given the previous research showing that students from underrepresented groups have less exposure to computing in high school (Margolis et al., 2008). As will be discussed further in chapter six, this finding may indicate that undecided students are a unique population, and as such, some differences between racial/ethnic groups may be less prevalent among students who are unsure about their major.

Differences by major status. There are several differences between the academic and computing backgrounds of undecided students and CS majors enrolled in introductory CS courses. Undecided students earned higher high school grades and had a higher mean SAT composite score than CS majors. In terms of their coursework, undecided students were more likely than CS majors to have taken the highest levels of several high school science courses, including biology, chemistry, environmental science, and psychology. However, 23.5% of CS majors reported taking AP/IB CS in high school, compared to only 15.9% of undecided students. Additionally, 57.3% of undecided students reported that they did not take *any* type of computer science course in high school, while a significantly smaller proportion of CS majors (46.1%) reported taking no high school CS coursework. Similarly, CS majors were more likely than undecided students to report having programming experience prior to taking the introductory course as well as some form of computing conference attendance. These findings support my hypothesis that CS majors would come to the introductory course with higher levels of prior exposure to computer science than undecided students.

Table 4.5. Differences in Academic and Computing Backgrounds

	Percent Among Undecided Students				Percent Among Intro CS Students	
	Women	Men	Majority	URM	Undecided	CS Major
HS GPA						
A or A+	**47.5**	31.6	**39.5**	29.6	**37.5**	32.1
A-	27.2	25.6	**28.7**	18.4	26.3	27.7
B-, B or B+	23.3	**37.3**	28.7	**44.8**	32.0	35.8
C+ or below	2.0	5.4	3.2	**7.2**	4.2	4.4
Mean	**3.2**	2.8	**3.0**	2.7	**3.0**	2.9
HS Coursework: Biology						
Regular	36.9	42.3	41.1	37.2	40.2	40.1
Honors	29.3	32.0	30.7	33.1	31.1	**37.2**
AP/IB	**29.3**	20.7	23.9	23.1	**23.9**	17.7
I did not take this class	4.5	5.0	4.3	6.6	4.7	5.1
Mean	2.8	2.7	2.7	2.7	2.7	2.7
HS Coursework: Chemistry						
Regular	35.8	34.8	35.4	34.4	35.3	35.8
Honors	31.8	33.9	32.1	36.1	33.2	37.5
AP/IB	27.9	23.1	**27.3**	18.0	**24.9**	19.4
I did not take this class	4.5	8.2	5.3	**11.5**	6.6	7.3
Mean	2.8	2.7	**2.8**	2.6	2.8	2.7
HS Coursework: Computer Science						
Regular	19.2	21.3	20.4	19.8	20.3	23.2
Honors	4.5	7.6	6.9	5.8	6.5	7.2
AP/IB	12.1	18.5	17.1	12.4	15.9	**23.5**
I did not take this class	**64.1**	52.5	55.6	62.0	**57.3**	46.1
Mean	1.6	**1.9**	1.9	1.7	1.8	**2.1**
HS Coursework: Environmental Science						
Regular	12.1	**21.7**	16.6	21.8	17.7	20.8
Honors	4.5	6.7	5.6	6.7	5.8	7.3
AP/IB	17.7	12.8	14.5	16.0	**14.6**	8.2
I did not take this class	65.7	58.8	63.3	55.5	62.0	63.7
Mean	1.7	1.7	1.7	1.8	**1.7**	1.6
HS Coursework: Physics						
I did not take this class	**26.1**	18.7	18.2	**33.3**	21.5	19.9
Regular	27.6	29.0	30.2	23.3	28.5	29.2
Honors	19.1	21.8	20.9	20.8	20.8	21.2
AP/IB	27.1	30.5	30.7	22.5	29.2	29.7
Mean	2.5	2.6	**2.6**	2.3	2.6	2.6

Table 4.5 Continued

	Percent Among Undecided Students				Percent Among Intro CS Students	
	Women	Men	Majority	URM	Undecided	CS Major
HS Coursework: Psychology						
Regular	18.1	18.0	19.4	13.4	18.1	18.6
Honors	4.5	2.8	3.8	3.4	3.6	5.0
AP/IB	26.6	19.9	24.4	17.6	**22.8**	18.1
I did not take this class	50.8	59.3	52.4	**65.5**	55.5	58.2
Mean	**2.1**	1.8	**2.0**	1.7	**1.9**	1.8
HS Coursework: Algebra II						
Regular	30.5	38.1	32.8	42.5	35.0	36.1
Honors	53.0	50.3	53.4	45.8	51.7	51.3
AP/IB	7.0	7.5	7.5	5.8	7.2	9.2
I did not take this class	**9.5**	4.1	6.3	5.8	**6.1**	3.4
Mean	2.6	2.6	2.6	2.5	2.6	2.7
HS Coursework: Pre-Calculus						
Regular	29.5	33.3	31.3	33.3	31.8	30.4
Honors	48.0	43.1	45.9	42.5	45.3	46.5
AP/IB	12.0	10.1	10.8	10.0	10.6	10.3
I did not take this class	10.5	13.5	12.0	14.2	12.3	12.8
Mean	2.6	2.5	2.6	2.5	2.5	2.5
HS Coursework: Calculus						
Regular	9.0	11.3	10.3	9.2	10.4	**13.8**
Honors	8.5	9.1	9.5	7.5	9.1	7.6
AP/IB	54.5	47.0	51.0	45.8	49.9	48.6
I did not take this class	28.0	32.6	29.3	37.5	30.6	30.0
Mean	2.9	2.7	2.8	2.6	2.8	2.8
HS Coursework: Statistics						
Regular	7.0	10.7	9.6	6.5	9.3	10.9
Honors	3.5	2.2	3.0	0.8	2.7	4.0
AP/IB	26.5	23.0	24.5	21.1	24.1	21.0
I did not take this class	63.0	64.2	62.9	71.5	64.0	64.1
Mean	1.9	1.8	1.9	1.7	1.9	1.8
Prior Programming Experience						
No	**47.3**	31.6	36.7	40.0	**41.1**	23.6
Yes	52.7	**68.4**	63.3	60.0	58.9	**76.4**
Computing Conference Attendance						
No	91.1	88.0	90.0	85.6	89.6	88.2
Yes	8.9	12.0	10.0	14.4	10.4	11.8

Bold indicates significant differences among groups p<.05; the higher value on each of the measures has been bolded.

Differences in self-ratings. Table 4.6 shows differences between men and women, White and Asian and URM students, and undecided students and CS majors on self-ratings measures.

Differences by gender. As I hypothesized, men tended to rate themselves higher than women across the spectrum of self-ratings items. For instance, men had significantly higher mean scores than women on measures of their academic ability, competitiveness, computer skills, mathematical ability, and intellectual self-confidence. Women were more likely than men to rate themselves as average, particularly in terms of their competitiveness, computing skills, and intellectual self-confidence. This finding supports my hypothesis and is consistent with previous research, which has found that women consistently rate themselves lower than their male counterparts across a variety of measures, both among all college students (Sax, 2008), as well as among students in STEM disciplines (Lehman et al., 2017). The gender differences in undecided students' self-rated computing skills are particularly striking as well-over half of men (59.1%) rated themselves as above average or in the highest 10% while nearly 70% of women rated themselves as average, below average, or in the lowest 10%. Though I expected women to rate their computing abilities lower than men do, the consistency with which women rate themselves lower on this measure, even among a unique population such as undecided students who enroll in an introductory course, warrants further discussion and attention in future research (see chapter six).

Differences by URM status. There were few significant differences between White and Asian students and URM students on self-ratings measures. There are no significant differences between White and Asian students' and URM students' mean scores on any of the self-rating measures. On the few measures that z-tests revealed differences between the proportions of URM and White and Asian students who selected a specific answer choice, URM students rated themselves higher than White and Asian students. For example, URM students were more likely than majority students to rate themselves in the highest 10% in terms of their social self-confidence, and they were less likely than White and Asian students to rate themselves as below average on artistic ability. It is notable that there are no differences between URM students and majority students in terms of their self-rated computing ability. In the literature on students from underrepresented groups, a great deal of attention is paid to how students view themselves, particularly with respect to how they view themselves in the context of STEM fields (Carlone & Johnson, 2007). Past research on underrepresented students in computing fields has suggested that URM students face many negative stereotypes that may cause them to doubt their computing abilities and negatively impact their success in CS (Margolis et al., 2008). However, as discussed further in chapter six, the results from this study show few differences between White and Asian students' and URM students' computing backgrounds and self-rated abilities, suggesting that for the population examined in this study (i.e., undecided students enrolled in introductory CS courses) racial/ethnic differences may be diminished.

Differences by major status. As shown in Table 4.6, undecided students generally rated themselves lower than students who decided on a CS major. In fact, they had significantly lower self-rating scores than CS majors on all measures except for artistic ability. It is interesting that undecided students were less confident than CS majors on measures such as academic ability and intellectual self-confidence, given the previous finding that undecided students earned higher high school GPAs and SAT scores than their computing peers. Still, it is not surprising that undecided students, who feel unsure about their future major plans, may also feel less confident in their abilities in general. Undecided students also rated themselves much lower on their computing abilities than CS majors. Over 50% of undecided students rated themselves as average or below, whereas more than two-thirds of CS majors described themselves as above average or in the highest 10%. Given that CS majors come to the introductory CS course with more computing experience than their undecided peers (see Table 4.5), it follows that they would also rate themselves higher on computing abilities than undecided students.

Table 4.6. Differences in Self-Rating Measures

	Percent Among Undecided Students				Percent Among Intro CS Students	
	Women	Men	Majority	URM	Undecided	CS Major
Academic Ability						
Highest 10%	13.3	**21.8**	18.6	17.6	18.5	18.5
Above Average	52.2	48.3	50.5	48.0	49.7	55.8
Average	30.0	26.0	27.5	28.0	**27.7**	23.7
Below Average	3.9	3.6	2.9	6.4	**3.7**	1.6
Lowest 10%	0.5	0.3	0.5	0.0	0.4	0.3
Mean	3.7	**3.9**	3.8	3.8	3.8	**3.9**
Artistic Ability						
Highest 10%	5.4	7.6	6.4	8.8	7.3	6.5
Above Average	28.6	21.8	24.8	23.2	24.2	26.4
Average	37.4	37.5	36.0	41.6	37.4	34.0
Below Average	22.7	24.5	**25.7**	16.8	23.5	25.9
Lowest 10%	5.9	8.8	7.1	9.6	7.5	7.2
Mean	3.1	3.0	3.0	3.1	3.0	3.0
Competitiveness						
Highest 10%	8.4	**17.1**	12.3	18.5	13.7	**17.4**
Above Average	33.5	36.3	34.5	36.3	35.1	39.1
Average	**41.9**	29.6	**36.7**	25.0	34.3	31.2
Below Average	13.8	13.4	13.8	15.3	**13.8**	9.9
Lowest 10%	2.5	3.7	2.7	4.8	3.1	2.4
Mean	3.3	**3.5**	3.4	3.5	3.4	**3.6**
Computer Skills						
Highest 10%	4.5	**13.6**	9.3	12.9	10.1	**15.6**
Above Average	26.7	**45.5**	38.1	39.5	38.4	**53.5**
Average	**50.0**	34.8	41.8	37.9	**40.8**	27.0
Below Average	**15.3**	5.8	9.3	8.9	**9.2**	3.6
Lowest 10%	**3.5**	0.3	1.5	0.8	**1.5**	0.4
Mean	3.1	**3.7**	3.4	3.6	3.5	**3.8**
Cooperativeness						
Highest 10%	17.2	20.0	17.9	22.6	18.9	20.7
Above Average	43.3	40.9	42.2	41.9	41.7	**48.8**
Average	35.0	33.3	34.6	30.6	**34.2**	26.5
Below Average	4.4	4.8	5.1	3.2	4.6	3.4
Lowest 10%	0.0	0.9	0.2	1.6	0.6	0.7
Mean	3.7	3.7	3.7	3.8	3.7	**3.9**

Table 4.6 Continued

	Percent Among Undecided Students				Percent Among Intro CS Students	
	Women	Men	Majority	URM	Undecided	CS Major
Creativity						
Highest 10%	12.3	12.1	11.3	14.4	12.3	**15.8**
Above Average	32.0	**40.9**	38.1	35.2	37.6	40.1
Average	40.9	34.2	37.3	36.8	36.9	32.8
Below Average	14.8	10.9	12.3	12.8	12.1	10.0
Lowest 10%	0.0	1.8	1.0	0.8	1.1	1.4
Mean	3.4	3.5	3.5	3.5	3.5	**3.6**
Drive to Achieve						
Highest 10%	23.6	25.8	23.8	28.0	24.6	28.5
Above Average	39.4	35.2	37.3	36.0	36.6	**43.3**
Average	27.1	30.3	30.2	24.0	**29.6**	22.8
Below Average	9.4	7.0	7.6	9.6	**7.9**	4.8
Lowest 10%	0.5	1.8	1.0	2.4	1.3	0.6
Mean	3.8	3.8	3.8	3.8	3.8	**3.9**
Leadership Ability						
Highest 10%	8.4	**16.0**	12.5	16.0	13.1	**18.0**
Above Average	37.6	36.6	36.4	38.4	36.8	38.1
Average	35.6	32.9	34.9	28.8	34.2	31.2
Below Average	18.3	12.4	15.0	14.4	**14.5**	10.8
Lowest 10%	0.0	**2.1**	1.2	2.4	1.5	1.8
Mean	3.4	3.5	3.4	3.5	3.5	**3.6**
Mathematical Ability						
Highest 10%	13.3	19.6	18.4	13.6	17.1	17.1
Above Average	39.4	41.7	40.4	41.6	40.9	45.2
Average	32.5	29.9	31.4	28.8	31.0	31.4
Below Average	**13.3**	6.0	7.8	12.8	**8.8**	5.4
Lowest 10%	1.5	2.7	2.0	3.2	**2.2**	0.9
Mean	3.5	**3.7**	3.7	3.5	3.6	**3.7**
Intellectual Self-Confidence						
Highest 10%	10.8	**20.3**	15.9	20.2	16.9	20.3
Above Average	36.0	43.0	41.4	35.5	39.8	**44.6**
Average	**38.4**	28.8	32.4	31.5	**32.5**	27.5
Below Average	**12.8**	4.8	8.1	8.1	8.1	6.1
Lowest 10%	2.0	3.0	2.2	4.8	**2.8**	1.5
Mean	3.4	**3.7**	3.6	3.6	3.6	**3.8**
Social Self-Confidence						
Highest 10%	7.4	**13.0**	9.3	**16.0**	10.8	13.5
Above Average	24.1	27.5	27.5	20.0	26.1	28.8
Average	38.4	31.1	32.6	37.6	33.8	33.6
Below Average	25.6	20.5	24.3	17.6	22.6	19.8
Lowest 10%	4.4	7.9	6.4	8.8	**6.8**	4.3
Mean	3.0	3.2	3.1	3.2	3.1	**3.3**

Bold indicates significant differences among groups p<.05; the higher value on each of the measures has been bolded

Undecided Students' Perceptions of Computer Science Climate

The second research question focuses on undecided students' views of the CS climate, particularly as it pertains to their perceptions of their introductory course faculty and the availability of peer support. Similar to the process I followed to address the first research question, I first analyzed frequencies on measures of undecided students' perceptions of the computer science climate (Table 4.7).

Frequency Analyses

Student perceptions of faculty. As I expected, most undecided students held favorable views of their introductory course faculty. The majority of undecided students felt their faculty were interested in helping them with questions and were responsive to questions both in class and over email. Further, nearly 60% of undecided students agreed or strongly agreed that their faculty were inclusive and supportive to women and students of color. While relatively small percentages of them disagreed with the statements, over a third of undecided students were neutral on these items. Given that all the students in this study are enrolled at BRAID institutions, which have made expressed commitments to incorporate a variety of initiatives to recruit and retain women and students from underrepresented groups, this finding is somewhat surprising. This finding may represent an opportunity for BRAID departments to increase training of introductory course instructors on issues of diversity to improve the extent to which students in these courses feel that women and students of color are welcomed and supported.

Availability of peer support. Undecided students' views on the availability of support from other computing students were less cohesive than their views on faculty. For example, relatively similar proportions of them rated the extent to which a peer was available to help them understand difficult homework problems as “very much” (16.1%) and “not at all” (15.2%). Across the four items that examined the availability of support from other computing students, undecided students felt the least certain about the accessibility of someone to confide in, such that over a quarter of the sample reported that this type of support was “not at all” available. This finding may suggest that undecided students have not yet developed the level of trust with other computing students that encourages them to exchange confidences.

Table 4.7. Frequencies for Course Climate Items

	Percent	Number
Introductory course faculty are:		
Inclusive and supportive to women		
Strongly agree	22.2	43
Agree	37.6	73
Neither agree nor disagree	36.6	71
Disagree	1.5	3
Strongly disagree	2.1	4
Inclusive and supportive to students of color		
Strongly agree	23.7	46
Agree	36.6	71
Neither agree nor disagree	35.1	68
Disagree	1.5	3
Strongly disagree	3.1	6
Interested in helping when I come with questions		
Strongly agree	26.7	52
Agree	39.5	77
Neither agree nor disagree	27.7	54
Disagree	4.1	8
Strongly disagree	2.1	4
Responsive to questions in class		
Strongly agree	33.8	66
Agree	44.1	86
Neither agree nor disagree	15.9	31
Disagree	4.1	8
Strongly disagree	2.1	4
Responsive to email		
Strongly agree	25.8	50
Agree	37.6	73
Neither agree nor disagree	27.3	53
Disagree	6.2	12
Strongly disagree	3.1	6

Table 4.7 Continued

	Percent	Number
Peer support: Someone to hang out with		
Very much	13.5	30
Quite a bit	24.7	55
Somewhat	27.8	62
A little	15.2	34
Not at all	18.8	42
Peer support: Someone to confide in		
Very much	12.1	27
Quite a bit	13.5	30
Somewhat	31.8	71
A little	15.7	35
Not at all	26.9	60
Peer support: Someone to get your coursework when you're sick		
Very much	15.2	34
Quite a bit	25.1	56
Somewhat	28.7	64
A little	13.0	29
Not at all	17.9	40
Peer support: Someone to help you understand difficult homework problems		
Very much	16.1	36
Quite a bit	28.7	64
Somewhat	28.7	64
A little	11.2	25
Not at all	15.2	34

Group Differences

Like the first research question, the second research question also examines the extent to which undecided students differ by gender and URM status, as well as how undecided students differ from CS majors. Therefore, I again ran cross-tabulations to conduct z-tests with Bonferroni corrections to determine if differences between groups were significant ($p < .05$), as well as independent paired sample t-tests to determine if there were significant differences between the groups' mean scores ($p < .05$). The following sections examine group differences in undecided students' views on the CS climate beginning with students' perceptions of their introductory CS course faculty and then moving to the availability of support from other computing students (Table 4.8).

Differences in students' perceptions of introductory course faculty. The results of the z-test and t-test analyses show few differences between groups in terms of students' perceptions of their introductory CS course faculty (see Table 4.8). There were no significant differences for any of the items examined by gender. However, there were a few differences found between White and Asian students' and URM students' perceptions of their introductory course professors, as well as between undecided students' and CS majors' views.

Differences by URM status. Though I had expected students from majority groups to view introductory course faculty more favorably, there were few differences between URM and White and Asian students' perspectives. In fact, URM students were more likely to agree that introductory course faculty are interested in helping them with questions than were White and Asian students. This was the only item for which there was a significant difference in the two groups' mean scores. The z-test analyses revealed a few differences between White and Asian and URM students' views on the extent to which faculty are inclusive of diverse students. Specifically, larger proportions of majority students agreed that faculty are inclusive and supportive of women and people of color than did URM students; URM students were more likely than White and Asian students to disagree that faculty supported students of color. These findings may suggest a lack of awareness about diversity issues in their introductory computing courses on the part of majority students. However, since this study did not have a large enough sample size to disaggregate racial categories, future research should further investigate the extent to which students' views of introductory course faculty may differ by specific racial/ethnic groups. For example, Asian and Asian American students may also experience an unwelcoming climate in introductory computer science classroom, but because this study has aggregated White and Asian students, it is impossible to detect differences between White and Asian students' experiences.

Differences by major status. Similar to the findings for URM and White and Asian students, there was only item for which there was a significant difference in the undecided students' and CS majors' mean scores on items relating to perceptions of their introductory CS course faculty: CS majors were more likely to agree that introductory course faculty are interested in helping when they come to them with questions than undecided students. The z-tests revealed some additional differences in undecided students' and CS majors' perceptions of faculty. In general, CS majors held a more positive view of their instructors than did undecided students. For example, 31.6% of CS majors strongly agreed that introductory course faculty are inclusive and supportive to women, compared to 22.2% of undecided students. Further, a significantly larger proportion of undecided students strongly disagreed that instructors are inclusive and supportive to students of color than did CS majors. Undecided students were also more likely than CS majors to disagree that introductory course faculty are responsive to questions in class or over email. These findings support my hypothesis that undecided students would hold less favorable views of the climate in their introductory CS courses than their CS major peers, perhaps due to the fact that undecided students have less prior experience with computer science and may be less accustomed to the classroom climate in this field than those who have already decided on a CS major.

Differences in availability of peer support. As shown in Table 4.8, among undecided students, women and men and URM and White and Asian students felt similarly about the availability of peer support, although a few differences were present between the groups. However, as discussed in more detail below, on every measure of peer support, undecided students were less likely than CS majors to report that peer support was available.

Differences by gender. There were no differences in the mean scores between men's and women's perceptions of peer support from other computing students. However, on three of the four items, including "someone to hang out with", "someone to confide in", and "someone to help you understand difficult homework problems," women were more likely than men to say that peer support was "very much" available. This finding is counter to my expectations that women might have a more difficult time connecting with computing peers than men, particularly as women may find few other women in their computing classes.

Differences by URM status. Like the comparisons between men and women, there were no differences in White and Asian and URM students' mean scores on perceptions of peer support items. URM students were more likely to say that someone to confide in was "not at all" available and that someone to get coursework when they are sick was "quite a bit" available than White and Asian students. However, given that there were no significant differences on mean scores, these findings suggest that, in general, URM and White and Asian undecided students did not have markedly different perceptions of peer support.

Differences by major status. On every measure related to the availability of support from fellow computing students, CS majors had a higher mean score than undecided students. It is notable that on all of the four items, undecided students were more likely than CS majors to say that support was "not at all" available, whereas CS majors said that support was "very much" or "quite a bit" available. When taken with the results related to students' perceptions of introductory course faculty, these findings provide additional evidence that CS majors find the introductory course climate to be more supportive than undecided majors. However, their vastly differing perceptions of peer support are striking given that all the students are introductory course students, and presumably, the introductory course is one of the first opportunities for both undecided students and computing majors to develop peer connections within computing. Hence, as will be discussed in chapter six, one of the ways the CS departments might support undecided students is to work on facilitating classroom communities that foster peer connections.

Table 4.8. Differences in Course Climate Perceptions

	Percent Among Undecided Students				Percent Among Intro CS Students	
	Women	Men	Majority	URM	Undecided	CS Major
Introductory course faculty are:						
Inclusive and supportive to women						
Strongly agree	17.7	26.9	20.4	34.2	22.2	**31.6**
Agree	41.8	36.1	**42.2**	18.4	37.6	33.0
Neither agree nor disagree	35.4	34.3	34.0	44.7	36.6	31.3
Disagree	2.5	0.9	0.7	2.6	1.5	2.3
Strongly disagree	2.5	1.9	2.7	0.0	2.1	0.9
Mean	3.7	3.9	3.8	3.8	3.9	3.8
Inclusive and supportive to students of color						
Strongly agree	20.3	27.8	21.8	36.8	23.7	30.3
Agree	39.2	35.2	**40.8**	18.4	36.6	33.0
Neither agree nor disagree	32.9	34.3	34.0	39.5	35.1	32.5
Disagree	2.5	0.9	0.7	**5.3**	1.5	2.1
Strongly disagree	5.1	1.9	2.7	0.0	**3.1**	1.1
Mean	3.7	3.9	3.8	3.9	3.8	3.9
Interested in helping when I come with questions						
Strongly agree	26.6	28.4	24.3	39.5	26.7	**33.8**
Agree	36.7	40.4	39.9	36.8	39.5	41.0
Neither agree nor disagree	26.6	27.5	29.1	21.1	**27.7**	20.5
Disagree	7.6	1.8	4.1	2.6	4.1	2.3
Strongly disagree	2.5	1.8	2.7	0.0	2.1	1.3
Mean	3.8	3.9	3.8	**4.1**	3.8	**4.0**
Responsive to questions in class						
Strongly agree	35.4	32.1	31.1	42.1	33.8	40.1
Agree	41.8	45.0	45.3	42.1	44.1	41.1
Neither agree nor disagree	15.2	17.4	17.6	10.5	15.9	14.9
Disagree	3.8	4.6	4.1	2.6	**4.1**	1.9
Strongly disagree	3.8	0.9	2.0	2.6	2.1	1.0
Mean	4.0	4.0	4.0	4.2	4.0	4.1

Table 4.8 Continued

	Percent Among Undecided Students				Percent Among Intro CS Students	
	Women	Men	Majority	URM	Undecided	CS Major
Responsive to email						
Strongly agree	29.5	22.9	23.1	34.2	25.8	29.7
Agree	35.9	39.4	38.1	39.5	37.6	40.2
Neither agree nor disagree	26.9	28.4	29.3	23.7	27.3	24.4
Disagree	5.1	6.4	6.8	2.6	6.2	3.5
Strongly disagree	2.6	2.8	2.7	0.0	**3.1**	1.0
Mean	3.8	3.7	3.7	4.1	3.8	3.9
Peer support: Someone to hang out with						
Very much	**18.9**	9.6	14.0	9.5	13.5	**21.2**
Quite a bit	20.0	27.2	23.4	28.6	24.7	29.2
Somewhat	24.4	32.0	29.8	23.8	27.8	26.4
A little	16.7	15.2	15.8	14.3	15.2	11.5
Not at all	20.0	16.0	17.0	23.8	**18.8**	11.7
Mean	3.0	3.0	3.0	2.9	3.0	**3.4**
Peer support: Someone to confide in						
Very much	**17.8**	7.2	11.1	11.9	12.1	14.8
Quite a bit	11.1	16.0	14.0	11.9	13.5	**23.8**
Somewhat	26.7	37.6	33.3	28.6	31.8	27.0
A little	15.6	15.2	18.1	7.1	15.7	15.9
Not at all	28.9	24.0	23.4	**40.5**	**26.9**	18.6
Mean	2.7	2.7	2.7	2.5	2.7	**3.0**
Peer support: Someone to get your coursework when you're sick						
Very much	18.9	12.8	15.8	7.1	15.2	**21.5**
Quite a bit	24.4	25.6	22.2	**40.5**	25.1	30.9
Somewhat	30.0	28.0	29.8	26.2	28.7	23.2
A little	11.1	15.2	15.8	4.8	13.0	11.5
Not at all	15.6	18.4	16.4	21.4	**17.9**	13.0
Mean	3.2	3.0	3.1	3.1	3.1	**3.4**
Peer support: Someone to help you understand difficult homework problems						
Very much	**22.2**	12.0	15.2	16.7	16.1	**24.1**
Quite a bit	20.0	**34.4**	27.5	35.7	28.7	32.0
Somewhat	30.0	28.8	29.2	26.2	28.7	23.5
A little	10.0	12.0	13.5	4.8	11.2	11.5
Not at all	17.8	12.8	14.6	16.7	**15.2**	8.8
Mean	3.2	3.2	3.2	3.3	3.2	**3.5**

Bold indicates significant differences among groups p<.05; the higher value on each of the measures has been bolded

Undecided Students' Introductory CS Course Experiences and CS Major Choice

The third and final quantitative research question in this study seeks to understand the relationship between undecided students' introductory course experiences and their plans to pursue a computing major and if that relationship depends upon their gender and/or URM status. Because the role of students' gender and race/ethnicity are central components of this study, I began to examine this question by running crosstabs to identify differences in undecided students' plans to major in computing at the conclusion of their introductory CS course by gender and URM status. The results, as shown in Tables 4.9 and 4.10, indicate that only a slightly higher proportion of men (45.4%) plan to major in computing than women (37.1%) and reveal virtually no difference in the proportions of URM (45.5%) and White and Asian (45.2%) students who intend to major in computer science. Hence, among undecided students, men and women and White and Asian and URM students who complete an introductory CS course go on to pursue computing majors at approximately the same rates. As discussed more in chapter six, this finding may be encouraging to CS faculty and administrators seeking to recruit more and diverse students to the major—once undecided students make the decision to enroll in an introductory computing course, their gender and URM status may have little to no impact on the likelihood that they will go on to choose a CS major.

Table 4.9. Undecided Students' Major Plans, by Gender (n=214)

	Computing (%)	Non-Computing (%)
Women	37.1	62.9
Men	45.4	54.6

Table 4.10. Undecided Students' Major Plans, by URM Status (n=207)

	Computing (%)	Non-Computing (%)
URM	45.5	54.8
White or Asian	45.2	54.5

Then, I conducted a logistic regression analysis predicting students' self-reported major on the end-of-term survey (i.e., computing vs. not). As discussed in detail in chapter three, variables were introduced into the model in five blocks. To examine interactions between undecided students' introductory CS course experiences and their plans to major in computing by gender and/or URM status, I ran separate models introducing two-way and three-way interaction terms. The following sections outline the results of the logistic regression analysis.

Logistic Regression Analysis

The variables included in the logistic regression were guided by Holland's (1997) Theory of Career Choice and blocked such that "person" variables, including undecided students' demographic and background characteristics and pre-course experiences and personality types were entered in the first two blocks, while "environment" measures, including departmental and course experiences and out-of-class experiences were entered in the final three blocks. A full list of measures included in the logistic regression model and their composition can be found in Appendix B. As detailed below and summarized in Table 4.11, the findings from the logistic regression analysis reveal several key predictors of undecided students' plans to major in computing after completing their introductory CS course.

Demographics and background. The first block of items to enter the logistic model included those related to students' demographic and background characteristics, notably their gender, URM status, socioeconomic status, and parents' educational and career backgrounds. Given what is known about the role of demographic and background differences in students' computing experiences (particularly gender and racial/ethnic differences), it is surprising that none of the variables in this block are significant predictors of students' computing major choice.

Pre-course experiences and personality. The second block of variables included a variety of pre-course experiences, such as students' high school grade point average, prior programming experience, and computing identity, as well as factors representing Holland personality types. Collectively, these items improved the overall model, as the model's classification accuracy increased from 56.7% after including demographic and background measures in the first block to 66.5% after the second block. Among these items, students' prior programming experience emerged as a significant, positive predictor of choosing a computing major, even when controlling for all other measures. In fact, prior programming experience is the strongest predictor in the final model such that having prior computer science experience significantly increases the likelihood that an undecided student will pursue a computing major. This finding is not surprising, as the literature has consistently found that prior programming experience is central to students' decision to major in computing (Badagliacco, 1990; Beyer et al., 2003; Margolis & Fisher, 2002; Margolis et al., 2008). Hence, even as undecided students were significantly less likely to have prior programming experience than CS majors enrolled in introductory CS courses (see Table 4.5), the extent to which undecided students do have prior experience is key to their plans to major in computing.

In addition to having prior computing experience, the extent to which students see themselves as computer scientists is also important to their major plans. The results of the blocked logistic regression analysis suggest that undecided students' computing identity is a significant, positive predictor of their plans to major in computer science until students' out-of-class experiences are added in the final model. As discussed in chapter two, students' science identity is a convergence of their ability to perform relevant tasks, display competence in the content area, and receive recognition from meaningful others (Carlone & Johnson, 2007). In this study, the computing identity factor is significantly and positively correlated with the hours per week that undecided students spend participating in computing-related student groups (r=.15) and playing video games (r=.21). Hence, it is likely that students who have strong computing identities are also engaged in relevant out-of-class computing activities, such as computer science clubs and gaming, that provide opportunities to affirm their CS identity. This study is focused on the relationship between students' computer science identities, their introductory course experiences, and plans to major in computing. However, as will be explored more in chapter six, this finding suggests that future research should investigate the role of out-of-class experiences in shaping students' computing identities.

This study used Holland's Theory of Career Choice (1997) to frame undecided students' major choice process in the context of an introductory CS course. Therefore, I included composite measures representing Holland personality types (i.e., artistic, enterprising, investigative, and social) in the logistic regression model. Contrary to my expectations, none of the personality measures were significant predictors of computing major choice. There are several possible reasons that students' personalities do not seem to play a role in undecided students' plans to major in computing after taking an introductory CS course. Of course, one possible explanation may be that students' personality does not shape their decision-making process. However, a more likely explanation is that students' personalities shape their decision to enroll in an introductory computer science course in the first place (e.g., undecided students whose personality aligns with the investigative type might be more likely to enroll in an introductory CS course than those who identify with the enterprising personality). Because the data available for this study could not account for the role of personality in undecided students' decision to enroll in an introductory CS course, future research should explore this relationship.

Departmental and introductory CS course experiences. Having controlled for students' background characteristics and pre-course experiences, students' perceptions of departmental support and then students' introductory course experiences were added to the model in blocks three and four. While adding the measure of departmental support slightly decreased the model's predictive accuracy (from 66.5% to 65.5%), students' introductory course experiences, including the pedagogical approaches employed in the class, students' perceptions of the instructors' responsiveness, and the availability of peer support, improved the model's classification accuracy to 71.4%. In both blocks, there are significant findings related to undecided students' plans to major in computing.

Departmental support. In this study, departmental support is a composite measure that incorporates items related to students' perceptions that the department cares about students and diversity, fosters a sense of community, and inspires students to do their best work (see

Appendix B). Much like students' computing identity, departmental support is a significant, positive predictor of undecided students' intent to major in computer science until students' out-of-class experiences are added in the final step of the model. In this case, departmental support is significantly and positively correlated with the hours per week that students spend studying or on homework (r=.13), such that students who spend more time studying also perceive the CS department to be more supportive. Because of this relationship, when out-of-class activities are added to the model, the time students spend on homework reduces the predictive power of departmental support. Therefore, despite the fact that students' perception of departmental support is not a significant predictor in the final model, it may still play an indirect role in undecided students' interest in pursuing a computing major. Hence, future studies should continue to investigate the role of the department in students' major decision.

Introductory course experiences. Undecided students' introductory course experiences are the key independent variables in this study, which focuses on how introductory CS courses may encourage or dissuade undecided students from pursuing a computing field. The findings from the logistic regression analysis do not support my hypothesis that pedagogical practices influence students' decision, as none of the composite measures related to teaching practices were significant predictors of computing major choice. However, instructor responsiveness is a significant, although negative, predictor. That is, students who report that their introductory CS course instructor welcomes questions and is responsive in-class or over email are less likely to pursue a computing major. Though counterintuitive, this finding aligns with scholarship on college students in general that suggests that faculty-student interactions can appear to have a negative impact on student outcomes due to the nature of why students seek out such interactions in the first place (Sax, Bryant & Harper, 2005). In this case, it may be that students who perceive their introductory CS course faculty as responsive are asking questions *because* they are struggling in the course and therefore are less likely to continue into the major after the introductory class.

While instructor responsiveness appears to be negatively associated with undecided students' plans to major in CS, students who felt that support was available from other computing students were significantly more likely to pursue a computing major than those who did not. In fact, in the final model, peer support was the second strongest predictor of computing major choice (after prior computing experience). This finding aligns with my expectation that students who felt supported in their introductory CS course would be more likely to choose a computing major. Further, given that peer support was significant, while teaching practices were not, it appears that peers may play a more direct role in shaping undecided students' introductory course experience than faculty themselves. This finding lends credence to peer-learning techniques and underlines the importance of creating a positive learning community among introductory CS course students.

Out-of-class experiences. The last block of items to enter the model included students' out-of-class activities. These items, which included the hours per week that students spent participating in computing and non-computing organizations, studying or doing homework, and playing video games, again improved the model, such the final model accurately predicted 74.4% of cases. Among these items, only time spent in non-computing clubs or groups was a significant predictor in the final model, The results show that the more time that undecided students spend engaged in non-computing activities, the less likely they are to select a computing major. Therefore, CS departments may find it useful to ensure that undecided students are aware of the types of extracurricular activities available within computing and ensure that such organizations and events are available to and promoted to non-majors.

Table 4.11. Blocked logistic regression predicting intent to pursue computing major (compared to all other majors) (n = 203).

Variable	Model One b	Model One SE	Model One Ex(B)	Model Two b	Model Two SE	Model Two Ex(B)	Model Three b	Model Three SE	Model Three Ex(B)	Model Four b	Model Four SE	Model Four Ex(B)	Model Five b	Model Five SE	Model Five Ex(B)
Person Variables															
Demographics and Background															
Student Gender: Female	-0.01	0.01	0.99	-0.01	0.01	0.99	-0.01	0.01	0.99	-0.02	0.01	0.98	-0.02	0.01	0.98
Race/Ethnicity: URM	-0.05	0.38	0.96	-0.21	0.42	0.81	-0.27	0.42	0.77	-0.01	0.45	0.99	-0.03	0.46	0.97
SES Scale	-0.07	0.18	0.93	-0.03	0.20	0.97	-0.08	0.20	0.93	-0.12	0.22	0.89	-0.12	0.23	0.89
Parents' Career: Computing	0.29	0.34	1.33	0.12	0.38	1.13	0.17	0.38	1.18	0.13	0.40	1.14	0.10	0.41	1.10
Pre-course Experiences and Personality															
High School GPA*				-0.07	0.18	0.93	-0.07	0.18	0.93	-0.21	0.20	0.81	-0.19	0.20	0.83
Prior Programming Experience				**0.87**	0.35	2.38	**0.95**	0.36	2.59	**0.97**	0.38	2.64	**0.85**	0.39	2.35
Computing Identity (Factor)				**0.65**	0.20	1.91	**0.56**	0.21	1.75	**0.48**	0.22	1.61	0.41	0.22	1.50
Holland Artistic Personality (Scale)				-0.07	0.10	0.93	-0.03	0.10	0.97	-0.05	0.11	0.95	-0.01	0.11	0.99
Holland Enterprising Personality (Factor)				-0.14	0.25	0.87	-0.12	0.25	0.89	-0.18	0.27	0.84	-0.17	0.28	0.85
Holland Investigative Personality (Factor)				0.10	0.21	1.10	0.01	0.21	1.01	0.08	0.23	1.08	0.10	0.23	1.10
Holland Social Personality (Factor)				0.42	0.24	1.53	0.34	0.24	1.41	0.43	0.26	1.54	0.52	0.27	1.68
Environment Variables															
Departmental Experiences															
Department Support Factor							**0.41**	0.20	1.51	**0.49**	0.24	1.63	0.47	0.24	1.60
Introductory CS Course Experiences															
Inclusive Pedagogy (Factor)										0.02	0.20	1.02	0.05	0.20	1.06
Collaborative Pedagogy (Factor)										0.03	0.22	1.03	0.03	0.23	1.03
Traditional Pedagogy (Scale)										-0.08	0.14	0.93	-0.07	0.14	0.93
Instructor Responsiveness (Factor)										**-0.47**	0.20	0.62	**-0.52**	0.21	0.59
Peer Support Factor										**0.55**	0.21	1.74	**0.60**	0.22	1.83
Out-of-Class Experiences															
Hours per week (this term): Computing-related student groups													0.05	0.13	1.05
Hours per week (this term): Other student groups or clubs													**-0.20**	0.10	0.82
Hours per week (this term): Studying/homework													-0.10	0.11	0.91
Hours per week (this term): Playing video/computer games													0.10	0.09	1.11
Chi Square	*χ^2=2.52. df=4, p=.64*			*χ^2=35.10. df=11, p=.00*			*χ^2=39.706 df=12, p=.00*			*χ^2=52.290 df=17 p=.00*			*χ^2=58.48 df=21 p=.00*		
Hosmer and Lemeshow Test	*p=.43*			*p=.01*			*p=.23*			*p=.78*			*p=.25*		
Classification Accuracy	56.70%			66.50%			65.50%			71.40%			74.40%		

Note: Bold indicates p < .05.

Interaction Effects

A key component of this study is to understand to what extent undecided students' gender and racial/ethnic identities impact their experiences in introductory CS courses and, ultimately, their major choice. As discussed above, neither gender nor URM status was a significant predictor of undecided students' computing major choice. However, I proceeded with the interaction term models to investigate if the salience of undecided students' experiences in introductory CS courses differed by gender and/or URM status. I ran three separate models with interaction terms that included a) the main effects variables and course experiences*gender (Table 4.12), b) main effects and course experiences*URM status (Table 4.13), and c) main effects and course experiences*gender*URM status (Table 4.14). Running separate models for different types of interaction terms makes it easier to interpret any significant interactions. After running the two-way interaction models, none of the gender or URM interaction terms were significant, suggesting that the importance of undecided students' introductory course experiences do not differ by gender or URM status. However, as discussed in more detail below, a three-way interaction term examining the use of traditional pedagogy was significant.

Table 4.12. Interaction effects by gender (n = 203).

Main Effects Variables	b	SE	Ex(B)
Student Gender: Female	-0.56	1.15	0.57
Race/Ethnicity: URM	-0.04	0.46	0.96
Inclusive Pedagogy (Factor)	0.03	0.24	1.03
Collaborative Pedagogy (Factor)	0.05	0.28	1.05
Traditional Pedagogy (Scale)	-0.10	0.16	0.90
Instructor Responsiveness (Factor)	**-0.55**	0.24	0.57
Peer Support Factor	**0.60**	0.26	1.82
Interaction Terms			
Inclusive Pedagogy X Gender	0.12	0.39	1.13
Collaborative Pedagogy X Gender	-0.09	0.37	0.91
Traditional Pedagogy X Gender	0.10	0.20	1.10
Instructor Responsiveness X Gender	0.13	0.24	1.14
Peer Support Factor X Gender	-0.02	0.31	0.98
Chi Square	*χ²=60.90. df=26, p=.00*		
Hosmer and Lemeshow Test	*p=..69*		
Classification Accuracy	75.90%		

Note: Bold indicates p < .05.

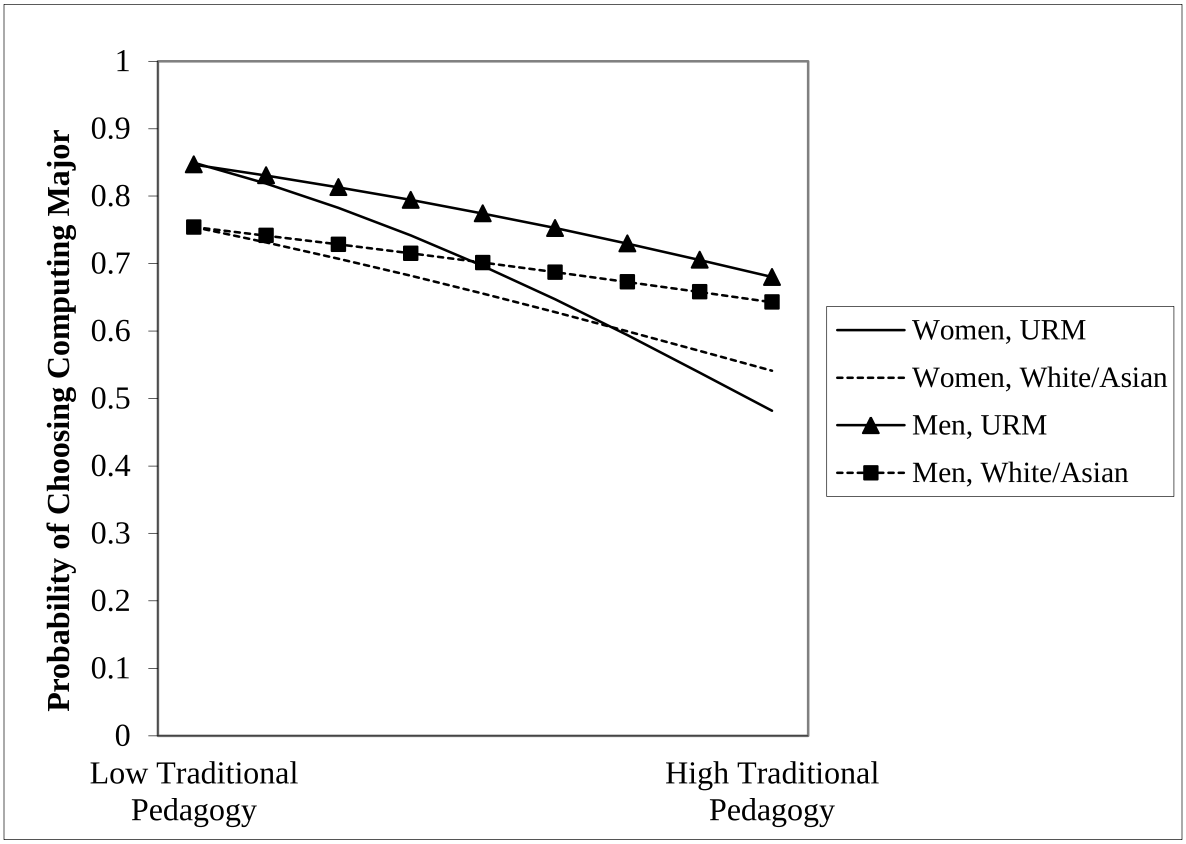
Table 4.13. Interaction effects by URM status (n = 203).

Main Effects Variables	b	SE	Ex(B)
Student Gender: Female	-0.02	0.02	0.98
Race/Ethnicity: URM	-3.60	2.39	0.03
Inclusive Pedagogy (Factor)	0.02	0.24	1.02
Collaborative Pedagogy (Factor)	0.13	0.27	1.14
Traditional Pedagogy (Scale)	-0.21	0.17	0.81
Instructor Responsiveness (Factor)	**-0.66**	0.23	0.52
Interaction Terms			
Inclusive Pedagogy X URM	0.14	0.49	1.15
Collaborative Pedagogy X URM	-0.37	0.58	0.69
Traditional Pedagogy X URM	0.49	0.34	1.62
Instructor Responsiveness X URM	0.86	0.56	2.36
Peer Support Factor X URM	-0.52	0.54	0.60
Chi Square	*χ²=63.95df=26, p=.00*		
Hosmer and Lemeshow Test	*p=.95*		
Classification Accuracy	75.40%		

Note: Bold indicates p < .05.

Three-way interaction terms. As discussed in chapter two, few studies have examined how students' experiences in computing may differ by gender *and* race/ethnicity. Though this study did not have the sample size to support running interaction terms by separate racial/ethnic groups, I did include three-way interaction terms that examined differences by gender and URM status. Among these, the traditional pedagogy interaction term emerged as a significant, negative predictor. As shown in the Figure 4.1 below, the role of traditional pedagogy is different for URM women than it is for URM men as well as White and Asian students of either gender. Specifically, women from underrepresented groups are less likely to choose a computing major when their introductory CS course instructor uses traditional methods (i.e., lecture and grading on a curve). Hence, even though the traditional pedagogy scale and students' URM status were not significant in the main effects model, we see that there is a significant effect when one considers the unique experience of women from underrepresented racial/ethnic groups. This finding underscores the importance of examining differences by gender and race/ethnicity.

Figure 4.1 Interaction between Traditional Pedagogy, Gender, and URM Status



Conclusion

This study takes a quantitative approach to explore the characteristics of undecided students who enroll in an introductory CS course, their perceptions of the climate in the course, and the predictors of undecided students choosing a computing major at the conclusion of the course. The results of these analyses show that undecided students have strong academic backgrounds and generally have positive views of the introductory course climate. However, there are some striking differences between male and female undecided students and between undecided students and CS majors in introductory CS courses, particularly in terms of their computing backgrounds and prior programming experiences. Further, the analyses reveal that certain introductory course experiences, notably instructor responsiveness and peer support, are significant in undecided students' decision to pursue a computing major. For women from underrepresented groups, the use of traditional pedagogy is particularly detrimental to their interest in a computing major. Taken together, these findings suggest that undecided students in introductory CS courses are a unique population and that their experience in the course helps shape their decision to pursue computing as a major.

The following chapter builds from these findings and presents the results from the qualitative stream of this study, which uses interview data from nine undecided students taking introductory CS courses at BRAID institutions. Their experiences provide a richer understanding of the findings discussed in this chapter and suggest additional insights into the experience of undecided students taking introductory CS courses that cannot be captured in quantitative analyses.

Chapter Five: Qualitative Results

This chapter presents the findings from the qualitative stream of this study which explores why undecided students enroll in an introductory computing course, how they make a decision about their major choice, and how their gender and/or racial/ethnic identities affect how they make meaning of their experiences and decision-making processes. The qualitative findings reflect those of the quantitative analyses, particularly in terms of the importance of peer interactions in introductory CS courses, and they provide additional context about the lived experiences of undecided students making a major choice in light of their enrollment in an introductory CS course. As will be evident in the sections that follow, the reasons why students who are uncertain about their major might enroll in an introductory CS course are complex, and the process by which these students go about making a major choice is, at times, messy. As discussed in chapter three, participants were interviewed twice: once in the spring of 2016 as they were finishing their introductory course and once in the fall of 2016 after their summer breaks. Because the interviews, and therefore the participants' responses and reflections, built upon each other, the findings in the following sections are organized thematically with data from both time points presented together. However, for each quotation shared, I have identified the time point to contextualize the participants' comments.

Choosing an Introductory Computing Course

The first qualitative research question guiding this study investigates why undecided students might enroll in an introductory computing course, as well as two sub-questions focused on how their gender and racial/ethnic identities and their career interests shaped this decision. At a high level, all of the participants in this study were taking an introductory computing course because they were interested in exploring a computing major. Beyond this, the participants offered myriad explanations of the circumstances that led them to enroll in an introductory CS course. Among their many reasons, several common themes emerged including experiences from childhood and high school, relationships with peers who were involved in computing, and pressure from their parents. Interestingly, the students interviewed reported that their social identities (i.e., gender and race/ethnicity) played no role in their reasons for enrolling in the course, but they did discuss how their gender and/or race/ethnicity shaped their experiences in the courses and, to some extent, their major choice. Hence, further discussion of the participants' gender and race/ethnicity will be explored later in this chapter as part of the findings on how the participants made a major choice. However, many of the students did explain that their career interests, specifically the perception that a computing major might lead to a high-paying career, informed their decision to enroll in an introductory CS course. In the sections that follow I will explore in more detail the participants' reasons for enrolling in a course. Taken together, these themes reveal the long and sometimes winding journey that steers an undecided student to a seat in the classroom of an introductory computing course.

Childhood Experiences

Many participants cited childhood experiences as important to their interest in STEM in general or even computing specifically. For some participants, these early experiences built a foundation of interest that ultimately led them to try a computing course in college. For example, Julie reflected on her childhood experiences with science, saying:

> I have positive memories. I enjoyed, like, asking questions and then like trying to solve them. And the reports where you write out your findings…whenever I dig up old things from kindergarten, they say things like 'I want to be an engineer' or 'I want to be a doctor.' Things like that. (Julie, Spring 2016)

For Julie, and for some other participants, the early interest in science was always connected with career interests. For others, like Devin, early experiences with science were more about curiosity and play, often at the encouragement of the participants' parents. Devin explains,

> My parents…why they gave me Legos, when I was 7 or 8, I don't remember, but since that day I was…Yeah, I think probably the first time they got me into science was playing with Legos. I mean, I wasn't a big extrovert; I'm more of an introvert. So, I was always playing Legos, trying to build things, and my dad would tell me, how about you trying fixing things, tables and legs on tables. I ended up fixing a table leg with Legos. And he said 'try doing this, try doing this.' He tried to make me do more innovative stuff without Legos. (Devin, Spring 2016)

Playing video games was particularly important to several of the participants' interest in computing. Carmen articulated how her early interest in playing massive multiplayer online (MMO) video games had a profound effect on her childhood, fostering not only an interest in computing but also a career goal to create similar kinds of connective experiences for others. In her own words, she explains:

> In middle school I started learning about MMO games. I truly…I just have fond memories of when I was like six and playing the Barbie games that were online. And then we just also had a Nintendo DS. And well, it's kind of hard to lie about how fun they are because I just played them extensively, in high school especially, when my stress level started to get high. They were really my stress relievers. And I've met…one of the things I explain to people about why I'm into computer science was that I met so many people, and people that I still connect with today, through like the usage of the new games and MMOs. And I wanted to, I wanted to have the same effect on someone. I want to produce a game where someone will also like…they can use this game to bond with someone else and then that friendship last a lifetime and such. (Carmen, Spring 2016)

For Carmen, the act of playing games on computers and the relationships she formed through these experiences fostered an interest in the technology itself. Her emotional description of how computers shaped her life highlights the profound impact early experiences can have in fostering an interest in or curiosity about computers which for many of the participants in this study helped facilitate the decision to enroll in an introductory CS course many years later.

High School Experiences

As is mentioned in some of the participant comments above, for many of the participants, childhood experiences intertwined with high school experiences that led to their continued interest in STEM and/or computing. While their childhood interests often manifested in play activities, participants described how their high school interests were reflected in their academic pursuits. Most of the interview participants did not take computing courses in high school, but almost all participants had been successful in math and science courses which played a key role in the reason they decided to explore STEM majors in college. Of her high school coursework, Julie said, “I never took any programming courses or any engineering courses, anything like that. I did the AP science and math classes. So as a high school student, I’d already decided I wanted a STEM career. But I didn’t know which one” (Julie, Spring 2016). This finding aligns closely with my expectations as I entered the study, as prior research has shown that students’ academic backgrounds are very important to their interest in computing (e.g., Beyer et al., 2003; Cohoon & Aspray, 2008).

While most participants reported positive experiences with STEM in high school as central to their decision to take an introductory computing course in college, one participant described avoiding STEM and computing in high school out of fear of how that might affect his image. Adam described:

> People might think I was weird or a nerd or something. But in college I was just like, ‘I don’t really care anymore, I just want to do what I love.’…And in high school, my high school had computer science classes but they were like, they didn’t really promote it at all. So, I was like, my senior year…I just realized they offered computer science class and I was like, ‘what!?’ (Adam, Spring 2016)

As Adam mentions, he not only avoided computing in high school out of fear for what his peers might think of him, but he also failed to get involved in computing because he was unaware that his high school offered programming courses (where perhaps he might have encountered like-minded peers). Several other participants mentioned that they might have enrolled in a programming course in high school had it been offered and/or publicized.

Beyond their interests in STEM courses, several of the participants also discussed taking art or music classes in high school. Robert explained that his creative interests were part of the reason why he did *not* take any programming courses prior to college. He said,

> I was busy taking art classes--I just didn't have time to take both…In high school, I didn't really do very much computer science. But my teacher, uh, physics you know, his class was probably one of the best I've ever taken. It was incredibly neat, but alongside that, the art classes I took with…one person in particular, I don't know, she was a wonderful lady. And I think, kind of encouraged me to seek out additional options besides what a lot of other guys in my high school were doing, just kind of doing engineering or like being doctors or lawyers or whatever. (Robert, Spring 2016)

Robert thought of his creative interests as distinct from his STEM interests. Several other participants also described their STEM and creative pursuits as separate, if not conflicting, interests; this divergence was part of the reason why some of the interview participants enrolled in their introductory computing course while still being undecided about their major. Julie described the dissonance her dual interests created when others learned about her plans to major in a STEM field. She reflected upon this, saying, "People seem confused when I tell them I'm studying engineering…They don't see me doing both-- they usually see me doing art and music" (Julie, Spring 2016). Prior research has found that women who plan to pursue computer science majors tend to see themselves as more creative than women in other STEM fields (Lehman et al., 2017), so it is not surprising that several participants were interested in art or music as well as computing. However, it is somewhat surprising that several participants did not view their creative endeavors in alignment with their computing interests, particularly given the recent movement to integrate arts education into STEM (Rhode Island School of Design, 2017).

Relationships with Peers in Computing

All of the participants in this study came to college with a general interest in STEM, even if they did not know much about computer science. However, several of them had friends who were very involved in programming or computer science and enrolled in an introductory computing course at their friends' encouragement. Alana explained how seeing the types of assignments her friend did in his CS courses piqued her interest in computing:

> Well, ok, so one of my really good friends is a comp sci major, and like, every time [he showed me] one of his projects…just the fact that like…you can see the results like right away, it's not like, hey memorize this and answer the question. Here, learn this, and you can apply it right then. So that really interested me. (Alana, Spring 2016)

Further, some participants felt more confident that they could succeed in computing after seeing their friends succeed. Robert described his experience as such:

> My friends were all computer science majors, and I was like, 'all right, I can learn programming.' I was trying out Python…trying to build this app, um, and so I said, 'what the

heck, this is part of my curriculum, and I'm going to try do this. I'm just going to do this computer science course next semester.' (Robert, Spring 2016)

Whereas their childhood and high school experiences often led the students interviewed for this study to a general interest in STEM, their relationships with peers who were in interested in computing is what encouraged several of the participants' specific interest in computing and their decision to try an introductory CS course in college. Though I expected that participants might enroll in an introductory CS course at their parents' urging, as discussed in the next section, I was surprised to learn that several participants' interest was prompted by relationships with their peers.

Pressure from Parents

Participants in this study indicated their parents had both positive and negative opinions about their plans to explore STEM majors, including computing. For a few of the participants, the pressure they felt from their parents and others in their lives had to do with their identity as a "smart kid." That is, some participants described how they were perceived as being "smart," and therefore their parents pushed them toward STEM fields simply because it was what "smart" people do. Devin explained how this pressure manifested into his decision to pursue some sort of STEM major saying, "People just told me I was good at math a lot and they, my parents, told me to get into a physics class. They kept pushing me to get into STEM…it kind of wasn't my choice" (Devin, Spring 2016). Though I expected that participants who had been successful in math and science and high school would be apt to consider a computing major in college, I was surprised to hear the participants speak about how their identities as "smart kids" became intertwined with their interest in STEM. As I will discuss in chapter six, the way intelligence may become associated with STEM has important implications for individual students' STEM and computing identities, as well as perceptions of the computing field at large.

Beyond a general sense that computing is a field that a "smart" person might pursue, the pressure that participants felt from their parents to take a computing course was often tied to their ultimate career choices. Some of the participants' parents encouraged their children to enroll in a CS course and consider a computing major because they saw a future career in computing as a lucrative, stable way to support oneself. Robert explained that he felt a great deal of pressure from his parents to "try and find a field that will give you a career quickly" (Robert, Spring 2016). On the other hand, at least one participant's parent discouraged her from pursuing computing because she felt other career paths might pay better than computing. Ning explained that her mother wanted her to "pursue business or law…she believes that makes more money, but I'm not sure I would be good in business or law as I am in science and computer science" (Ning, Spring 2016). Ning's mother was in the minority, however, as many of the participants themselves (including Ning) agreed that the career opportunities in computing were a main reason they were considering the major.

Career Interests

Just as the participants' parents had views about careers that influenced their decision to enroll in an introductory CS course, for most of the students interviewed for this study, their own career aspirations played a part in their decision to explore computing by taking an introductory class. Though the participants' own career interests played less of a role in why they enrolled in an introductory CS course than why they ultimately decided to pursue a computing major, many participants were exploring CS courses because they saw a computing degree as a pathway to a high-paying career. For example, Ning explained that one of her reasons for taking a computing class had to do with the career opportunities in the field. She explained, "It's a growing field, so there's a lot of new things I can move around in and try with in the field. And the salary is pretty good as well, or so I've heard" (Ning, Fall 2016). One participant was relatively far into his major but became unsure about his major when he looked into his future job prospects. Devin described his thinking as follows:

> My major [nuclear engineering] if you don't know, is declining because the USA is saying they don't want nuclear jobs. There's a…seven percent decline in nuclear jobs, according to the latest statistics, so I was really, maybe, looking at computer science, if I need to. Looking at the job market, petroleum went down under, and it's the same thing that's happening to nuclear, so I was thinking maybe computer science would be a good backup. (Devin, Spring 2016)

In general, participants saw taking computing courses as a good investment in their futures, even as they were unsure about completing a degree in computing. Many of them felt that taking a programming course might augment their career potential and make them more marketable, whether they were like Ning and just beginning to think about their careers, or if they were like Devin and further along in their decision making process and exploring computing as a backup to their original major and/or career plan.

Deciding to Major (or Not) in Computing

The second research question of the qualitative component of this study focuses on how undecided students make a decision to pursue computing or to pursue another field, as well as how their experiences in their introductory CS course and their gender or racial/ethnic identities inform their decision-making process. Much as their career interests encouraged some of the participants to enroll in an introductory CS course, career interests and values also guided many participants in their major choice process. Some participants also discussed how being undecided presented unique challenges, such as bureaucratic obstacles and limited access to information, that made it harder to choose or succeed in a computing major. To make their decision, almost all the participants in this study employed the same key strategy—they were taking a variety of courses in a sort of "trial and error" method to gather information about a variety of possible majors. Hence, the participants often cited aspects of the introductory CS course, particularly their experiences with peers, instructors, and assignments and the extent to which they fit in computer science, as factors that helped them gauge if a computing major was the right choice for them. Finally, some participants spoke about experiences related to their gender and/or race/ethnicity that shaped their experience in their introductory CS course and/or their major choice. The following sections explore these themes as they pertain to the participants' major choice process.

Career Interests

As discussed previously, many participants enrolled in an introductory CS course because of their (or their parents') view that a computing major would lead to a good job. Though the potential career opportunities did come up for some participants as they weighed their major decision, this became less important relative to other factors, perhaps because many of the participants were only considering majors that had relatively high-earning potential such as in other STEM fields or in business. However, other aspects of their career interests shaped participants' major choices, namely the social value of careers associated with a major, the participants' creative pursuits, and the knowledge participants had about computing careers.

Social value. Several participants discussed how helping others through their future career was important to them. While one participant, Carmen, talked explicitly about the social value of computing (see above discussion about how her childhood experiences with games fostered a desire to make video games to help others develop friendships), there was a general sense among the participants that a career in computing was not the best avenue for helping others. In some cases, this perception was key to the participants' decision to pursue another field besides computing. For example, Devin found a clear path from a major in nuclear engineering to helping others. He explained:

> One of the things that really pushed me was I go out and help children…I looked and I looked and I researched what kind of job in nuclear engineering will help me help children? And nothing in nuclear engineering came up, but medical physicist did come up. Nuclear engineers can become medical physicists, I learned, through grad school. They can go into hospitals--of course, they have to do what every doctor has to do, go through residency, go through all that training. But I do get to end up helping children, and that's what I want, what would be the best thing, and I can help other people, serving

other people. And I'll be doing something I love, then I will do it happily. (Devin, Spring 2016)

Julie had a similar experience with chemical engineering. In the fall following the term that she took her introductory computing course, Julie took a chemical engineering class that had a service-learning component. She discussed the social value of the class project and how it was shaping her career and major plans:

> Yeah, so this community--it has a vine that's invasive. It's called mikania; it grows all over the place and smothers all the wildlife, so it's not very possible to eradicate because most people there are on the public or national reserve [protected lands]. But they're trying to harvest it off trees, and then raise it and turn it into like a charcoal to put in fertilizer and put it in the soil and get rid of the plant. So we're trying to find a way to get the plant off the tree and then burn it. And then maybe integrating that solution into the community… I also have an interest in energy and energy engineering in general so I think it would be cool to fit in that [to my career], and also, biofuels are really important and sustainable. (Julie, Fall 2016)

Prior to taking this course, Julie had been deciding between majoring in computer science and majoring in chemical engineering. Ultimately, Julie decided to pursue a chemical engineering degree. Though she gave several reasons for this decision, this course, which made explicit how a chemical engineering degree could lead to a career that helped others, was among the most important. When framing this study, I anticipated that students whose professors emphasized the real-life applications of CS in their courses would be more likely to choose a computing major; while I found little evidence of that in this study, these examples show how some students abandoned computing as a major choice because they found another field to be more relevant to their interest in helping others.

Creative endeavors. As discussed previously, several participants mentioned artistic or creative endeavors as important to them, but participants were split on whether these interests were important to their future careers and their plans to major in computing.

Similar to the way some participants saw their high school involvement in activities and courses like art and music separate from their STEM interests, some participants also felt that their creative pursuits should be distinct from their future careers and were therefore not considering their creative interests in their decision to major in computing. Julie felt pursuing her musical talents would be a "more selfish choice" because she felt she could "help more people" by taking STEM courses and pursuing a related career (Julie, Spring 2016). During the first interview, Abdel described his pursuit of art as a "hobby," whereas his interest in computing was fueled by a desire to "have a profession which makes some money" (Abdel, Spring 2016). Further, he argued that keeping those interests separate prevented him from compromising his "artistic integrity." However, during his second interview, Abdel began to question his interest in a computing major and became less sure about his major plans. At that time, he began to explore ways to integrate his creative and computing interests by either adding a studio art major or minor to a computing major or switching to another major altogether. He explained:

> I thought that those two things would go really well together, having a degree in computer science and a degree in art, and just in 3D modeling and animation, you could probably get something in level design, or in animation or something like that, so I'm open to any field related to computer science, but I'm guessing anything closer to the art side…(Abdel, Fall 2016)

Some other participants did not have concrete creative interests like doing art or playing an instrument. Rather, some participants valued creativity more generally and saw computing as a way to be creative in their work. For example, Carmen felt that her creative pursuits would align with her technical interests. She explained, "I want to express myself like in the products I make…So then I just realized, it was more of like I have an interest in computer games" (Carmen, Spring 2016). Like Abdel, Carmen saw opportunities for a career in a computing that would allow her to integrate creativity into her future work, and this helped her decide to pursue a computing major.

Knowledge of computing careers. For some participants in this study, a sense of uncertainty about career choices overcast their major choice process. That is, several participants, especially those who became increasingly sure they wanted to major in computing, cited their lack of understanding about the types of jobs available to computing degree recipients as main barriers to making an informed choice. Two of the participants are at institutions where there are many computing majors from which to choose. They both remained undecided about their specific major choice within computing at the end of the study. For example, Carmen was considering several computing majors ranging from artificial intelligence (AI) systems to visual design. She spoke about how her lack of specific knowledge about careers in these fields impacted her major choice:

> I need to put more thought about it, especially being a second year now, the realization of I have to actually make goals for myself in order to succeed has hit…But, the fact that I still don't know, like, [how] the back end works in AI or visual system design and such and software engineering, because I still don't really know the backend, I… can only get a big um, generalization of what companies are different compared to other smaller niche companies. So it's more of trying to actually learn more about what I'm going to do. (Carmen, Fall 2016)

Even for a participant like Adam, who felt fairly sure of his plans to major in computer science, a lack of knowledge about computing careers was evident. He explained that he was possibly interested in pursuing a career in either gaming or analytics. Upon being asked to explain the field of analytics, he said, "I'm not really sure myself…I've just heard the term thrown around a few times in the class and in some of the classes. It has to do with more like analysis um, analyzing algorithms and how efficient they are" (Adam, Fall 2016). Though minimal research exists on college students' knowledge about computing careers, at least one other study has found that most students enrolled in introductory CS courses lack an understanding of the types of careers in computing, even among CS majors (Dempsey, Snodgrass, Kishi & Titcomb, 2015). Chapter six includes a more thorough discussion of how this lack of knowledge may affect students' identity as a computing major, and in turn, their decision to pursue or persist in a CS degree.

Unique Experience of Being Undecided

Though tangential to their decision-making process, a few participants discussed ways in which being "undecided" made it harder for them to succeed in computing, and, therefore, harder to choose a computing major. For instance, Carmen described how being "undecided" meant that she did not have access to some of the support systems that could help her be successful in computing. Upon deciding to major in computing, Carmen described her excitement at joining a group for women in computing. She explained:

> I'm sort of proud of myself to actually join a club because I felt that, 'oh, I'm not a computer science [major], I can't join it,' but now that I'm really decided and now that sort of negative is out of the way, it feels nice to have a club that actually supports me and does networks… undecided or undeclared had such a terrible stigma in high school, which I'm sort of sad about because…the counselors I had…were actually really phenomenal in teaching me to take those baby steps into my major. Even if I wasn't in the major myself. In high school, undecided and undeclared you had no goals or probably no future, just very negative, and I guess it did end up trickling down to me feeling I wasn't good enough to be in the major or good enough to actually go to these computer science clubs and whatnot. (Carmen, Fall 2016)

Though Carmen probably could have joined a computing club as a non-major, the stigma that surrounded being an undecided student prevented her from doing so. Klahan spoke about a different type of barrier that made his decision to major in computing more difficult. He faced a bureaucratic barrier that made it administratively difficult for him to become a computing major. He described his major declaration process as follows:

> I had to jump through tons of hoops to switch my major which was really frustrating for a while because I wasn't officially the major, I couldn't sign up for the classes I needed… So the requirements to switch are taking…one of three math classes you can choose to take, and then you have to take two CS classes. So I took the two CS classes and I had AP credit for two of the three math courses I had to choose from. So I tried switching and they said because I had the AP credit, and that I didn't get an actual grade in the class so I couldn't switch, which was like really weird I thought. And after that, like the only remaining math course that I could take that would allow me to switch was for majors only, so I didn't get into it for a really long time, and I kept waiting to get in. They wouldn't make an exception for me, even though my AP test I'd gotten 5s on both of them. They still wouldn't agree to take it into account. So what I ended up doing was I switched to a different major that allowed me to take the course and then from there I switched to computer science. (Klahan, Fall 2016)

Klahan faced barriers on many levels. First, before he decided on a computing major, being undecided restricted the courses he could take. Once he did decide on a computing major, a departmental rule about the requirements and how to fulfill him prevented him from declaring his major. Finally, even though he was willing to take an additional course to meet the requirement, he could not enroll in that course because he was undecided.

Trial and Error

As discussed above, the decision-making process for many of the participants involved trying courses from the fields in which they were most interested and using their experiences in those courses to inform their major choice. Carmen described her approach as "trying to see what I love academics-wise" (Carmen, Spring 2016). Similarly, Ning knew she was interested in a STEM major, so she said her plan for making a major choice "is to take a lot more classes in the science and math fields and see what I really enjoy doing" (Ning, Spring 2016).

For some participants, like Robert, taking courses allowed them to eliminate potential majors from their list. Robert explained, "Basically, I tried engineering, I liked it, but I don't think it's the thing for me. So I've decided to go another direction" (Robert, Spring 2016). Similarly, Alana described her process of trying out different majors as such:

> Last semester the classes I took were all like biochem, but like this semester I added comp sci to it. And I like chem; I realized even though it's a class I struggle in sometimes, it's still something I like, and I enjoy learning about. I don't think it would stress me out so I know I want to keep chem. Bio, I know for sure I cannot do because it stresses me out like, it's just not something I'm interested in anymore…I'm taking math which I'm good at, comp sci, I'm taking that right now which I like kind of. (Alana, Spring 2016)

In general, most participants came to college with a few different majors in mind, often concentrated in the STEM fields, and then they took a variety of introductory courses in those fields to try them out. If they did not like the course, this often led to that major being eliminated from their list of potential majors. When participants liked a course, however, they would often add more of that discipline's courses to their schedule in the following term. Though limited previous research has investigated the role of introductory courses as recruitment tools (Hoisch & Bowie, 2010), this finding supports the idea that some students in courses are treating them as such.

Introductory Course Experiences

As is outlined above, the participants used the experiences in their courses as means of narrowing their major choices. Hence, the participants evaluated the experiences in their introductory CS course through this lens and used those experiences to help them decide if they would pursue a computing major or not. For example, Alana explained that the introductory CS course helped her "to not only learn what CS is but to experience the struggles of writing code, of debugging, and it allowed me to see what being a programmer in computer science might feel like" (Alana, Fall 2016). Similarly, Devin described how his introductory CS course helped him discover "what I do like about computer science and what I do not like about computer science. Overall it helped me learn that I am passionate about not…working *with* computers…I'm more interested in the hands-on, working with people" (Devin, Fall 2016).

Participants identified various aspects of their introductory CS course that informed their opinions of that specific class and, in turn, whether a computing major might be a good fit for them. Among the many relevant introductory course experiences participants described, several themes emerged, namely their experiences with peers in the course, their perceptions of the course instructors, their success on assignments, and their sense of fit in the course and/or major.

Experiences with peers. Participants reported that their experiences with the peers in their courses played a key role in the extent to which they felt that they fit in computing and heavily influenced their major decision. Not surprisingly, participants who relayed negative experiences with peers had concerns about continuing in the major, whereas participants who described positive peer climates also had more positive feelings about a computing major.

Negative experiences. For some, their experiences with peers in their intro CS courses were negative, especially compared to their peers in other courses. Several participants described negative experiences with the degree to which their intro CS classmates were social. For Devin, experiences with the people in computer science, compared to the people in nuclear engineering, was the most important reason he decided to continue in nuclear engineering and not pursue a computing major. He said:

> Well, the biggest factor was the people in it. Nuclear engineers, they were really social. Well, they weren't as social as you think. But they were the right kind of social where they would interact with people, but they would still do their work, and they were all about having fun at the end of the day and enjoying one another…But the average computer science people were very lonely; they weren't very social. And they had irritable attitudes because they were all about business. And it was really off-putting to me just to see that because I want to be, I'm not the most social person, but I still want to be social sometimes. Everybody needs to be social sometimes. (Devin, Spring 2016)

Julie also cited a want for social experiences with computing peers as a contributor to her lack of fit in computing and ultimately her decision to major in chemical engineering instead. When asked why she did not feel that she fit in, she explained, “Well the people, we never talked to each other, so there was never any connection made. Like, they were trying *not* to talk” (Julie, Spring 2016). In reflecting back on this sentiment during her follow-up interview, Julie expounded:

> I didn’t have social connections last semester [in her CS course] and then, in this class [her chemistry class] it feels like I’m on the same page as everyone else, but I’ve had no prior experience…In the computer science course it felt like most of the other students had [experience] so it was a little intimidating. (Julie, Fall 2016)

Julie had no experience in either programming or chemical engineering prior to taking the introductory courses. However, in the CS course, she described feeling isolated, in part because it seemed that her peers in that course had more experience and were therefore intimidating. In her chemical engineering class, Julie felt that she entered the class at the same level of experience with her peers, which made it easier for her to form connections. Hence, for Julie, her lack of experience in programming created at least two levels of disadvantage—it put her behind in the class and created a barrier to forming relationships in the class. Julie’s experiences reflects what is known about the importance of prior programming experience in women’s success in computing (Badagliacco, 1990; Beyer et al., 2003; Margolis & Fisher, 2002; Margolis et al., 2000) and helps give voice to the emotional and relational implications of feeling left behind in a computing course.

Positive experiences. Other participants recounted positive social interactions with other students in the class. Of her introductory CS course peers, Ning said, "It was really cool getting to talk to other people who were also interested in computer science and getting to see what they were planning and why they wanted to take computer science" (Ning, Spring 2016). For Ning, who had not taken formal computing classes in high school but had always been interested in computing, part of the excitement of the introductory CS was the opportunity to spend time with like-minded peers who shared her passion for computing.

Adam talked about how he made friends in his introductory CS course in part because his professor fostered a positive peer learning environment. Adam said:

> I saw people becoming more friendly with each other cause our teacher would, for like the lab, we would work with the person next to us. Our teacher would change the seats often, like every couple weeks we'd be working with a new person. So we got to work with a decent amount of students in the class, which I thought that was a good idea. (Adam, Spring 2016)

Both Ning and Adam talked about making friends in their introductory courses, but for Ning this is something that just happened as a result of a shared passion for the topic. However, for Adam, the professor intentionally structured the class to encourage social connections among the students, and this helped him to make friends. This example speaks to the role instructors can play in creating a positive and inclusive classroom environment, though few participants besides Adam provided examples of how their introductory CS course instructors did so, as will be discussed further in the next section.

Experiences with instructors. Participants described their instructors, both professors and teaching assistants (TAs), as important to their course experiences, and in some cases discussed how their instructors shaped their major plans. Most participants were generally positive about the course instructors, but they struggled to give specific examples of how a professor helped them learn the course content or fostered a positive learning environment. For example, Abdel described his computing professors as “really friendly and really helpful, but what I found was both of the teachers are sort of dated. They’ve been teaching for 15 years now, and they aren’t open to suggestions” (Abdel, Spring 2016). Still, several of the participants described positive interactions with the course professors, especially those who participants perceived to be approachable and interested in answering their questions. Robert explained how he would often run ideas by his professor after class, saying “She was always available after class so I often talked to her about…I had an idea of ‘oh, I want to try this on my next assignment, what do you think?’… she was always really helpful” (Robert, Spring 2016).

TAs played a central role for many of the participants, and most of the participants reported that TAs were helpful and improved the quality of their introductory course experience. In some cases, participants explained that TAs helped students work through the initial intimidation of learning a topic about which they had limited experience. For instance, Abdel described how TAs showed students “how to install the software and have it running on your computer so you can do your assignments” (Abdel, Spring 2016). In other cases, the TAs became role models and even friends. Carmen explained that she met some of her upper-class friends when they were serving as peer tutors for her introductory CS course, and they helped her learn about various computing majors. She recounted that making friends with the peer tutors allowed her to get to know people who "are in those specializations and who I've talked to and asked about their coursework and how it's going for them. And what they just tell me, even in layman's terms, sounds really interesting" (Carmen, Spring 2016). In some cases, the TAs offered the participants support and encouragement to overcome difficulties in the course. When describing how he overcame a period of doubting his abilities in computing, Klahan explained, "Uh, just the TAs actually. Whenever I had problems I just asked them" (Klahan, Spring 2016).

I anticipated that course instructors, and the methods they used to teach their courses would be central to the students' experience in the course and their major choice process. However, even when asked about the instructors and teaching methodologies, the participants had few opinions. For the students in this study, the content of the course, particularly the projects that they were assigned, mattered more than the instructor and teaching style.

Assignments. Participants in this study talked at length about the assignments in their introductory CS courses. Somewhat surprisingly, participants spoke about their affective responses to the assignments, particularly how they felt when they succeeded on a class project, as being central to their continued interest in computing. Klahan described his final project in his introductory course; he said, "It was a really hard project, and also really interesting…but when I completed it, it was really satisfying. I realized that I liked it a lot." (Klahan, Spring 2016). Alana had a similar experience with one of her course assignments. She said:

My second project, it wasn't working at all for like the longest time, and then at the end, the very last day I was like, 'I need to do something,' and all of a sudden, something clicked. And it worked! And I was like, 'oh, wow!' And those kinds of moments…my efforts were actually worth it. (Alana, Spring 2016)

For both Alana and Klahan, the experience of succeeding in the face of a challenging assignment helped create strong, positive emotions around their computing abilities. Further, both of them spoke to the idea that the projects were "interesting" or that their efforts were "worth it." In short, they felt that the amount of time and effort required paid off in the end, and this experience was affirming for them.

While several participants spoke about how succeeding at interesting projects encouraged their interest in computing, a few participants had the opposite experience. For example, Devin, described his experience with course assignments in this way:

Each week I would get to the class earlier and the earlier. The thing about it, it was kind of boring, to be honest, because I was just doing project after project for the class. It was nothing like, they weren't teaching me like, if they taught me how to make an app or if they gave me one big project to do over the semester that I could work on every week that incorporated every new technique that taught me. I thought that would be a great idea for the class that way I'm keeping myself interested, and I get to show off what I'm making at the end of the year. So, really [you are] just creating something for them and abiding by their rules… I thought C++ was… so free, you can do anything on a computer, by learning this class, but they're just teaching you their ways of learning. (Devin, Spring 2016)

Like Alana and Klahan, Devin also felt as if he was investing a great deal of his time and energy in his introductory CS course, but he did not find the same pay-off and satisfaction that they did because he did not see the value in the assignments and felt constrained by the project guidelines. Therefore, for him, the experience was discouraging to his interests in a computing major. Hence, as will be discussed further in chapter 6, future research should consider how relevant assignments and opportunities to feel successful at programming may be key to affirming students' identities as potential computer scientists, while repeated failures or a sense that assignments are irrelevant may discourage a students' ability to see themselves as a computing person.

Sense of fit. As the participants evaluated their collective experiences in the course, from their interactions with instructors and peers to course assignments, participants described how they sought to answer a larger question with respect to computer science: "do I fit here?" More than the other aspects of the introductory computing course, how the participants answered this question seemed to be the most important to their decision to major in computing or pursue another field. Robert, who chose not to pursue computing, described his decision process as follows:

So, actually for a while, I was just kind of thinking 'hey, this is kind of neat, maybe I should keep doing this. 'Cause I'm good at it.'…I think kind of, what made me kind of step back for

> a moment was, I didn't, I didn't know, I didn't like, breathe algorithms like a lot of people did. I really enjoyed programming, I really enjoyed solving problems, but…I don't think I was really set out to just be programming a lot, all the time. (Robert, Spring 2016)

Devin had a similar reaction to his experiences in the introductory CS course. He said:

> Programmers are some of the smartest people. I would not fit in that category simply because I don't, I'm not into computers like they are. Like computer science programmers, I feel like they are, well, I think like they know everything about the program. They are intrigued by computers… I mean, by computers in general. I'm not that kind of intrigued by computers in general. I'm more intrigued in what the program can do, like innovating the programs is more my, more what I feel like. (Devin, Spring 2016)

Both Robert and Devin were interested in programming and liked it, but both of them decided against pursuing a computing major. They had a sense that there was a specific way of being in computer science that did not align with their personalities or interests. Further, they both struggled to articulate what was different about computer scientists. However, they also recognized that there was a specific identity associated with computing, and neither one saw himself adopting that identity.

On the opposite end of the spectrum, some participants who decided to pursue computing majors talked about how they came to find a fit in computing. Carmen described how her first CS course introduced her to the "culture of learning coding" which has been key to her success in the major, even as she has seen others fail. She described how computing required students to spend a great deal of time on assignments, such that when people did not understand this "culture of learning" they often left the major. Similarly, Adam, a participant who went on to choose a computing major, explained how developing a "computer science mindset" helped him succeed in the major. In reflecting back on his introductory course experience, he said:

> I still think it was challenging just because it was just a lot to take in. Especially since I wasn't in that computer science mindset, it was like, like learning all the stuff initially was kind of abstract, if that makes sense…Well, my teacher this semester, he emphasizes a lot on drawing pictures and like, always going step by step. Like last year my teacher did, but she didn't like embed it into us, but I feel like the teacher I have now is really focused on drawing pictures and visualizing and tracing what goes on with like each command. And now that I've kind of got in the mood of doing that, I understand it a lot better… I think it needs to be emphasized more. Cause… the difference between the really good students and just the ok students is that, like that concept of always visualizing. (Adam, Fall 2016)

Both Carmen and Adam described how the particular way one learns to program, what they called the "culture of learning coding" and the "computer science mindset," was important for potential computer science majors to grasp. Carmen put the emphasis on the individual student—in her view, students who left the major were not spending enough time or focusing enough on the course. On the other hand, Adam believed that course instructors could teach students how to think like a computer scientist. However, both Carmen and Adam framed the behaviors associated succeeding in computing as a skill that students could develop, either through hard work or with the assistance of the teacher. This is contrary to the image of successful computer science students portrayed by Robert and Devin, who both viewed the computing identity as more of an innate ability or persona.

Role of Gender and Race/Ethnicity

In general, participants' gender and/or race/ethnicity did not come up in their decision to take the introductory CS course or in their major choice decision. In chapter six, I will discuss possible reasons why participants did not readily discuss their social identities with respect to their course and major choices. However, when explicitly questioned about gender and racial/ethnic dynamics, many of them described gendered or racialized experiences in the course related to the course instructors, social dynamics, and stereotypes about success. Though the participants themselves rarely tied these experiences with their major choices, certainly such experiences may have indirectly affected their thinking about the decision-making process.

Course instructors. The gender of the course instructors came up in discussions with several participants. Adam was surprised to have a woman as his professor: "I'm surprised, she didn't really seem like the type of woman to be into computers, but she really knew what she was talking about…And she really had a passion for it. And it really showed in the way she taught" (Adam, Spring 2016). On the other hand, Alana discussed that she looked up to her TA as a role model for women succeeding in computing. She said, "When you're trying to get females into a comp sci place, it's good to know there's women who've succeeded in that area, that like you can look up to and stuff" (Alana, Spring 2016). The literature on women's success in computing supports Alana's statement; departments with a higher proportion of female faculty are more successful at retaining women in the CS major (Cohoon, 2001). However, research has not investigated the impact of having more female instructors on men in computing majors. In this example, having a woman as his professor challenged Adam's stereotype about "the type of woman to be into computers." Perhaps this experience will help Adam become more open-minded in his future interactions in computing. Future research should consider how positive interactions with women professors and TAs may help men in undergraduate computing majors become better allies for gender inclusivity in the field.

Social dynamics. When asked about the gender and racial make-up of their introductory CS class, all participants acknowledged that women and people of color were in the minority. However, many of them did not feel the course demographics were central to their own experience. For example, Ning described the course demographics and their impact on her as such: "Women were definitely a minority…maybe 20 percent or 30 percent? Well, I never felt unwelcome because of my gender in that class, so…I didn't have to pay attention to who was male or who was female" (Ning, Spring 2016).

A few participants discussed how the course demographics impacted the social dynamics of their courses. In her introductory CS course, Carmen only noticed gender dynamics when doing partner work in class. She explained, "It's mostly same gender partnering, especially when it comes to girls. So it's very weird to see a guy and a girl together as partners, but it will happen because everyone needs to have a partner" (Carmen, Spring 2016). Devin described similar dynamics with respect to race. He explained:

> It was very normal to see only one person, only one black person in a classroom. So, I'm kind of used to it now. So when there is black person, usually always try to say 'hey.' You always try to stick together, and we'll always get through this class together just because you know, you know minorities can really help each other. And this last semester there was an Asian girl in my class, and we did the same thing. We would always say we need to get through this together…The minority people help me more than the white people would. (Devin, Spring 2016)

In both cases, Carmen and Devin describe how students of like gender or racial backgrounds came together in their introductory courses. Devin describes as situation where finding other students with minority backgrounds is a survival technique in hard classes. When asked why the women tended to work together, Carmen said she was unsure, though it seems likely that similar dynamics may be at play. It is interesting to note that in Devin's example, he spoke about working with an Asian woman. The NSF considers Asian and Asian American individuals to be majority students in STEM disciplines; however, as illustrated by Devin's experience, Asian/Asian American students may still experience a CS classroom as a racialized environment. Therefore, while it is important to consider issues of representation, future research needs to further consider the experiences of Asian/Asian American students who may be "majority students" but continue to face difficult climates.

Stereotypes. A few of the participants discussed how stereotypes about women and people of color impact how others perceived their likelihood of being successful in an academically rigorous course like introductory CS. Ning spoke about stereotypes of women, though she expected those stereotypes to impact her more later in her career. Still, she used those stereotypes to motivate her to do well in her computing courses. She explained:

> I know that eventually that my gender will play a role into 'oh ,she can't do it because she's female,' but at the same time I don't want that to decide like, where, what my interests are. And I think that if I do well, then I can also, I feel like another female in the workplace that might encourage more females to come. And it's also a bit out of spite…it's just the feeling of 'oh, you don't think I'm going to do well?' Well, let me now just, you know, do better than you by like two grade letters and prove you wrong. (Ning, Fall 2016)

While Ning was able to use the stereotypes about women in computing as a source of motivation, one participant in the study, Devin, faced a very difficult racial climate that had a profoundly negative on him. Devin is a student at a campus that was involved in a high-profile racist incident during the same term that he was enrolled in the introductory CS course. Devin spoke at length about the impact that incident had on him as a student:

> I feel like, it's just society don't expect us to pass. Being honest… Do you know about that whole [high-level university administrator] saying racist things? To be honest, I tried ignoring as best as possible, but I was [a leader in diversity-oriented student groups], a member of student diversity and outreach to women's' programs, so it really hit me hard, knowing that the [high-level university administrator] was saying stuff like that." (Devin, Spring 2016)

Devin felt that, as a black man, people did not expect him to succeed in a course like CS. Further, his comments about the campus racial incident coupled with his statements about seeking out other students of color to survive difficult classes suggests there is a difficult racial climate on his campus that extends far beyond his introductory CS course. The limited sample size for the qualitative component of this study does not allow for an investigation of how institutional and departmental climates influence students' experiences in their introductory CS courses. However, future research should seek to investigate the relationships these levels of the student environment to better understand how various contexts foster or hinder supportive introductory CS courses.

Conclusion

This study utilizes qualitative data to better understand what it is like to be an undecided student who is considering a computing major. In this chapter, we have heard from nine individuals in such a situation. From their experiences, we see that there are many ways to be an undecided student—each of them has a unique story about why they are undecided about their major, why they decided to sign-up for an introductory course, what their course was like, how they decided on a major (or are working on making that choice), and how their gender and racial/ethnic identities played into that process. Yet, from their unique experiences, a number of themes emerged ranging from the role their childhood played in shaping their initial interest in computing to the way their programming homework assignments made them feel about the idea of being a computer scientist. In the next chapter, I will take the participants' experiences and examine them alongside the quantitative findings in a discussion of how the results of this study contribute to the collective knowledge about students' experiences in introductory CS courses and what some of the implications might be for faculty and administrators in CS departments as well as other researchers whose work might build off this study.

Chapter Six: Discussion and Conclusions

The concluding chapter begins with an overview of this study, including a summary of the study's purposes, research questions, theoretical framing, and methodological approaches. I will then discuss the study's key findings from the quantitative and qualitative streams in the context of the extant literature before synthesizing the results. Next, I will outline the implications of this study for CS departments and faculty. Finally, the chapter concludes with a summary of the study's limitations and suggestions for future research.

Study Overview

In the United States, there has been an increased focus on attracting and retaining more and diverse college students to computing majors to ensure that there is a trained workforce to fulfill jobs in the growing tech sector as well as to increase the representation of women and people of color in the computing industry. Given that computing departments may have limited control over who is admitted to their undergraduate majors (Sax et al., 2015), leading scholars and computing organizations have suggested that departments seek to recruit undecided students to computing majors, particularly those who may be enrolled in introductory CS courses (Cohoon, 2002; NCWIT, 2015). However, limited knowledge exists about the pathways for undecided students to pursue a computing major and the role of introductory CS courses in recruiting these students. Further, studies have not examined how the experiences of undecided students in introductory CS courses may vary by gender and/or race/ethnicity. To address these gaps in the literature, this study was framed by five questions:

Quantitative questions:

1. What are the demographic and family traits, academic and computing backgrounds, and self-ratings of undecided students who choose to take an introductory CS course? Do these characteristics differ significantly by gender? By race/ethnicity? Between undecided students and declared CS majors?

2. What are undecided students' perceptions of the climate in their introductory CS courses, particularly in terms of their experiences with the course instructor and their peers? Do their perceptions vary by gender? By race/ethnicity? Between undecided students and declared CS majors?

3. To what extent is there a relationship between undecided students' experiences in introductory CS courses (e.g., teaching and evaluation practices, faculty attitudes toward students, and experiences with peers) and their intention to major in CS? What is the magnitude of the relationship? Does the relationship vary by the students' gender and race/ethnicity?

Qualitative questions:

4. Why do undecided students choose to take an introductory CS course?
    a. How do their gender and/or racial/ethnic identities play into their decision to take an introductory CS course?
    b. How do their career aspirations play into their decision to take an introductory CS course?
5. How do undecided students make the decision to major or not major in CS?

a. How do their experiences in the introductory course factor into their decision-making process?
b. How do their gender and/or racial/ethnic identities play into their major choice?

In considering these questions, this study drew from two different theoretical perspectives. I used Holland's (1997) Theory of Career Choice as a lens to understand the reciprocal relationship between undecided students and their experiences in an environment, such as an introductory CS course, and to frame how undecided students might make a major choice. Further, I relied on Carlone and Johnson's (2007) science identity theory to center undecided students' gender and racial/ethnic identities in their decision-making process. This provided a framework to understand how undecided students' experiences in CS introductory courses might differ by gender and race/ethnicity and how undecided students reconcile their experiences with their ability to view themselves as computer scientists.

The study took a convergent, mixed-methods approach. The quantitative stream drew from survey data from over 500 undecided students enrolled in introductory CS courses at 15 institutions across the United States. The qualitative stream relied on data from 17 interviews with 9 undecided students who had taken an introductory CS course in the spring of 2016. This study was conducted in the context of the BRAID initiative, a collaborative effort between The Anita Borg Institute, Harvey Mudd College, UCLA, and 15 CS departments across the country to increase the representation of women and URM students in undergraduate computing majors.

The quantitative data for this study were drawn from the BRAID Research project, specifically the introductory course start-of-term (STS) and end-of-term (ETS) surveys conducted during the 2015-2016 academic year and the fall of 2016. The samples for the quantitative stream included 535 undecided students who took the STS, 214 of whom went on to take the ETS. The quantitative data were analyzed in two phases. First, descriptive analyses (i.e., frequencies, z-tests, and t-tests) were conducted to examine undecided students' characteristics and backgrounds and their perceptions of the introductory CS course climate as well as how undecided students differed on these measures by gender, URM status, and major status (undecided students vs. declared CS majors). Then, a logistic regression analysis was conducted to examine the predictors of undecided students' choosing a CS major at the conclusion of their introductory CS course. Finally, interaction terms examining the salience of undecided students' introductory course experiences by gender and URM status were incorporated into the model.

The qualitative sample included 9 interview participants who were all undecided students enrolled in an introductory CS course at a BRAID institution during the spring of 2016. Semi-structured interview protocols were employed to interview participants during the spring of 2016 while they were enrolled in the introductory course as well as in the fall of 2016 after they had completed the course. The interviews were recorded, transcribed verbatim, and analyzed for thematic similarities.

Discussion of the Findings

Quantitative Stream

The quantitative stream of this study sought to explore three research questions related to the characteristics and backgrounds of undecided students who enroll in an introductory CS course, their experiences in the course, and the extent to which those experiences predicted undecided students' plans to major in computing. In framing the study, I developed hypotheses related to each of the three research questions. The following sections summarize those hypotheses, assess the extent to which the findings from this study support those hypotheses, and discuss how the findings fit into the extant literature.

Research question one. What are the demographic and family traits, academic and computing backgrounds, and self-ratings of undecided students who choose to take an introductory CS course? Do these characteristics differ significantly by gender? By race/ethnicity? Between undecided students and declared CS majors?

Hypothesis 1a.1. *Most of the undecided students enrolled in introductory CS courses would be male, White or Asian, and from higher income families and have taken advanced math, science, and computing coursework in high school—Partially supported.*

The findings from this study show that undecided students tend to be majority men, come from higher socioeconomic backgrounds, and have advanced math and science high school coursework. These findings align with previous research on undecided students that found that undecided students who choose a STEM major tend to be male and White or Asian and to have strong math and science backgrounds (Green & Sanderson, 2014; Hurtado et al., 2015). However, the majority of undecided students in this study had *not* taken computing coursework in high school, contrary to my expectations. Most of them did report that they had some prior programming experience, such as an online course or computing camp. A possible reason that a smaller percentage than expected had taken a course in high school could have to do with the availability of computer science courses in high schools. Given that only 40% of high schools in the United States offer computer science courses (Google Inc. & Gallup Inc., 2016), it is possible that many of the undecided students in this study were interested in computing prior to college but were unable to access a CS course in high school.

Hypothesis 1b.2. *Women would have higher grades than the men but less computing experience and less confidence in their intellectual, mathematical, and computing abilities than their male counterparts—Supported.*

The findings from this study show that among undecided students enrolled in an introductory computing course, women reported higher high school grades than men but were less confident in their abilities on a variety of measures, including their intellectual, mathematical, and computing abilities. These results support a prior study that considered gender differences in the self-ratings among men and women pursuing computing in college (Lehman et al., 2017). As mentioned in chapter four, the findings related to computing abilities are particularly important, even if they are not surprising. That is, Lehman and colleagues also found that women had lower self-ratings on computing abilities, and past research has demonstrated that women are less confident in their computing abilities than men, even when comparing women who are CS majors to men who are *not* CS majors (Beyer et al., 2003). Research continues to find that women consistently rate themselves significantly lower on measures of computing ability, despite many efforts to encourage girls in computing and build computing confidence from an early age, such as through programs like Girls Who Code and Black Girls Code.

Hypothesis 1b.3. *URM students would have less science, math, and computing experience than majority students and would also tend to have lower self-ratings—Partially supported.*

This study found that among undecided students enrolled in an introductory CS course, URM students were less likely than White and Asian students to take certain math and science courses, namely chemistry, physics, and psychology. However, counter to my expectations, there were no significant differences between URM and majority students in terms of their prior programming experience or CS high school coursework. Additionally, there were very few differences between the two groups' self-ratings, and when there was a difference, URM students rated themselves higher than their White and Asian peers.

Prior research on URM students' participation in the computing has indicated that students from underrepresented groups are less likely to have access to computer science courses in high school as well as access other resources, including computers themselves, that promote an interest in pursuing a computer science major in college (Charleston, 2012; Kodaseet & Varma, 2012; Margolis et al., 2008; Varma, 2006). Further, as discussed in chapter four, research has also suggested that URM students face negative stereotypes about their ability to succeed in STEM and/or computing fields, which can affect their confidence and deter them from pursuing a career in computing (Carlone & Johnson, 2007; Margolis et al., 2008). Hence, it was somewhat unexpected to find no differences between URM students and White and Asian students on measures related to prior computing experience or on self-ratings measures related to STEM abilities.

Taken together, these findings lead me to believe that undecided students who enroll in introductory CS courses are a unique population, and there may be circumstances related to the very reason that these students are uncertain about their major that diminish differences between groups. For example, as mentioned above, only 40% of American high schools offer computer science coursework (Google Inc. & Gallup Inc., 2016). Perhaps students who come to college undecided about their major tend to come from high schools with limited course offerings and are therefore undecided about a college major *because* they have had limited opportunity to explore different disciplinary fields. As discussed further in the limitations section, this study focused on the experiences of undecided students who were already enrolled in an introductory CS course, so the quantitative data for this study did not allow for an investigation of the various factors that might contribute to an undecided students' decision to take the course.

Hypothesis 1b.4. *Undecided students would be more diverse in terms of race and gender than declared CS majors. Undecided students would have less computing experience than students who had already decided on the CS major—Partially supported.*

Given that national data show that CS majors are a fairly homogeneous group, made up of mostly White or Asian men (NSF & NCES, 2012), I had expected the undecided students enrolled in introductory CS courses to be more diverse than CS majors. The analyses exploring differences between undecided students and CS majors reveal that while there is a larger proportion of women among undecided students than among CS majors, there was a greater percentage of URM students among CS majors than among undecided students.

The findings from this study also revealed important differences between CS majors and undecided students in terms of their computing backgrounds. Prior research has found that CS majors tend to come to the major with previous computing experience (Beyer et al., 2004; Margolis et al., 2000), so it was not surprising that in this study, CS majors did have more computing experience than undecided students. As discussed in chapter four, prior programming experience was a key predictor of undecided students' choice of a computing major at the conclusion of their introductory CS course. As introductory CS course instructors design their courses, they must navigate the various levels of prior computing experience that exist among their students. If they are to recruit more undecided students to the major, seeking ways to support those undecided students with less programming experience may increase the likelihood that they will pursue computing.

Research question two. What are undecided students' perceptions of the climate in their introductory CS courses, particularly in terms of their experiences with the course instructor and their peers? Do their perceptions vary by gender? By race/ethnicity? Between undecided students and declared CS majors?

Hypothesis 2a.1. *Undecided students would have positive perceptions of the climate in their introductory CS course and would find their instructors and classmates to be supportive and accessible—Partially supported.*

Because all the students in this study attend institutions that are a part of the BRAID initiative and have made expressed commitments to create inclusive computing departments, I expected that most undecided students would have positive perceptions of the climate in their introductory CS course, particularly in terms of their interactions with instructors and classmates. While the majority of undecided students did report positive perceptions of their instructors, they were divided in their views on the accessibility of support from peers, with approximately equal proportions reporting positive and negative views. Given that the availability of peer support emerged as a key predictor of undecided students' plans to major in computing (see discussion of findings for research question three), the variation in undecided students' views of peer support is particularly important. I was unable to disaggregate students by institution because of the relatively small sample in this study; however, it is probable that some of the variation in students' experiences with their peers may be due to departmental and institutional differences.

Hypothesis 2a.2. *Students in majority groups, including men and White and Asian students, would have more positive perceptions of the climate than women or minority students—Not supported.*

Research has shown that women and students of color often face challenging climates in computer science courses and departments (e.g., Cech, 2014; Cohoon & Aspray, 2008; Margolis et al., 2008), so I expected that majority students (i.e., men and White and Asian students) would have more positive views of the climate in the introductory CS course. However, the analyses for this study revealed no differences between male and female students' views and only a few differences between majority and URM students' views on course climate measures. Though unexpected, these findings further support the unique nature of the undecided student population that enrolls in introductory CS courses. Additionally, all of the students in this study are enrolled at institutions that are participating in the BRAID initiative to increase the representation of women and URM students in computing fields. Therefore, it is possible that few differences were found between men and women and majority and URM students on climate measures because of the work BRAID institutions have done to make their introductory CS courses more inclusive.

Hypothesis 2a.3. *Students who have declared a CS major would view the climate in their introductory CS courses more favorably than undecided students—Supported.*

As I expected, CS majors had more positive views of their introductory CS course instructors and the availability of peer support. The differences in undecided students' and CS majors' views of peer support were particularly striking, as on all measures of peer support, there were significant differences between the groups at the extremes of the scales. That is, CS majors were more likely than undecided students to perceive high levels of peer support, whereas undecided students were more likely than CS majors to perceive low levels of peer support. Given the importance peer support seems to play in undecided students' plans to pursue a computing major (see discussion of findings for research question three), these differences are important to address in the context of introductory CS courses.

Research question three. To what extent is there a relationship between undecided students' experiences in introductory CS courses (e.g., teaching and evaluation practices, faculty attitudes toward students, and experiences with peers) and their intention to major in CS? What is the magnitude of the relationship? Does the relationship differ by the students' gender and race/ethnicity?

Hypothesis 3a.1. *There would be a positive relationship between undecided students' experiences in the CS course and their intent to major in CS, such that students who reported favorable experiences in the course will have a higher likelihood of reporting an intent to major in CS at the end of the course—Partially supported.*

Among the course experience items included in the logistic regression analysis, only faculty responsiveness (a negative predictor) and peer support (a positive predictor) emerged as significant in the final model, while other course experiences, notably measures related to pedagogical practices, were not significant. Previous research has found that student-centered teaching and learning practices are key to students' retention in computing fields (Radermacher & Walia, 2011; Settle, 2012; Werner et al., 2005), yet the findings from this study suggest that they are not significant predictors of undecided students' recruitment to the major. Instead, their relationships with computing peers seems to be key to their decision to pursue computing major. These findings, especially when taken in the context of the findings from the qualitative stream (discussed in the next section), suggest that CS introductory course instructors can play an important role in facilitating a positive learning community that promotes peer interactions and support.

Hypothesis 3a.2. *Students' course experience would be more important for women than for men and for URM students than majority students—Not supported.*

Because prior studies found that student-centered pedagogy and inclusive course environments were key for women's and URM students' success in computing (Cohoon, 2001; Hewlett et al., 2014; Varma, 2006), I expected to find that undecided students' course experiences would be more important for women's and URM students' plans to major in computing than they would be for men or White and Asian students. While the two-way interaction terms (course experiences*gender or course experiences*URM status) yielded no significant effects, I did find a significant interaction when I incorporated three-way interaction terms (course experiences*gender*URM status). Specifically, the importance of traditional pedagogy is different for URM women than it is for URM men as well as White and Asian men and women. Though this finding was different than what I initially expected, it supports the general hypotheses that course experiences play a different role for some students, in this case, women from underrepresented groups. As discussed in chapter two, women of color face many obstacles to their success, yet limited research exists on their unique experiences in computing. Hence, this finding highlights the importance of examining differences by gender *and* race.

Qualitative Stream

The qualitative stream of this study centered around two main research questions, focusing on why undecided students enroll in an introductory computing course and how they use their experiences in that course to inform their major choice. In framing the study, I did not put forth specific hypotheses associated with each qualitative question in order to limit the extent to which my own biases and preconceived ideas might influence data collection and analysis. Instead, I outlined assumptions that I brought to the study, drawn from my knowledge of prior research (see chapter three). The following section discusses the relevant findings from the qualitative data and the extent to which these findings aligned with my assumptions and fit within existing literature.

Research question four. Why do undecided students choose to take an introductory CS course?

Related assumptions. Coming into the study, I expected that the participants might report that they enrolled in an introductory CS course because of prior success in math and science and/or encouragement of a family member or teacher.

Prior academic experiences. The findings for research question four largely aligned with my assumptions. As discussed in chapter five, one of the key reasons that the participants in this study enrolled in an introductory CS course had to do with their high school experiences in STEM classes. A previous study on undecided students found that having a strong academic background from high school, particularly taking advanced mathematics coursework, is important to their pathway to choose a STEM degree in college (Green & Sanderson, 2014). Further, prior research has found that high-achieving students are more likely to pursue computing majors in college (Beyer et al., 2003; Cohoon and Aspray, 2008). Hence, it is not surprising that in this study, students' high school experiences with math and science courses led them to consider a STEM major in college and to take an introductory CS course as part of their major choice process.

Role of parents. Several participants mentioned that their parents encouraged them to continue to pursue STEM in college because of their previous success and because they were "smart." That is, there was a sense among several participants that their parents pushed them toward a field like computing because that is the kind of major a "smart kid" *should* pursue. As discussed above, prior research does suggest that academic success is a key factor in students' plans to pursue a computing degree, however this more qualitative characterization of students' intellectual abilities is interesting when one considers the literature regarding stereotypes about individuals in computing. Previous studies have found that stereotypes about computer scientists, particularly the idea that they are anti-social, hackers, and geeks, may deter some students, especially women, from pursuing a CS major (Beyer et al., 2004; Cheryan et al., 2013; Margolis & Fisher, 2002). The finding from the present study suggests that certain stereotypes about computer scientists, namely that one must be "smart" to succeed, may influence how some parents guide their children with respect to major choice. Given the limited sample for this study, it was not possible to tease out if the parents' advice might be gendered; however, it is possible that majority men might receive more encouragement to enroll in a computing course than women or students of color.

Research question five. How do undecided students make the decision to major or not major in CS?

Related assumptions. I expected that participants in the study would utilize their experiences in introductory courses, including their CS course, to inform their major decision-making process. I further anticipated that the pedagogy employed by the professors would play a role in students' interest in computing such that students who encountered more traditional methods (e.g., lectures) might find CS uninteresting and not pursue a computing major, whereas participants who had professors who utilized student-centered teaching approaches might find CS engaging and continue into the major. Finally, I anticipated that interview participants who felt that they "fit in" with the students in their introductory CS course would be more likely to choose a computing major.

Role of introductory courses in major choice process. Nearly all of the participants in this study described a decision-making process that involved taking a variety of courses across disciplines in a "trial and error" method. Hence, in this respect the findings closely aligned with my assumption. As discussed in chapter two, few studies have considered the role of introductory courses in *recruiting* students to a major instead of *retaining* students in a field. This finding supports the idea that even if introductory courses are not designed as recruitment tools, some undecided students are using their experiences in them to gather information about potential majors.

Role of pedagogy. Contrary to my assumptions, teaching practices did not seem to factor into participants' decision to pursue CS or another field. However, throughout the interviews, participants consistently cited the importance of programming assignments as a key source of encouragement or discouragement to their interest in CS. That is, several students pointed to experiences where they had worked very hard on a course assignment, and once the code successfully compiled, they would have a moment of joy and excitement at the prospect of continuing into a CS major. Other participants described scenarios where they unable to complete projects, despite significant time and effort, and these moments of failure made them question a major in CS. In the context of Carlone and Johnson's (2007) theory of science identity, one might identity this experience as being at the nexus of the three spheres of science identity (i.e., competence, performance, and recognition). That is, students who succeeded at course assignments felt affirmed in their computing identity by applying programming content knowledge to develop the code (competence and performance), and they received recognition for their success (albeit from a computer, not a human) when their code compiled. However, students who failed to complete course projects may have felt rejected in their computing identities across one or more of the three spheres, jeopardizing their ability to see themselves as a computer scientist and thereby dissuading them from choosing a computing major.

This finding suggests that introductory CS course instructors can play a key role in fostering their students' computing identities through the way that they design course assignments and offer support to help students succeed on them. There is a great deal of research on various introductory course practices that might support student success, such as the efficacy of pair programming (Radermacher & Walia, 2011; Werner et al., 2005). Further, prominent scholars in the field of computer science education have argued that course assignments are central to a student-centered classroom and advocate that CS faculty provide early and consistent feedback to students on their work and make assignments relevant to student interests and goals (Barker & Cohoon, 2009). While the previous research has linked assignments with student success, they have not connected assignments to students' science and/or computing identities. Therefore, this study contributes to the extant knowledge by suggesting a possible reason why assignments may be so crucial to student success—course assignments may be a key vehicle for establishing students' computing identities.

Sense of fit. I anticipated that the extent to which participants felt that they "fit in" with other students in their introductory CS course would be central to their major choice process. The findings from this study support this assumption, as social interactions with peers emerged as one of the most important themes in participants' major choice process. As discussed in chapter five, for at least two participants, a lack of social connection with other students in their introductory computing course was cited as the main reason they decided to pursue another major. One participant mentioned specifically how it felt that the other students in her course were "trying *not* to talk." Other participants in this study spoke more explicitly about the culture of computing and its importance to their decision to major in computing. Two students who chose not to go into a computing major talked about how there were particular ways of being in computing, such as "breathing algorithms," that did not align with their interests or abilities. On the other hand, some of the participants who went on to choose computing majors talked about developing a "computer science mindset" as a key to their success.

These students' experiences may hint at the larger culture of computing disciplines. Previous research has demonstrated that undergraduates in computing courses prefer to work alone and favor a focus on the outcome, rather than the process, of doing computing work (Waite et al., 2004). Further, Cech (2014) has written about a "culture of disengagement" in fields like engineering and computer science that encourages students to be narrowly focused on the technical problem at hand and ignore the wider, social implications of the work. Taken in the context of Holland's (1997) theory about making vocational choices, it seems likely that participants' experiences in the course, particularly those with their peers, communicated key information about the culture of computing and the expectations of computer scientists. Some participants successfully socialized into the field and adopted the "computer science mindset" while others felt isolated and sought a different environment in another major.

Interestingly, some of the participants spoke about the role their instructors played in fostering inclusive classrooms, such as by facilitating social connections among students in the class or by teaching students how to visualize the coding process in order to think like a computer scientist. Therefore, while peer relationships seemed to communicate certain norms about computing disciplines, sometimes emphasizing stereotypes about the field that might deter students from the major, some instructors mitigated those messages in the classroom by encouraging a sense of community among students or making explicit the process of learning to code. One of the key tenets of the BRAID initiative is fostering inclusive communities in CS. BRAID co-founder Maria Klawe has spoken about the important role instructors can play in creating supportive computing classrooms as well as mitigating negative classroom behaviors, such as when a few students with extensive prior programming experience dominant class discussions (Isaacson, 2014). The participants' experiences in this study provide evidence of the effectiveness of such efforts.

Convergence of Quantitative and Qualitative Findings

The overarching purpose of this study was to develop a better understanding of the role of introductory CS courses in recruiting undecided students, especially women and URM students, to computing majors. To try to capture a more complete picture of this topic, I chose a convergent, mixed-methods approach in which I collected, analyzed, and interpreted quantitative and qualitative data separately. As discussed in the previous two sections, findings from both the quantitative and qualitative streams provided insights into the characteristics and backgrounds of undecided students who enroll in an introductory CS course, their experiences in the course, and the role those experiences play in shaping their major choice. However, these findings become more powerful when the data from the quantitative and qualitative streams are brought together. Though there are many places of convergence between the two data streams, two overarching themes emerged from the mixed-methods findings that speak to the main purpose of the study (i.e., how to recruit undecided students, especially women and URM students, to computing majors). First, the results suggest that peer relationships are one of the most important factors in recruiting undecided students to a computing major. Second, the findings from both datasets suggest that undecided students' gender and racial/ethnic identities play a limited role in their recruitment to the major. The following sections will focus on these two themes in more detail, drawing from both data streams to allow for a more holistic discussion.

Importance of Peer Experiences

The importance of peer relationships emerged as a central theme in undecided students' experience in the introductory CS course and their major choice decision. From the descriptive quantitative analyses, key differences between undecided students' and CS majors' perceptions of peer support were found, such that undecided students had much lower ratings of the availability of peer support than their CS major peers. In the logistic regression analyses, peer support was the second strongest predictor of undecided students' decision to major in computing at the end of the introductory course. Many of the undecided students interviewed for this study discussed the importance of computing peers in their decision to enroll in an introductory CS course in the first place. With respect to their introductory course experience, several of the participants talked about feeling a lack of a social connection with classmates and cited the lack of peer connections as a key reason that they chose not to pursue a computing major. In short, peer connections are central to undecided students' experiences in their introductory CS course and play an important role in encouraging or dissuading undecided students to pursue a computing field.

As mentioned many times in this study, the literature on students' experiences in introductory CS courses has focused on the importance of teaching and learning practices, often suggesting that student-centered pedagogy promotes student success in CS (Barker et al., 2014; Cohoon, 2001; Settle, 2012). Further, some research has found that collaborative and peer learning techniques, such as pair programming (Radermacher & Walia, 2011; Werner et al., 2005) or peer instructors (Porter et al. 2013), promote student success. Certainly, as such teaching approaches may foster peer connections, the findings from this study support that body of research.

While collaborative and peer learning may be a good place to start, the interview participants who spoke about the importance of peers did not emphasize peer learning techniques (though those did come up) but rather the *social* connections (or lack thereof) with their peers. The quantitative measures used to capture peer support in this study also focus on social connections—they asked students about the extent to which they had peers in computing whom they could hang out with, confide in, get assignments from when they were sick, and get help with homework. Hence, it is probably not enough to incorporate group work assignments into the course syllabi to foster positive peer connections. In fact, doing so might result in negative peer experiences for undecided students, given that the findings from this study show a wide gap between how CS majors and undecided students perceive the availability of support. Further, one interview participant explained how her lack of prior programming experience made her feel intimidated by her computing peers and was part of the reason she felt isolated in her introductory course. Therefore, when undecided students are assigned to work in groups with CS majors without instructor guidance, they may end up feeling even more isolated. Instead, computing departments and CS instructors may need to think intentionally about creating classroom norms that promote positive interactions among students and encourage connections between students who are and are not CS majors. Fostering a classroom learning environment that prioritizes social connections between students requires a skilled facilitator, and many introductory CS course instructors may feel ill-prepared for such a role. Therefore, CS departments may want to consider offering training for instructors to help them develop facilitation techniques.

Role of Gender and Racial/Ethnic Identities

This study was predicated on the premise that recruiting undecided students may be a source for computing departments to recruit more women and URM students, as has been suggested by leading scholars and computing organizations (Cohoon, 2002; NCWIT, 2015). Therefore, a central component of all the analyses for this study was to understand the relationship between students' gender and race/ethnicity and their introductory CS course experiences and major choice. Across both the quantitative and qualitative streams, the findings revealed that students' gender and race/ethnicity often played a smaller role than one might expect based on prior research. This is not to say that the students' gender and racial/ethnic identities were not important, but rather that these identities did not factor directly into undecided students' major decision-making process. Looking at the findings from both datasets helps clarify how gender and race/ethnicity may be functioning for undecided students in their major choice process. The following sections synthesize key findings related to undecided students' gender and race/ethnicity across both streams before turning to a discussion of the larger meaning of these findings in the context of extant literature.

Undecided students as a pool of diverse students. The descriptive, quantitative analyses from this study revealed that undecided students enrolled in introductory computing courses are more diverse than CS majors in terms of gender but not in terms of URM status. As discussed previously, this finding suggests recruiting more undecided students to computing majors may help address a lack of gender diversity more than racial/ethnic diversity.

Differences in undecided students' computing backgrounds. The descriptive analyses found no differences between majority and URM students' prior computing coursework, their previous programming experience, or their self-rated computing abilities. However, there were significant differences between men and women on all of these measures, as men had significantly more computing experience and were more confident in their computing abilities than women.

Role of gender and race/ethnicity in undecided students' course experiences. The descriptive, quantitative analyses revealed few differences by gender or URM status in terms of students' perceptions of their introductory CS course climate. Further, the interview participants had little to say about how their gender and/or racial/ethnic identities shaped their course experiences, even as they acknowledged that White and Asian men made up the majority of their classmates in their introductory CS course. Finally, in the logistic regression analyses, interaction terms looking at gender*course experiences and URM status*course experiences were not significant, suggesting that the importance of undecided students' introductory CS course experiences was not different for students of different genders or racial/ethnic groups in terms of the likelihood that they would choose a computing major. However, one three-way interaction term found that the use of traditional pedagogy had a stronger, negative effect on URM women's plans to major in computing than it did for URM men or majority students of either gender.

Importance of gender and race/ethnicity in undecided students' major choice. As discussed in chapter four, crosstab analyses between students' gender and the dependent variable (i.e., choosing a computing major at the end of the intro CS course) and URM status and the dependent variable revealed that there were not significant differences between the proportions of men and women and White and Asian and URM students who went on to choose a computing major after taking an introductory CS course. Therefore, it seems that once undecided students were enrolled in the introductory class, all undecided students were equally likely to choose a computing major regardless of their gender and/or race/ethnicity. The logistic analysis further supported this conclusion, as neither gender nor URM status was a significant predictor that an undecided student would choose a computing major. Finally, when asked about how their gender and/or racial identities played into their major choice process, the interview participants in this study did not feel that their social identities played any role in their decision.

Gendered and racialized experiences in the introductory CS course. In the interviews with undecided students, the participants had little to say about the role of gender and/or race/ethnicity in their course experiences or in their major choice process. However, when pressed, several of the students described gendered or racialized experiences in the class. For example, for some, the gender of their course instructor was salient, whereas other participants described how students' social identities affected the dynamics of group work, as students with like identities tended to work together. Further, some of the participants who were women or students of color described stereotypes that they faced or expected to face in the future. Therefore, the interview participants acknowledged that issues of gender and race/ethnicity were present in their introductory course experiences, but they did not directly connect these issues to their own experience in the course or feel that they factored into their decision to major in computing or some other field.

Implications of findings related to gender and/or race. As summarized in the above sections, both the quantitative and qualitative analyses reveal many aspects of undecided students' backgrounds, experiences, and major decision that relate to gender and/or race/ethnicity, but these differences seem to operate tangentially to the students' experiences in the intro CS course and their major decision, rather than playing a more direct role. Prior literature has tended to find that students' gender and racial/ethnic identities are central to their interest and success in computing majors (e.g., Cohoon & Aspray, 2008; Margolis et al., 2008;

Sax et al., 2017), hence the findings from this study are somewhat surprising. There are many possible explanations as to why students' gender and race/ethnicity played a smaller role than expected in this study, but it seems likely that these findings are related to the particular sample utilized for this study, as discussed in more detail below.

One likely explanation is that the population of focus for this study—undecided students enrolled in introductory CS courses—is somewhat unique. Recent research on undecided college students is limited, as discussed in chapter two, so it is difficult to examine the extent to which the undecided students in this study (i.e., those who have decided to enroll in an introductory CS course) are representative of all undecided college students. However, it is possible that some characteristics of being undecided not captured in this study may be diminishing gender and racial/ethnic differences. For instance, earlier in this chapter, I advanced a hypothesis that perhaps undecided students tend to come from high schools with few elective course offerings. Their limited opportunity to explore different disciplinary fields in high school might be part of the reason that students feel uncertain about their major choice, and the lack of access to computer science coursework in high school might be minimizing some of the differences one would expect to see between White and Asian and URM students. More research on undecided students' characteristics and backgrounds would provide important context for this study as well as help inform computing departments' efforts to encourage more undecided students to try a computer science course.

The institutional sample used for this study may also affect the role of gender and race/ethnicity in the students' experiences. As mentioned previously, all of the participants for both the quantitative and qualitative streams of this study came from institutions involved in the BRAID initiative, which is designed to recruit and retain more women and students of color in undergraduate computing majors. So, as the departments redesign introductory CS courses to be more inclusive for underrepresented students and implement various other strategies to promote diversity within their computing majors, their efforts may be mitigating differences between students from different gender and racial/ethnic groups.

Implications

Throughout this chapter and in chapters four and five, I have mentioned some implications for practice that relate to specific research findings. In the following sections, I will summarize the overarching implications of this study specifically as they relate to theory, introductory CS instructors, and CS departments.

Theoretical Implications

As mentioned previously, this study employed Holland's (1997) Theory of Career Choice and Carlone and Johnsons (2007) theory of science identity. The findings from this study suggest a few implications for the application of these theories.

I relied heavily on Holland's work in framing the quantitative aspects of this study, particularly with respect to the selection and blocking of variables for the logistic regression analysis (see chapter three for a full discussion). In general, following Holland's guidance led to a model that was fairly successful at classifying undecided students' major choice into computing and non-computing, as the final model accurately predicted over 70% of the cases. However, as discussed in chapter four, none of the Holland personality measures entered the model as significant. This may be due to the limited items available to capture some of the Holland personality types, so future studies may be able to clarify the role of undecided students' personality in choosing a major with better representations of Holland types.

I drew upon Carlone and Johnson's work on science identity both to develop a measure of science identity for the logistic regression model and as a lens to interpret the interview participants' experiences in their introductory course. The findings from both data streams support the importance of science identity in undecided students' interest in computing. In interpreting the results, particularly the role that students' success on programming assignments might play in shaping their science identity, I began to wonder how science identity may vary across STEM sub-fields. At least one study has attempted to measure science identity and computing identity separately and found that the two measures were not strongly correlated, particularly for women, such that women with high science identities often had low computer science identities (Dempsey et al., 2015). Dempsey and colleagues' work, along with the findings from this study, suggest that there may be an opportunity to extend Carlone and Johnson's work by exploring how the formation of college students' science identities may differ between computer science and other STEM fields.

Implications for Introductory CS Instructors

The findings from this study show that while the specific pedagogical approaches employed in introductory CS courses may not play a large role in the recruitment of undecided students to computing majors, their experiences in the introductory CS course are key to their decision. Hence, CS introductory course instructors can play a vital role in undecided students' decision-making process, particularly by creating classrooms inclusive of undecided students, facilitating positive peer connections, and promoting students' computing identities.

One of the key but perhaps obvious findings from this study is that the undecided students who enroll in introductory CS classes are *different* from those students enrolled in the class who have already chosen a computing major. From the stories of the nine interview participants in this study, we learned that being an undecided student can be messy. As undecided students, they may be facing bureaucratic obstacles that makes it more challenging for them to enroll in courses. They may be interested in a computing major but shy away from getting involved in computing clubs or organizations since they are not officially in the major. They likely come to the introductory CS course with less prior computing experience and less confidence about their abilities than their peers who have already declared a computing major. Undecided students who enroll in introductory CS courses are likely there because they want to try out computing and see if it may be a good fit for them, but as undecided students, they have different needs than CS majors. Instructors have the opportunity to create a classroom that is welcoming to these students and can help recruit them to the major. For example, when the instructors address the class, they might be careful not to assume that everyone in the class is a computing major; some are undecided and some are pursuing other fields. Further, when there is an exciting or relevant computing event, instructors might make an in-class announcement, encouraging all students to go, since undecided students may not be on departmental e-mail distribution lists. When developing the course, instructors should take into consideration the varying levels of prior programming experience students bring to the course and ensure that all the assignments are accessible to students with no prior experience. These small actions can send the message to undecided students that they are welcome in the class and, by extension, the major itself.

In addition to developing a welcoming classroom environment, instructors can play an important role in fostering a supportive classroom community. As discussed at length in the previous section, peer support is essential to undecided students' decision to choose a computing major. While introductory CS instructors may not immediately see peer connections as falling under their purview, the interview participants in this study talked about how effective instructors could create classroom communities that fostered supportive peer relationships. As mentioned above, CS instructors might think about ways to facilitate positive peer connections, including the use of collaborative teaching approaches (e.g., group work, peer instructor, etc.), but also by developing classroom norms to promote positive interactions among students (e.g., ensuring that a few students with extensive prior programming experience do not dominate class discussions).

Finally, instructors can play a role in affirming undecided students' computing identities. Results from both the quantitative and qualitative streams indicate developing a computing identity (i.e., the extent to which students see themselves as computer scientists) is important to undecided students' interest in a computing major. Though fostering students' identity development may go beyond the traditional role of an introductory course instructor, there may be opportunities to support students' computing identities in the course. For instance, succeeding on programming assignments may be one way in which students' computing identities can be affirmed. Rather than assigning students one large project, instructors might try scaffolding the project so that students have a series of smaller checkpoints to receive feedback. Relatedly, one interview participant spoke about the “computer science mindset” and described how one of his professors helped him learn how to think like a computer scientist by emphasizing visual pictures of each step in the coding process. As shown through this participants’ example, when instructors make the culture of computing explicit, they may also make a computer science identity more accessible to students.

Implications for CS Departments

As CS departments work to recruit more and diverse students to computing majors, department chairs may have limited control over the admissions of new students to the major (Sax et al., 2015). Therefore, undecided students, particularly those who express interest in computing by enrolling in an introductory CS course, may be a pool of students from which to recruit. The findings from this study show that more than 40% of undecided students who enroll in an introductory CS course go on to choose a computing major by the end of the course. Further, the results show that these students, regardless of gender or URM status, choose a computing major at similar rates. Therefore, there is a significant opportunity to recruit undecided students to the major. Additionally, the findings show that approximately 38% of undecided students enrolled in introductory CS courses are women, whereas only 24% of CS majors in intro classes are women, so undecided students may be a particularly good pool from which to recruit more women to the field.

The findings from this study suggest a number of implications to support CS departments' efforts to recruit undecided students to computing majors. First, just as CS instructors must remember the unique needs of undecided students, so must the computing department. For example, to the extent possible, CS departments should try to remove course enrollment barriers to make accessing computing courses easier for undecided students. Additionally, making departmental events and departmental-sponsored student clubs and organizations open to undecided students might give these students an opportunity to explore computing beyond their introductory course, as well as help them meet and make friends with other computing students. Additionally, CS departments can promote positive introductory CS course experiences for students. For example, offering different sections of the introductory course for students of various programming backgrounds may be helpful for undecided students who are less likely to have prior computing experience compared to CS majors. Further, CS departments can support the introductory course instructors, such as by offering training to improve their facilitation skills so that the instructors feel confident in the abilities to develop supportive, inclusive classrooms.

Limitations of the Study

This study contributes knowledge about the experiences of undecided students in introductory CS courses, but like all research, this study has several important limitations. First, as discussed in chapter two, defining what it means to be an undecided student is challenging. This study followed the advice of recent research on undecided students and accounted for students who (a) may technically have a major but still feel significant indecision about their major choice and (b) those who have not yet declared a major but have already made a major choice. However, the variables used to define a student's degree of decision about a major were based upon their response to the relevant questions at one moment in time (the pre-test survey). Therefore, the undecided data set that was used for quantitative analysis (as well as to identify interview participants) may include some students who decided on a major and may have excluded some students who became less confident about their major choice shortly after taking the pre-test. Further, this study was focused on undecided students who had already made the choice to enroll in an introductory course. Therefore, this study cannot speak to the experiences of undecided students more generally. It may be that various characteristics of undecided students, such as their gender and/or race, play a large role in whether they initially sign-up for an introductory CS course, but the data available for this study only captured participants who had already made that choice

Additionally, this study aims to understand the factors that contribute to an undecided student choosing a CS major. The dependent variable (intent to major in CS) was drawn from the end-of-term survey, which students take during the last few weeks of their introductory CS course. Again, this measure captures students' intentions about majoring in CS at one point in time. This quantitative component of this study cannot account for students who may not have decided on a CS major by the end of the course but ultimately go on to declare a computing major or students who plan to major in CS at the end of the course but do not go on to complete a CS degree. The qualitative component included follow-ups with participants through the academic term after the completion of the course, but even in this case, it is impossible to know if students continued on to complete a CS degree.

The quantitative stream of this study is limited to the variables available on the 2015-2016 and 2016-2017 administrations of the BRAID introductory course start-of-term and end-of-term surveys. These instruments include a broad set of measures, but no survey could capture all of the experiences relevant to students in computing. In particular, the availability of variables related to students' personality, as defined in Holland's (1997) taxonomy, was limited, especially for the artistic personality. As mentioned in chapter four, none of the Holland personality types emerged as significant predictors of undecided students' plans to major in computing. This may be due, in part, to the limited items available to measure students' personalities. Further, this study is particularly interested in the impact of introductory CS courses on undecided students' major decision. Hence, the variables for this study primarily focus on introductory course experiences, although a number of other variables were included to account for the role of students' pre-course, departmental, and out-of-class experiences. However, there may be factors not measured by the instruments that influenced students' major decisions, particularly those that happen outside the students' educational contexts (e.g., experiences with family). To help account for this shortcoming, the qualitative interview protocol specifically asked students to discuss people and experiences across a variety of contexts that are important to their major choice.

The samples for both the qualitative and quantitative streams put some restrictions on analytical approaches. The population of interest (i.e., undecided students enrolled in introductory CS courses) was very specific; therefore, this study prioritized developing a deep understanding of the specific phenomenon of being an undecided student enrolled in an introductory CS course. Hence, relatively small sample sizes were available for both data streams and impacted some analytical approaches. In the quantitative stream, the limited sample of undecided students from certain racial/ethnic groups precluded the possibility of breaking students out by specific racial/ethnic groups for either descriptive or inferential analyses. Because I wanted to account for variations in students' experiences based on their racial identities, I chose to aggregate students into a majority group (i.e., White and Asian students) and a URM group (i.e., students who identified as Black, Hispanic, Native American, Native Hawaiian, Arab, or Two or more races on the survey). However, had I been able to further disaggregate different races/ethnicities, I may have found additional differences in undecided students' experiences in introductory CS courses. Further, the small and unique nature of the sample may have influenced the findings. For example, the sample may be part of the reason why few differences were found between URM and majority students and why variables related to pedagogy did not emerge as significant in the regression model. In both the quantitative and qualitative streams, the small populations of students from some of the BRAID institutions made it impossible to examine institutional differences. Finally, it is important to note that demographic data was not available for students who did not respond to the BRAID introductory course surveys, so it is impossible to know the extent to which the quantitative sample used for this study is representative of the larger population of students taking introductory courses at BRAID institutions. Because I anticipated that there would by several limitations in studying the small but important population of undecided students, I chose to employ a mixed-methods approach to provide a more holist understanding of their experiences in computing. While mixed-method data does not eliminate the aforementioned limitations, the convergence of findings across both data streams lends support to their reliability and trustworthiness.

Future Research

The findings from this study, as well as some of this study's limitations, imply many suggestions for future research. In the following sections, I will suggest areas of continued study, particularly as they pertain to knowledge about undecided students and the role of gender and race/ethnicity in students' computing experiences.

Undecided Student Experience

The recent research on undecided students' college experiences is limited, so in general, more research on undecided students would be beneficial, particularly for computing departments as they seek new pools from which to recruit diverse students. For example, this study did not capture the role of institutional environments in undecided students' major selection process. Yet institutional contexts (e.g., the proportion of students at an institution who are undecided about their major, the resources available to support undecided students in their decision-making process, etc.) likely impact undecided students' experiences, so future research should examine how undecided students' institutions impact their major choice process.

This study suggests that undecided students are taking introductory courses as a way to make a major decision, but research on the role of introductory courses (across all fields, not just in CS) in students' major choice is minimal. Given that at least 10% of incoming first-year students are undecided about their major choice (Eagan et al., 2015), it follows that most introductory courses have a sizeable population of students who are there to explore a major field. Therefore, future research should continue to investigate undecided students' decision-making process and the role of introductory courses so that instructors may be more informed about the unique needs of these students.

Additionally, this study examined the role of undecided students' introductory course experiences in their major choice, but it could not fully account for the reasons students enrolled in the course. Therefore, future research should investigate the reasons that undecided students might sign-up for an introductory CS course to better understand this population and provide insight into how computing departments might recruit undecided students to take computing courses in the first place. Similarly, the timeframe was limited to the term in which students took the introductory course, so future research should follow undecided students across a longer time period to clarify undecided students' pathways into various degrees and careers.

Role of Gender and Race/Ethnicity

As discussed at length above, undecided students' gender and race/ethnicity did not play a direct role in their major choice process in this study. However, several findings suggest that there are key differences between students from different gender and/or racial/ethnic backgrounds. For instance, this study found a clear divide between men's and women's confidence in their computing abilities, as has been found in several other studies. As this confidence gap has been persistent, future research should continue to document the computing confidence gap between men and women and specifically investigate why the gap does not appear to be closing and what efforts might be most effective at addressing it. Additionally, this study found that traditional pedagogy was more important to URM women's decision to pursue a computing major than it was for URM men or majority students of either gender. As mentioned previously, this finding underscores the importance of examining differences in students' experiences by gender *and* race. Future research should continue to examine how the impact of experiences in computing may differ across students from various gender and racial/ethnic backgrounds and pay particular attention to the experiences of women of color. In doing so, future research would ideally have samples large enough to disaggregate racial/ethnic groups more than could be done in this study.

Conclusion

Computer science departments face increasing pressure to respond to public outcry over the lack of diversity in the computing field, yet CS department chairs may have limited control over the admissions process that selects the students who enter college as computing majors. Hence, as CS department chairs seek opportunities to increase the representation of women and underrepresented minority students to their majors, they may turn to undecided students, particularly those who are already enrolled in their introductory courses, as a pool of students from which to recruit. There is limited research on the pathways for undecided students to choose a STEM or computing major or the impact their experiences in an introductory course might have on their major choice. This study provides information about the background characteristics of undecided students enrolled in introductory courses, their perceptions of the introductory course, and the aspects of the course that influence their college major choice. The findings suggest that many undecided students will go onto to choose a computing major and that their experiences in the course, especially the extent to which they feel peer support is available, play a role in whether or not they will decide to major in computing.

Certainly, not all undecided students who enroll in an introductory CS course should go on to pursue a computing major. Some undecided students who take introductory computing courses and choose not to pursue computing may leave because they find that computing is not a good fit for their talents or interests. However, others may choose another major—despite the fact that they were interested in computing—perhaps after a negative introductory course experience. The findings from this study suggest that by creating environments that support the unique needs of undecided students and developing inclusive introductory CS courses, CS departments and instructors can increase the number of undecided students who ultimately decide to pursue a computing major

Appendices

Appendix A: Survey Instruments

A1. 2015-2016 BRAID Introductory Course Pre-test
A2. 2015-2016 BRAID Introductory Course Post-test

A1. 2015-2016 BIC Pre-Test

By checking this box, I agree that the UCLA BRAID Research team may contact my institution and access my school records (specifically, my student ID number, course number and section number for introductory CS course(s) in which I am enrolled, course grade(s), major(s), minor(s), and class standing.) I understand these records will be accessed for research purposes only.

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.
- ❑ It fulfilled another requirement.
- ❑ 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.

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

What is your major? (Note: This list is used for ALL questions asking participants to choose a major or minor.)

- 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
- Electrical or Electronic Engineering
- Industrial Engineering
- Mechanical Engineering
- Other Engineering
- Other Computing ____________________
- 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
- Biology (general)
- Biochemistry or Biophysics
- Botany
- Environmental Science
- Marine (Life) Science
- Microbiology or Bacteriology
- Zoology

- Other Biological Science
- Accounting
- Business Admin. (general)
- Finance
- International Business
- Marketing
- Management
- Secretarial Studies
- Other Business
- Business Education
- Elementary Education
- Music or Art Education
- Physical Education or Recreation
- Secondary Education
- Special Education
- Other Education
- Astronomy
- Atmospheric Science (incl. Meteorology)
- Chemistry
- Earth Science
- Marine Science (incl. Oceanography)
- Mathematics
- Physics
- Statistics
- Other Physical Science
- 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
- Anthropology
- Economics

- Ethnic Studies
- Geography
- Political Science (gov't. international relations)
- Psychology
- Social Work
- Sociology
- Women's Studies
- Other Social Science
- Agriculture
- Communications
- Forestry
- Kinesiology
- Law Enforcement
- Military Science
- Other ____________________

Answer If What is your major? Other Computing Is Selected

Please specify your other computing major below.

Answer If What is your major? Other Is Selected

Please specify your other major below.

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

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

Select one of your majors from the list below.

Answer If Select one of your majors from the list below. Other Computing Is Selected

Please specify your other computing major below.

Answer If Select one of your majors from the list below. Other Is Selected

Please specify your other major below.

Answer If Which of the following applies to you: I have more than 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 major.

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

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

Select your second major from the list below.

Answer If Select your second major from the list below. Other Computing Is Selected

Please specify your other computing major below.

Answer If Select your second major from the list below. Other Is Selected

Please specify your other major below.

Answer If Which of the following applies to you: I have more than 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 second major.

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

Answer If Which of the following applies to you: I have not decided on a major. Is Selected

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

Answer If You indicated that your major is undecided. If you had to choose a major today, what would it be? <o:p></o:p> Other Computing Is Selected

Please specify your other computing major below.

Answer If You indicated that your major is undecided. If you had to choose a major today, what would it be? <o:p></o:p> Other Is Selected

Please specify your other major below.

Answer If Which of the following applies to you: I have not decided on a major Is Selected

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

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

What is your minor?

Answer If What is your minor? Other Computing Is Selected

Please specify your other computing minor below.

Answer If What is your minor? Other Is Selected

Please specify your other minor below.

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

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

Answer If Which of the following applies to you: I have more than one minor Is Selected

Please select one of your minors from the list below.

Answer If Please select one of your minors from the list below. Other Computing Is Selected

Please specify your other computing minor below.

Answer If Please select one of your minors from the list below. Other Is Selected

Please specify your other minor below.

Answer If Which of the following applies to you: I have more than one minor Is Selected

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 minor.

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neither Agree nor Disagree
- ❍ Agree
- ❍ Strongly Agree

Answer If Which of the following applies to you: I have more than one minor Is Selected

Please select your second minor from the list below.

Answer If Please select your second minor from the list below. Other Computing Is Selected

Please specify your other computing minor below.

Answer If Please select your second minor from the list below. Other Is Selected

Please specify your other minor below.

Answer If Which of the following applies to you: I have more than one minor Is Selected

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 second minor.

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neither Agree nor Disagree
- ❍ Agree
- ❍ Strongly Agree

Please rate your agreement with the following.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	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? Please select one.

❍ 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
❑ 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 Uninterested	Somewhat Uninterested	Neither Uninterested 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	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 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 disagree or agree 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.	❍	❍	❍	❍	❍

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

	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat 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 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)	❍	❍	❍	❍	❍

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 related to computing	❍	❍
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])	❍	❍

During the past year, were you involved 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	❍	❍
CRA-W Virtual Townhall Meetings	❍	❍
Computing 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 high school (e.g., Java, Python, HTML, etc.).
- ❑ I took a computer programming course at computer camp.
- ❑ I took a computer programming course online.
- ❑ I took a computer programming course at this college.
- ❑ I took a computer programming course at another four-year college.
- ❑ I took a computer programming course at community college.
- ❑ 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.

Just a few more questions... You are nearly finished!

Please indicate your gender.

- ❍ Female
- ❍ Male
- ❍ 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, Napalese, Sri Lankan)
- ❑ Other Asian
- ❑ White/Caucasian
- ❑ Native Hawaiian/Pacific Islander
- ❑ Mexican American/Chicano
- ❑ Puerto Rican
- ❑ Other Latino
- ❑ Other; please specify: ____________________

What was your average grade in high school?
- ❍ A or A+
- ❍ A-
- ❍ B+
- ❍ B
- ❍ B-
- ❍ C+
- ❍ C
- ❍ C-
- ❍ D

Answer If What is your current class standing? First year Is Not Selected

What is your college GPA?

Please indicate on a 4.0 scale.

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

What was your total ACT score (1-36)

What was your mathematics score on the ACT (1-36)

What was your reading score on the ACT (1-36)

Did you take the SAT?

- ❍ Yes, I took it between 2005 and 2015?
- ❍ Yes, I took it prior to 2005.
- ❍ No, I did not take the SAT.

Answer If Did you take the SAT? Yes, I took it prior to 2005. Is Selected

Please provide us with your scores for the following tests.

What was your total SAT score (400-1600)

What was your mathematics score on the SAT (200-800)

What was your reading score on the SAT (200-800)

Answer If Did you take the SAT? Yes, I took it between 2005 and 2015? Is Selected

Please provide us with your scores for the following tests.

What was your total SAT score (600-2400)

What was your mathematics score on the SAT (200-800)

What was your reading score on the SAT (200-800)

In what year were you born?

- ❍ 2005 or later
- ❍ 2004
- ❍ 2003
- ❍ 2002
- ❍ 2001
- ❍ 2000
- ❍ 1999
- ❍ 1998
- ❍ 1997
- ❍ 1996
- ❍ 1995
- ❍ 1994
- ❍ 1993
- ❍ 1992
- ❍ 1991
- ❍ 1990
- ❍ 1989

- ❍ 1988
- ❍ 1987
- ❍ 1986
- ❍ 1985
- ❍ 1984
- ❍ 1983
- ❍ 1982
- ❍ 1981
- ❍ 1980
- ❍ 1979
- ❍ 1978
- ❍ 1977
- ❍ 1976
- ❍ 1975
- ❍ 1974
- ❍ 1973
- ❍ 1972
- ❍ 1971
- ❍ 1970
- ❍ 1969
- ❍ 1968
- ❍ 1967
- ❍ 1966
- ❍ 1965
- ❍ 1964
- ❍ 1963
- ❍ 1962
- ❍ 1961
- ❍ 1960 or earlier

What is your citizenship status? Please select one.

- ❍ 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? Please select one.

- ❍ Poor

- Below average
- Average
- Above average
- Wealthy

Growing up, what was your family's income bracket? Please select one.

- 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?

- 0
- 1
- 2
- 3
- 4 or more

Answer If How many people do you consider to be your parent or guardian? 1 Is Selected Or How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

We would like to know more about the education of each of your parents or guardians. Please provide this information for each of them.

Answer If How many people do you consider to be your parent or guardian? 1 Is Selected Or How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

What is the highest level of education attained by one of your parents/guardians? You will have an opportunity to respond for each of your parents individually.

- 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: ____________________

Answer If How many people do you consider to be your parent or guardian? 1 Is Selected Or How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

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)
- Other or not employed

Answer If How many people do you consider to be your parent or guardian? 1 Is Selected Or How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

Please indicate the gender of this parent or guardian.

- Male
- Female
- Non-binary category or something else; please specify: ____________________

Answer If How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

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: ____________________

Answer If How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

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)
- ❍ Other or not employed

Answer If How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

Please indicate the gender of this parent or guardian.

- ❍ Male
- ❍ Female
- ❍ Non-binary category or something else; please specify: ____________________

Answer If How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 Is Selected

What is the highest level of education attained by your third 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: ____________________

Answer If How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 Is Selected

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)
- Other or not employed

Answer If How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

Please indicate the gender of this parent or guardian.

- Male
- Female
- Non-binary category or something else; please specify: ____________________

Answer If How many people do you consider to be your parent or guardian? 4 Is Selected

What is the highest level of education attained by your fourth 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: ____________________

Answer If How many people do you consider to be your parent or guardian? 4 Is Selected

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)
- Other or not employed

Answer If How many people do you consider to be your parent or guardian? 4 Is Selected

Please indicate the gender of this parent or guardian.

- Male
- Female
- Non-binary category or something else; please specify: ____________________

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. Email:

A2. 2015-2016 BIC Post-test

Answer If Consent Is Not Equal to 1

By checking this box, I agree that the UCLA BRAID Research team may contact my institution and access my school records (specifically, my student ID number, course number and section number for introductory CS course(s) in which I am enrolled, course grade(s), major(s), minor(s), and class standing.) I understand these records will be accessed for research purposes only.

- ❑ I agree

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: ____________________

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

- ❍ 2015
- ❍ 2016
- ❍ 2017
- ❍ 2018
- ❍ 2019
- ❍ 2020
- ❍ 2021
- ❍ Later than 2021; please specify: ____________________

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? (Note: This list is used for ALL questions requiring studies to identify a major or minor)

- Computer Science
- Computer Information Systems/Informatics
- Bioinformatics
- Computing and business (including Business Information Management and Management Information Systems)
- Information Technology
- Computer Engineering (including Computer Engineering and Software Engineering)
- Other Computing
- Aeronautical or Astronautical Engineering
- Civil Engineering
- Chemical Engineering
- Electrical or Electronic Engineering
- Industrial Engineering
- Mechanical Engineering
- Other Engineering
- Biology (general)
- Biochemistry or Biophysics
- Botany
- Environmental Science
- Marine (Life) Science
- Microbiology or Bacteriology
- Zoology
- Other Biological Science
- 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
- Accounting
- Business Admin. (general)
- Finance
- International Business
- Marketing
- Management
- Secretarial Studies
- Other Business
- Astronomy
- Atmospheric Science (including Meteorology)
- Chemistry
- Earth Science
- Marine Science (including Oceanography)
- Mathematics
- Physics
- Statistics
- Other Physical Science
- Architecture or Urban Planning
- Home Economics
- Health Technology (including medical, dental, laboratory)
- Law
- Library/Archival Science
- Medicine, Dentistry, Veterinarian
- Nursing
- Pharmacy
- Social Work
- Therapy (including occupational, physical, speech)
- Other Professional Degree
- Anthropology
- Economics
- Ethnic Studies
- Geography
- Political Science (including govt. international relations)

- Psychology
- Sociology
- Women's Studies
- Other Social Science
- Agriculture
- Communications
- Forestry
- Kinesiology
- Law Enforcement
- Military Science
- Other

Answer If What is your major? Other Is Selected Or What is your major? Other Engineering Is Selected Or What is your major? Other Computing Is Selected Or What is your major? Other Biological Science Is Selected Or What is your major? Other Arts and Humanities Is Selected Or What is your major? Other Business Is Selected Or What is your major? Other Physical Science Is Selected Or What is your major? Other Professional Is Selected Or What is your major? Other Social Science Is Selected

Please specify your major in the space below.

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 your major:I am very committed to my major.

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

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

Which of the following is true:

- I have not started taking courses in my major yet
- I am currently enrolled in courses for my major
- I have completed coursework for my major

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

Select one of your majors from the list below.

Answer If Select one of your majors from the list below. Other Is Selected Or Select one of your majors from the list below. Chemical Engineering Is Selected Or Select one of your majors from the list below. Other Computing Is Selected Or Select one of your majors from the list below. Other Biological Science Is Selected Or Select one of your majors from the list below. Other

Arts and Humanities Is Selected Or Select one of your majors from the list below. Other Business Is Selected Or Select one of your majors from the list below. Other Physical Science Is Selected Or Select one of your majors from the list below. Other Professional Is Selected Or Select one of your majors from the list below. Other Social Science Is Selected

Please specify your major in the space below.

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

Indicate how much you disagree or agree with the following statement about your first major:I am very committed to my major.

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

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

Which of the following is true about your first major:

- I have not started taking courses in my major yet
- I am currently enrolled in courses for my major
- I have completed coursework for my major

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

Select your second major from the list below.

Answer If Select your second major from the list below. Other Is Selected Or Select your second major from the list below. Other Social Science Is Selected Or Select your second major from the list below. Other Professional Is Selected Or Select your second major from the list below. Other Physical Science Is Selected Or Select your second major from the list below. Other Business Is Selected Or Select your second major from the list below. Other Arts and Humanities Is Selected Or Select your second major from the list below. Other Biological Science Is Selected Or Select your second major from the list below. Other Computing Is Selected Or Select your second major from the list below. Other Engineering Is Selected

Please specify your second major in the space below.

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

Indicate how much you disagree or agree with the following statement about your second major:I am very committed to my second major.

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

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

Which of the following is true about your second major:

- I have not started taking courses in my major yet
- I am currently enrolled in courses for my major
- I have completed coursework for my major

Answer If Which of the following applies to you: I have not decided on a major Is Selected

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

Answer If You indicated that your major is undecided. If you had to choose a major today, what would it be? Other Is Selected Or You indicated that your major is undecided. If you had to choose a major today, what would it be? Other Engineering Is Selected Or You indicated that your major is undecided. If you had to choose a major today, what would it be? Other Computing Is Selected Or You indicated that your major is undecided. If you had to choose a major today, what would it be? Other Biological Science Is Selected Or You indicated that your major is undecided. If you had to choose a major today, what would it be? Other Arts and Humanities Is Selected Or You indicated that your major is undecided. If you had to choose a major today, what would it be? Other Business Is Selected Or You indicated that your major is undecided. If you had to choose a major today, what would it be? Other Physical Science Is Selected Or You indicated that your major is undecided. If you had to choose a major today, what would it be? Other Professional Is Selected Or You indicated that your major is undecided. If you had to choose a major today, what would it be? Other Social Science Is Selected

Please specify your major choice in the space below.

Answer If Which of the following applies to you: I have not decided on a major Is Selected

Mark how much you agree or disagree with the following statement: I am confident that this will be my major.

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

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

What is your minor?

Answer If What is your minor? Other Is Selected Or What is your minor? Other Social Science Is Selected Or What is your minor? Other Professional Is Selected Or What is your minor? Other Physical Science Is Selected Or What is your minor? Other Business Is Selected Or What is your minor? Other Arts and Humanities Is Selected Or What is your minor? Other Biological Science

Is Selected Or What is your minor? Other Computing Is Selected Or What is your minor? Other Engineering Is Selected

Please specify your minor in the space below.

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

Indicate how much you disagree or agree with the following statement about your minor:I am very committed to my minor.

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

Answer If Which of the following applies to you: I have more than one minor Is Selected

Select one of your minors from the list below.

Answer If Select one of your minors from the list below. Other Is Selected Or Select one of your minors from the list below. Other Social Science Is Selected Or Select one of your minors from the list below. Other Professional Is Selected Or Select one of your minors from the list below. Other Physical Science Is Selected Or Select one of your minors from the list below. Other Business Is Selected Or Select one of your minors from the list below. Other Arts and Humanities Is Selected Or Select one of your minors from the list below. Other Biological Science Is Selected Or Select one of your minors from the list below. Other Computing Is Selected Or Select one of your minors from the list below. Civil Engineering Is Selected

Please specify your minor in the space below.

Answer If Which of the following applies to you: I have more than one minor Is Selected

Mark how much you disagree or agree with the following statement about your first minor:I am very committed to my minor.

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

Answer If Which of the following applies to you: I have more than one minor Is Selected

Select your second minor from the list below.

Answer If Select your second minor from the list below. Other Is Selected Or Select your second minor from the list below. Other Social Science Is Selected Or Select your second minor from the list below. Other Professional Is Selected Or Select your second minor from the list below. Other Physical Science Is Selected Or Select your second minor from the list below. Other Business Is Selected Or Select your second minor from the list below. Other Arts and

Humanities Is Selected Or Select your second minor from the list below. Other Biological Science Is Selected Or Select your second minor from the list below. Other Computing Is Selected Or Select your second minor from the list below. Other Engineering Is Selected

Please specify your second minor in the space below.

Answer If Which of the following applies to you: I have more than one minor Is Selected

Mark how much you disagree or agree with the following statement about your second minor:I am very committed to my second minor.

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

Answer If What is your major? Computer Science Is Not Selected And What is your major? Computer Information Systems/Informatics Is Not Selected And What is your major? Bioinformatics Is Not Selected And What is your major? Computing and business (including Business Information Management and Management Information Systems) Is Not Selected And What is your major? Information Technology Is Not Selected And What is your major? Computer Engineering (including Computer Engineering and Software Engineering) Is Not Selected And What is your major? Other Computing Is Not 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	❍	❍	❍	❍	❍

Answer If CurrentCSMajor Is Equal to 1

Over the past year, have you seriously considered changing to a non-computing major?

- ❍ Yes
- ❍ No

Answer If Over the past year, have you seriously considered changing to a non-computing major? Yes Is Selected

Why did you consider leaving computing?

Answer If Over the past year, have you seriously considered changing to a non-computing major? Yes Is Selected

What helped you continue in your program when you were contemplating leaving?

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 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

How interested are you in having the types of jobs listed below after you finish your highest degree?

	Very uninterested	Somewhat uninterested	Neither uninterested nor interested	Somewhat interested	Very interested
College/University professor in computing field	❍	❍	❍	❍	❍
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.
In your opinion, to what extent would a career in computing allow you to do the following....

	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 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 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	❍	❍	❍	❍	❍

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	❍	❍	❍	❍	❍
Competativeness	❍	❍	❍	❍	❍
Computer skills	❍	❍	❍	❍	❍
Cooperativeness	❍	❍	❍	❍	❍
Creativity	❍	❍	❍	❍	❍
Drive to achieve	❍	❍	❍	❍	❍
Emotional health	❍	❍	❍	❍	❍
Leadership ability	❍	❍	❍	❍	❍
Mathematical ability	❍	❍	❍	❍	❍
Physical health	❍	❍	❍	❍	❍
Public speaking ability	❍	❍	❍	❍	❍

Self-confidence (intellectual)	❍	❍	❍	❍	❍
Self-confidence (social)	❍	❍	❍	❍	❍

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 current institution?

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I would recommend taking computing courses at my institution to a friend	❍	❍	❍	❍	❍
Overall, I am satisfied with the computing program at my institution	❍	❍	❍	❍	❍
I am glad that I chose to study computing	❍	❍	❍	❍	❍

How do you feel about the environment of the department of your 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	❍	❍	❍	❍	❍

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.

- ❑ A professor within my department
- ❑ A professor at my college/university who is outside of my department
- ❑ An individual I met through a formal mentoring program sponsored by an outside organization
- ❑ No one
- ❑ Someone else; please specify ____________________

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 other computing students if you need it?

	Not at all	A little	Somewhat	Quite a bit	Very much

Someone to hang out with	❍	❍	❍	❍	❍
Someone to confide in or talk to about your problems	❍	❍	❍	❍	❍
Someone to get class assignments for you if you were sick	❍	❍	❍	❍	❍
Someone 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	❍	❍	❍	❍	❍	❍

Within your computing department and/or classes, how often do 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 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	❍	❍	❍	❍	❍

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])	❍	❍	❍	❍	❍	❍	❍	❍
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.)	❍	❍	❍	❍	❍	❍	❍	❍

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

	Yes	No
Visiting lectures related to computing	❑	❑
Computing-related student groups	❑	❑
Computing-related contests (hacking, robotics competitions, etc.)	❑	❑
Computing-related online social networking (listservs, etc.)	❑	❑
Professional societies related to computing	❑	❑
Technical conferences related to computing	❑	❑
Outreach to K-12 students related to computing	❑	❑
Trainings or workshops in computing (other than conferences)	❑	❑
Summer institutes or short courses related to computing	❑	❑

(other than summer research programs)		
Study support in computing (e.g. received tutoring; supplemental Instruction [SI])	❑	❑

During your undergraduate career to date, have you participated in any of the following conferences or programs?

	Yes	No
Grace Hopper Celebration of Women in Computing	❑	❑
Regional "Hoppers" or Celebrations of Women in Computing	❑	❑
Richard Tapia Conference	❑	❑
CRA-W Virtual Townhall Meetings	❑	❑
Discipline-Specific Workshops - if you aren't sure, click here to see previous events.	❑	❑

Since September 2014, have you participated in any "formal" research experiences? Formal research includes an experience you applied for, and through which you worked closely with a mentor or research advisor.Within the past year, I have participated in... Select all that apply.

- ❑ formal undergraduate research at my home institution
- ❑ formal undergraduate research at another institution
- ❑ a research internship in an industry or government lab
- ❑ None of the above

Answer If Since September 2014, have you participated in any of the following research activities? (Select... formal undergraduate research at my home institution Is Selected Or Since September 2014, have you participated in any of the following research activities? (Select... formal undergraduate research at another institution Is Selected Or Since September 2014, have you participated in any of the following research activities? (Select... a research internship in an industry or government lab Is Selected

Was your research experience related to computing? Please select all that apply.

- ❑ No, my research was unrelated to computing
- ❑ Yes, it was in a computer science department
- ❑ Yes, it was in another related computing department
- ❑ Yes, it was interdisciplinary. Please specify (e.g., computing and business): ____________________
- ❑ Other, please specify: ____________________

Answer If Since September 2014, have you participated in any of the following research activities? (Select... formal undergraduate research at my <u>home institution</u> Is Selected

When did your formal undergraduate research at your home institution take place? Please select all that apply.

- ❑ Fall 2014 semester
- ❑ Winter 2014 break/semester
- ❑ Spring 2015 semester
- ❑ Summer 2015
- ❑ Other ____________________

Answer If Since September 2014, have you participated in any of the following research activities? (Select... formal undergraduate research at <u>another institution</u> Is Selected

When did your formal undergraduate research at another institution take place? Please select all that apply.

- ❑ Fall 2014 semester
- ❑ Winter 2014 break/semester
- ❑ Spring 2015 semester
- ❑ Summer 2015
- ❑ Other

Answer If Since September 2014, have you participated in any of the following research activities? (Select... research internship in an industry or government lab Is Selected

When did your research internship in an industry/government lab take place? Please select all that apply.

- ❑ Fall 2014 semester
- ❑ Winter 2014 break/semester
- ❑ Spring 2015 semester
- ❑ Summer 2015
- ❑ Other; please specify: ____________________

Are you currently enrolled in an introductory computer science course?

- ❍ Yes, I am in one introductory course.
- ❍ Yes, I am in more than one introductory course.
- ❍ I was enrolled in an introductory course this term, but I dropped it.
- ❍ No,I was not enrolled in an introductory course this term.

If No,I was not enrolled in an... Is Selected, Then Skip To End of Block

Answer If Are you currently enrolled in an introductory computer science course? I was enrolled in an introductory course, but I dropped it. Is Selected

Why did you drop your introductory computing course? Select all that apply.

- ❑ It didn't meet my expectations
- ❑ It was too challenging
- ❑ It was not challenging enough
- ❑ I'm no longer interested in computer science
- ❑ It was no longer a requirement for my degree
- ❑ I didn't enjoy the professor's teaching style
- ❑ I had a scheduling conflict
- ❑ Other, please specify: ____________________

If Why did you drop your intro... Is Greater Than or Equal to 0, Then Skip To End of Block

Please enter the course number of your introductory computing course. (If you are in more than one computer science introductory course, please select only one.)

For the following questions, please respond in relation to the course you entered above.

Why did you enroll in this 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

How frequently does the instructor(s) for this introductory course use the following?

	Never	Rarely	Sometimes	Frequently	Always
Class discussion	❍	❍	❍	❍	❍
Group work	❍	❍	❍	❍	❍
Lecturing	❍	❍	❍	❍	❍
Paired programming	❍	❍	❍	❍	❍
Use of real world problems involving relevant social issues	❍	❍	❍	❍	❍
Use of examples	❍	❍	❍	❍	❍

involving women					
Use of examples involving people of color	❍	❍	❍	❍	❍
Student presentations	❍	❍	❍	❍	❍
Grading on a curve	❍	❍	❍	❍	❍
Discussions addressing misconceptions about the field of computer science	❍	❍	❍	❍	❍
Grouping students by level of computer science experience	❍	❍	❍	❍	❍
Peer instruction	❍	❍	❍	❍	❍
Working through examples or problems as a class	❍	❍	❍	❍	❍
Student choice in activities and assignments	❍	❍	❍	❍	❍
Interdisciplinary connections to computer	❍	❍	❍	❍	❍

science (e.g., biology and computer science)					
Rubric-based assessment of your work	❍	❍	❍	❍	❍

On average, how frequently do you communicate with introductory course faculty for this course 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	❍	❍	❍	❍	❍
By email	❍	❍	❍	❍	❍
By phone call	❍	❍	❍	❍	❍
By text messages	❍	❍	❍	❍	❍
Via course website (e.g., Blackboard)	❍	❍	❍	❍	❍
In informal meetings (e.g., coffee with a professor)	❍	❍	❍	❍	❍

Please rate your agreement with the following as they pertain to your experiences with faculty for this introductory course and administrators in computer science.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Introductory course faculty are inclusive and supportive of women	❍	❍	❍	❍	❍
Introductory course faculty are inclusive and supportive of students of color	❍	❍	❍	❍	❍
Introductory course faculty are interested in helping me when I come to them with questions	❍	❍	❍	❍	❍
Introductory course faculty are responsive to questions in class	❍	❍	❍	❍	❍
Introductory course faculty are responsive to email communication	❍	❍	❍	❍	❍
Computer science administrators	❍	❍	❍	❍	❍

(e.g., the department chair) care about diversity					

Does your introductory course have one or more teaching assistants (TAs)?
❍ Yes
❍ No

Answer If Does your introductory course have one or more teaching assistants (TAs)? Yes Is Selected

On average, how frequently do you communicate with introductory course TAs for this introductory course 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	❍	❍	❍	❍	❍
By email	❍	❍	❍	❍	❍
By phone call	❍	❍	❍	❍	❍
By text message	❍	❍	❍	❍	❍
Via course website (e.g., Blackboard)	❍	❍	❍	❍	❍
In informal meetings (e.g., coffee with a TA)	❍	❍	❍	❍	❍

Answer If Does your introductory course have one or more teaching assistants (TAs)? Yes Is Selected

Please rate your agreement with the following as they pertain to your experiences with TAs in this introductory course.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Introductory course TAs are inclusive and supportive of women	❍	❍	❍	❍	❍
Introductory course TAs are inclusive and supportive of students of color	❍	❍	❍	❍	❍
Introductory course TAs are interested in helping me when I come to them with questions	❍	❍	❍	❍	❍
Introductory course TAs are responsive to questions in class	❍	❍	❍	❍	❍
Introductory course TAs are responsive to email communication	❍	❍	❍	❍	❍

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

- ❍ Yes
- ❍ No
- ❍ I don't know

Answer If Does your institution offer a GPA that is greater than 4.0? Yes Is Selected Or Does your institution offer a GPA that is greater than 4.0? No Is Selected Or Does your institution offer a GPA that is greater than 4.0? I don't know Is Selected

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

Overall

Major

Minor

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

What was your total ACT score (1-36)

What was your mathematics score on the ACT (1-36)

What was your reading score on the ACT (1-36)

Did you take the SAT?

- ❍ Yes, I took the SAT between 2005 and 2015
- ❍ Yes, I took the SAT prior to 2005
- ❍ No, I did not take the SAT

Answer If Did you take the SAT? Yes, I took the SAT prior to 2005 Is Selected

Please provide us with your SAT scores.

What was your total SAT score (400-1600)

What was your mathematics score on the SAT (200-800)

What was your reading score on the SAT (200-800)

Answer If Did you take the SAT? Yes, I took the SAT between 2005 and 2015 Is Selected

Please provide us with your SAT scores.

What was your total SAT score (600-2400)

What was your mathematics score on the SAT (200-800)

What was your reading score on the SAT (200-800)

Please indicate your gender.

- ❍ Female
- ❍ Male
- ❍ 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 ____________________

In what year were you born?

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 ____________________

Do you have any type of disability (physical, learning, mental, etc.)?

- ❍ Yes
- ❍ No

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 ____________________

Have you ever attended community college?

- ❍ Yes
- ❍ No

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

Answer If How many children, if any, do you have? Include biological, adopted, and step-children. 1 Is Selected Or How many children, if any, do you have? Include biological, adopted, and step-children. 2 Is Selected Or How many children, if any, do you have? Include biological, adopted, and step-children. 3 Is Selected Or How many children, if any, do you have? Include biological, adopted, and step-children. 4 or more Is Selected

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, I do have any children who need caregiving.
- No, my partner/spouse or other family member is the primary caregiver.
- No, I share caregiver responsibility equally with my partner/spouse or other family member.

Are you the primary caregiver to any family members who are not children (e.g., parents, grandparents)? A primary caregiver is the person most responsible for caregiving.
- Yes, I am 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

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

- ❍ 0
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4 or more

Answer If How many people do you consider to be your parent or guardian? 1 Is Selected Or How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

What is the highest level of education attained by one of your parent(s)/guardian(s)?

- ❍ I do not have a 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 ____________________

Answer If How many people do you consider to be your parent or guardian? 1 Is Selected Or How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

Please indicate the career of this parent/guardian.

- 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 specify: ____________________

Answer If How many people do you consider to be your parent or guardian? 1 Is Selected Or How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

Please indicate the gender of this parent/guardian.

- Female
- Male
- Non-binary category or something else; please specify: ____________________

Answer If How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

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

- I do not have a 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 ____________________

Answer If How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

Please indicate the career of this parent/guardian.

- 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) ____________________

Answer If How many people do you consider to be your parent or guardian? 2 Is Selected Or How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

Please indicate the gender of this parent/guardian.

- Female
- Male
- Non-binary category or something else; please specify: ____________________

Answer If How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

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

- I do not have a 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 ____________________

Answer If How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

Please indicate the career of this parent/guardian.

- 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) ____________________

Answer If How many people do you consider to be your parent or guardian? 3 Is Selected Or How many people do you consider to be your parent or guardian? 4 or more Is Selected

Please indicate the gender of this parent/guardian.

- ❍ Female
- ❍ Male
- ❍ Non-binary category or something else; please specify: ____________________

Answer If How many people do you consider to be your parent or guardian? 4 or more Is Selected

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

- ❍ I do not have a 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 ____________________

Answer If How many people do you consider to be your parent or guardian? 4 or more Is Selected

Please indicate the career of this parent/guardian.

- ❍ 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) ____________________

Answer If How many people do you consider to be your parent or guardian? 4 or more Is Selected

Please indicate the gender of this parent/guardian.

- ❍ Female
- ❍ Male
- ❍ Non-binary category or something else; please specify: ____________________

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

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

What is your best estimate of your parents' total income last year? Please select one.

- ❍ 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 - $249,999
- ❍ More than $250,000

Appendix B: Variables and Coding Schemes

B1. Variable List for Descriptive Analyses (Research Questions 1 and 2)

B2. Composition of Measures for Regression Analysis (Research Question 3)

Table B1. Variable List for Descriptive Analyses (Research Questions 1 and 2)

Variables	Mean	SD	Measurement and Coding Scheme
Socioeconomic Status Scale	2.08	0.84	3-point scale: 1=low; 3=high
Socioeconomic Status	3.13	0.88	5-point scale: 1=Poor; 5=Wealthy
Income Bracket	5.83	3.31	12-point scale: 1=Less than $30,000; 12=$250,000 or more
Parents' Education	2.86	1.09	Parents' highest level of education collapsed into 4 groups: 1=High school or less; 2=Some college or associate's degree; 3=Bachelor's degree; 4=Graduate/Professional Degree
Parents' Career: Computing	0.18	0.39	Dichotomous, 1=no; 2=yes
High School GPA	2.97	0.93	4-point scale: 1=C+ or below; 2=B-, B, or B+; 3=A-; 4=A or A+
SAT	1845.72	297.62	Continuous, 400-1600
Class standing	1.65	0.91	4-point scale: 1=First Year; 2=Second Year; 3=Third Year; 4=Fourth Year or Beyond
High school coursework: Biology	2.74	0.88	4-point scale: 1=Did not take class; 4=AP/IB
High school coursework: Statistics	2.76	0.90	4-point scale: 1=Did not take class; 4=AP/IB
High school coursework: Chemistry	1.81	1.11	4-point scale: 1=Did not take class; 4=AP/IB
High school coursework: Computer Science	1.73	1.09	4-point scale: 1=Did not take class; 4=AP/IB
High school coursework: Environmental Science	2.58	1.12	4-point scale: 1=Did not take class; 4=AP/IB
High school coursework: Physics	1.94	1.23	4-point scale: 1=Did not take class; 4=AP/IB
High school coursework: Psychology	2.60	0.71	4-point scale: 1=Did not take class; 4=AP/IB
High school coursework: Algebra II	2.54	0.84	4-point scale: 1=Did not take class; 4=AP/IB
High school coursework: Pre-calculus	2.78	1.34	4-point scale: 1=Did not take class; 4=AP/IB
High school coursework: Calculus	1.87	1.27	4-point scale: 1=Did not take class; 4=AP/IB
Prior programming experience	0.59	0.49	Dichotomous, 1=no; 2=yes
Computing Conference/Workshop Attendance	0.10	0.31	Dichotomous, 1=no; 2=yes

Table B1. Variable List for Descriptive Analyses (Research Questions 1 and 2), Continued

Variables	Mean	SD	Measurement and Coding Scheme
Self-rating: Artistic ability	3.82	0.78	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Creativity	3.00	1.04	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Competitiveness	3.42	0.99	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Leadership ability	3.47	0.85	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Social self-confidence	3.74	0.84	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Academic ability	3.48	0.90	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Drive to achieve	3.75	0.96	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Intellectual self-confidence	3.45	0.94	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Mathematical ability	3.62	0.94	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Computer skills	3.60	0.95	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Cooperativeness	3.12	1.09	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Perceptions: Introductory course faculty are inclusive and supportive of women	3.76	0.88	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Perceptions: Introductory course faculty are inclusive and supportive of students of color	3.76	0.94	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Perceptions: Introductory course faculty are interested in helping me when I come to them with questions	3.85	0.93	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Perceptions: Introductory course faculty are responsive to questions in class	4.04	0.92	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Perceptions: Introductory course faculty are responsive to email communication	3.77	1.00	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Peer Support: Someone to hang out with	2.99	1.30	Five-point scale: 1=Not at all; 5=Very much
Peer Support: Someone to confide in	2.68	1.33	Five-point scale: 1=Not at all; 5=Very much
Peer Support: Someone to get class assignments from	3.07	1.31	Five-point scale: 1=Not at all; 5=Very much
Peer Support: Someone to help you understand assignments	3.19	1.27	Five-point scale: 1=Not at all; 5=Very much

Table B2. Composition of Measures for Regression Analysis (Research Question 3)

Variables	Factor Loadings	Measurement and Coding Scheme
Person Variables		
Demographics and Background Traits		
Student Gender: Female		Dichotomous, 1=male; 2=female
Race/Ethnicity: URM		Dichotomous, 1=White or Asian; 2=Black, Hispanic, Native American, Native Hawaiian, Arab, and Two or more races (URM)
SES Scale		3-point scale: 1=low; 3=high
Socioeconomic Status		5-point scale: 1=Poor; 5=Wealthy
Income Bracket		12-point scale: 1=Less than $30,000; 12=$250,000 or more
Parents' Career: Computing		Dichotomous, 1=no; 2=yes
Pre-course Experiences and Personality		
High School GPA		4-point scale: 1=C+ or below; 2=B-, B, or B+; 3=A-; 4=A or A+
Prior programming experience (e.g., high school, online or other college course, computing camp, or self-taught)		Dichotomous, 1=no; 2=yes
Computing Identity Factor (α = .89)		Five-point scale: 1=Strongly disagree; 5=Strongly agree
Fit in CS: I feel like I "belong" in computing.	0.87	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Fit in CS: I see myself as a "computing person."	0.82	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Fit in CS: Computing is a big part of who I am.	0.77	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Fit in CS: I care about doing well in computing.	0.70	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Fit in CS: Using computers to solve problems is interesting.	0.67	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Fit in CS: I am interested in learning more about what I can do with computing	0.66	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Self-Efficacy: I am confident that I can complete an undergraduate degree in computing.	0.62	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Fit in CS: I feel welcomed in the computing community.	0.55	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Fit in CS: I feel like an outsider in the computing community.*	0.55	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Self-rating: Computer skills	0.53	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-Efficacy: I am confident that I can quickly learn a new programming language on my own.	0.53	Five-point scale: 1=Strongly disagree; 5=Strongly agree

Table B2 Continued

Variables	Factor Loadings	Measurement and Coding Scheme
Holland Artistic Personality Scale		
Self-rating: Artistic ability		Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Creativity		Five-point scale: 1=Lowest 10%; 5=Highest 10%
Holland Enterprising Personality Factor (α =.82)		
Career Orientation: Make important decisions at work	0.84	Five-point scale: 1=Not at all; 5=Extremely
Career Orientation: Have a lot of responsibility at work	0.79	Five-point scale: 1=Not at all; 5=Extremely
Career Orientation: Become well-known in my field	0.66	Five-point scale: 1=Not at all; 5=Extremely
Career Orientation: Be in charge	0.64	Five-point scale: 1=Not at all; 5=Extremely
Career Orientation: Decide for myself what I will work on	0.57	Five-point scale: 1=Not at all; 5=Extremely
Self-rating: Competitiveness	0.51	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Leadership ability	0.51	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Holland Investigative Personality Factor (α =.75)		
Self-rating: Academic ability	0.79	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Mathematical ability	0.76	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Intellectual self-confidence	0.64	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Self-rating: Drive to achieve	0.48	Five-point scale: 1=Lowest 10%; 5=Highest 10%
Holland Social Value Orientation Factor (α =.88)		
Career Orientation: Serve humanity	0.81	Five-point scale: 1=Not at all; 5=Extremely
Career Orientation: Help others	0.80	Five-point scale: 1=Not at all; 5=Extremely
Career Orientation: Have a social impact	0.78	Five-point scale: 1=Not at all; 5=Extremely
Career Orientation: Be a role model for people in my community	0.77	Five-point scale: 1=Not at all; 5=Extremely
Career Orientation: Give back to my community	0.75	Five-point scale: 1=Not at all; 5=Extremely
Career Orientation: Work collaboratively with others	0.60	Five-point scale: 1=Not at all; 5=Extremely
Environment Variables		
Departmental Experiences		
Department Support Factor (α =.85)		
Support: The environment in the computing department inspires me to do the best job that I can	0.87	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Support: The department cares about its students	0.78	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Support: I feel a sense of community in the computing department	0.77	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Satisfaction: Overall, I am satisfied with the computing program at my institution	0.71	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Support: Computer science administrators care about diversity	0.50	Five-point scale: 1=Strongly disagree; 5=Strongly agree

Table B2 Continued

Variables	Factor Loadings	Measurement and Coding Scheme
Introductory CS Course Experiences		
Inclusive Pedagogy Factor (α =.86)		
Use of examples involving people of color	0.83	Five-point scale: 1=Never; 5=Always
Use of examples involving women	0.82	Five-point scale: 1=Never; 5=Always
Discussions addressing misconceptions about the field of CS	0.69	Five-point scale: 1=Never; 5=Always
Interdisciplinary connections to CS	0.65	Five-point scale: 1=Never; 5=Always
Student choice in activities and assignments	0.63	Five-point scale: 1=Never; 5=Always
Student presentations	0.60	Five-point scale: 1=Never; 5=Always
Use of real world problems involving relevant social issues	0.54	Five-point scale: 1=Never; 5=Always
Grouping students by level of CS experience	0.54	Five-point scale: 1=Never; 5=Always
Collaborative Pedagogy Factor (α =.72)		
Pair programming	0.80	Five-point scale: 1=Never; 5=Always
Group work	0.74	Five-point scale: 1=Never; 5=Always
Peer instruction	0.48	Five-point scale: 1=Never; 5=Always
Class discussion	0.47	Five-point scale: 1=Never; 5=Always
Traditional Pedagogy Scale		
Lecturing		Five-point scale: 1=Never; 5=Always
Grading on a curve		Five-point scale: 1=Never; 5=Always
Instructor Responsiveness Factor (α =.86)		
Perceptions: Introductory course faculty are interested in helping me when I come to them with questions	0.93	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Perceptions: Introductory course faculty are responsive to questions in class	0.79	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Perceptions: Introductory course faculty are responsive to email communication	0.74	Five-point scale: 1=Strongly disagree; 5=Strongly agree
Peer Support Factor (α =.90)		
Peer Support: Someone to hang out with	0.89	Five-point scale: 1=Not at all; 5=Very much
Peer Support: Someone to confide in	0.84	Five-point scale: 1=Not at all; 5=Very much
Peer Support: Someone to get class assignments from	0.80	Five-point scale: 1=Not at all; 5=Very much
Peer Support: Someone to help you understand assignments	0.80	Five-point scale: 1=Not at all; 5=Very much
Out-of-Class Experiences		
Hours per week (this term): Computing-related student groups		8-point scale: 1=none; 8=Over 20 hours
Hours per week (this term): Other student groups or clubs		8-point scale: 1=none; 8=Over 20 hours
Hours per week (this term): Studying/homework		8-point scale: 1=none; 8=Over 20 hours
Hours per week (this term): Playing video/computer games		8-point scale: 1=none; 8=Over 20 hours

*Item was reverse coded.

Appendix C: Interview Protocols

Interview 1 (spring 2016 term--during CS course): 60 minutes

1. Tell me the story of how you came to be an undecided student at X university. Listen and ask about:
    a. Schooling experiences
    b. Familial influences
    c. Decision to attend specific institution
    d. Specific majors s/he is considering (i.e., is s/he considering a CS major? What other majors are on the list?)
2. Tell me about your talents and interests.
    a. What are you good at?
        i. Academically
        ii. Personally
    b. What areas do you feel most-confident about? Least confident?
        i. Probe for their sense of self-efficacy related to math, science, and academics in general
    c. What do you love to do?
        i. In school contexts
        ii. Exracurriculars/hobbies
3. What are your plans for the future: what do you want to do with your college degree?
    a. Career orientation and values (intrinsic, extrinsic, flexibility, prestigious, etc.)
    b. Types of work they like to do (e.g., work with people, work with information, have responsibility)
    c. Specific career interests (programmer, doctor, business, etc)
4. How do you plan to make the decision about your college major?
    a. Role of coursework
    b. Role of extracurricular activities
    c. Role of family, friends, advisors, teachers, other role models/mentors
5. Tell me about your decision to enroll in [name of introductory CS course]. Listen and ask about:
    a. Prior computing experience
    b. The experience most responsible for their decision to enroll in the course
    c. Role of family/friends, advisors, other role models/mentors
    d. University requirements
6. What do you think of your [name of introductory CS course]?
    a. Course material: assignments, method of evaluation, course content

b. Experiences w/ professors and TAs (accessibility, support, attitudes toward students)
c. Teaching/learning: tell me about the instructor's teaching style. What helps you learn the material the best? What is not effective in your opinion?
d. Climate: how would you describe the climate of your course? (E.g., Do you feel welcome? Are you free to ask questions? Do you feel judged by your instructor or peers?)
e. Peers and culture: If you were to describe the characteristics of the students in your introductory CS course, what would they be? Do you fit in? How do your peers in the course treat you? Do you tend to study for this course alone or in groups?
f. Course difficulty: On a scale of 1 to 10, how hard do you find the content of this course, with 10 being the hardest, and 1 being the easiest?
g. Course evaluation: How are you doing in the course? What grade do you expect to earn?

7. How does your intro course experience factor into your college major decision?
    a. Experiences in the course that might encourage them to consider a CS major?
    b. Experiences in the course that might dissuade them from considering a CS major?

Interview 2 (fall 2016 term--after CS course): 60 minutes

1. Tell me about your college major choice decision. Listen and ask about:
    a. The status of their decision about a major.
    b. The majors they are considering/considered
    c. The experiences most central to their decision-making process
    d. The people most central to their decision-making process
2. How has your thinking about choosing a major evolved since we last spoke (summarize key points from previous interview)? Listen and ask about:
    a. Changes in views on careers
    b. New experiences, such as classes or summer internships, and new people, such as new mentors or friends that affect their decision
    c. Changes in their views on their talents and interests (i.e., have they discovered new interests or realized they no longer enjoy something they used to like)
3. With the benefit of hindsight, tell me what you thought about your CS course. List and ask about:
    a. Course materials/design
    b. Instructors
    c. Climate

d. Peers
e. Difficulty
f. Evaluation (i.e., what was your final course grade?)

4. Complete this sentence with the first thing that comes to your mind: My intro CS course was important to my major decision because…(Then discuss why)
5. If you had to declare a major today, what would be it?
    a. How sure are you about that choice?
    b. Why?
6. Is there anything else related to your college major choice or experience in the introductory CS course that you want me to know?

References

Allen, W. R., Jayakumar, U. M., Griffin, K. A., Korn, W. S., & Hurtado, S. (2005). *Black undergraduates from Bakke to Grutter: Freshmen status, trends and prospects, 1971-2004*. Los Angeles: Higher Education Research Institute, UCLA.

Alvarado, C., & Judson, E. (2014). Using targeted conferences to recruit women into computer science. *Communications of the ACM*, *57*(3), 70–77. http://doi.org/10.1145/2500883

Astin, A. W. (1968). *The college environment*. Washington, DC: American Council on Education.

Astin, A. W. (1993). *What matters in college?: Four critical years revisited*. San Francisco: Jossey-Bass.

Astin, A. W., & Astin, H. S. (1992). *Undergraduate science education: The impact of different college environments on the educational pipeline in the sciences*. Los Angeles, CA: Higher Education Research Institute, UCLA. Retrieved from http://eric.ed.gov/?id=ED362404

Badagliacco, J. M. (1990). Gender and race differences in computing attitudes and experience. *Social Science Computer Review*, *8*(1), 42–63. http://doi.org/10.1177/089443939000800105

Barker, L. J., & Cohoon, J. M. (2009). *Key practices for retaining undergraduates in computing*. National Center for Women in Technology. Retrieved from http://www.ncwit.org/resources/key-practices-retaining-undergraduates-computing

Barker, L. J., O'Neill, M., & Kazim, N. (2014). Framing classroom climate for student learning and retention in computer science. In *Proceedings of the 45th ACM Technical Symposium on Computer Science Education* (pp. 319–324). New York, NY: ACM. http://doi.org/10.1145/2538862.2538959

Becher, T. (1981). Towards a definition of disciplinary cultures. *Studies in Higher Education*, *6*(2), 109–122. http://doi.org/10.1080/03075078112331379362

Beyer, S., Rynes, K., & Haller, S. (2004). Deterrents to women taking computer science courses. *IEEE Technology and Society Magazine*, *23*(1), 21–28. http://doi.org/10.1109/MTAS.2004.1273468

Beyer, S., Rynes, K., Perrault, J., Hay, K., & Haller, S. (2003). Gender differences in computer science students. In *Proceedings of the 34th SIGCSE technical symposium on Computer science education* (pp. 49–53). New York, NY: ACM. http://doi.org/10.1145/611892.611930

Blickenstaff, J. (2005). Women and science careers: leaky pipeline or gender filter? *Gender and Education*, *17*(4), 369–386. http://doi.org/10.1080/09540250500145072

Brickhouse, N. W. (2001). Embodying science: A feminist perspective on learning. *Journal of Research in Science Teaching*, *38*(3), 282–295.

Bureau of Labor Statistics. (2015). *Occupational outlook handbook*. Retrieved from http://www.bls.gov/ooh/

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218. http://doi.org/10.1002/tea.20237

Carroll, R. (2014, July 2). Sexism in Silicon Valley: Tinder, the “Dave rule” and tech’s glass ceiling. *The Guardian*. Retrieved from http://www.theguardian.com/technology/2014/jul/02/silicon-valley-sexism-tinder-culture-women-ageism

Cech, E. A. (2014). Culture of disengagement in engineering education? *Science, Technology & Human Values*, *39*(1), 42–72.

Cech, E., Rubineau, B., Silbey, S., & Seron, C. (2011). Professional role confidence and gendered persistence in engineering. *American Sociological Review*, *76*(5), 641–666.

Charleston, L. J. (2012). A qualitative investigation of African Americans' decision to pursue computing science degrees: Implications for cultivating career choice and aspiration. *Journal of Diversity in Higher Education*, *5*(4), 222.

Charleston, L. J., George, P. L., Jackson, J. F. L., Berhanu, J., & Amechi, M. H. (2014). Navigating underrepresented STEM spaces: Experiences of Black women in U.S. computing science higher education programs who actualize success. *Journal of Diversity in Higher Education*, *7*(3), 166–176. http://doi.org/http://dx.doi.org/10.1037/a0036632

Cheryan, S., Drury, B. J., & Vichayapai, M. (2013). Enduring influence of stereotypical computer science role models on women's academic aspirations. *Psychology of Women Quarterly*, *37*(1), 72–79.

Cheryan, S., Siy, J. O., Vichayapai, M., Drury, B. J., & Kim, S. (2011). Do female and male role models who embody STEM stereotypes hinder women's anticipated success in STEM? *Social Psychological and Personality Science*, *2*(6), 656–664.

Clark, B. R., & Trow, M. (1966). The organizational context. In T. M. Newcomb & E. K. Wilson (Eds.), *College peer groups: Problems and prospects for research* (pp. 17–70). Chicago, IL: Aldine.

Cohoon, J., & Aspray, W. (2008). A critical review of the research on women's participation in postsecondary computing education. In *Women and Information Technology: Research on Underrepresentation* (pp. 137–180). Cambridge, MA: MIT Press. Retrieved from http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6280964

Cohoon, J. M. (2001). Toward improving female retention in the computer science major. *Commun. ACM*, *44*(5), 108–114. http://doi.org/10.1145/374308.374367

Cohoon, J. M. (2002). Recruiting and retaining women in undergraduate computing majors. *ACM SIGCSE Bulletin*, *34*(2), 48–52.

College Board. (2014). *Program summary report*. Retrieved from http://media.collegeboard.com/digitalServices/pdf/research/2014/Prog-Summary-Report-2014.pdf

Crenshaw, K. (1991). Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford Law Review*, 1241–1299.

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches*. (J. W. Creswell, Ed.). Los Angeles: SAGE Publications.

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed). Los Angeles: SAGE Publications.

Dempsey, J., Snodgrass, R. T., Kishi, I., & Titcomb, A. (2015, February). The emerging role of self-perception in student intentions. In *Proceedings of the 46th ACM Technical Symposium on Computer Science Education* (pp. 108-113). ACM.

Denner, J., Werner, L., O'Connor, L., & Glassman, J. (2014). Community college men and women: A test of three widely held beliefs about who pursues computer science. *Community College Review*, *42*(4), 342–362.

Diekman, A. B., Brown, E. R., Johnston, A. M., & Clark, E. K. (2010). Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychological Science*, *21*(8), 1051–1057.

Eagan, M. K., Stolzenberg, E. B., Bates, A. K., Aragon, M. C., Ramirez Suchard, M., & Rios-Aguilar, C. (2015) *The American freshman: National norms fall 2015*. Los Angeles, CA: Higher Education Research Institute, UCLA. Retrieved from http://www.heri.ucla.edu/monographs/TheAmericanFreshman2015.pdf

Ensmenger, N. (2010). Making programming masculine. In *Gendered Codes: Why Women are Leaving Computing* (pp. 115–142). Hoboken, NJ: John Wiley & Sons, Inc. Retrieved from http://www.sas.upenn.edu/~nathanen/files/cbi-gender.pdf

Farkas, D., & Murthy, N. (2005). Attitudes toward computers, the introductory course and recruiting new majors: Preliminary results. In *17th Workshop of the Psychology of Programming Interest Group, Sussex University* (pp. 268–277). Citeseer. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.115.7904&rep=rep1&type=pdf

Feldman, K. A., Ethington, C. A., & Smart, J. C. (2001). A further investigation of major field and person-environment fit: Sociological versus psychological interpretations of Holland's theory. *Journal of Higher Education*, *72*(6), 670–698.

Feldman, K. A., Smart, J. C., & Ethington, C. A. (2004). What do college students have to lose? Exploring the outcomes of differences in person-environment fits. *The Journal of Higher Education*, *75*(5), 528–555.

Frieze, C., & Blum, L. (2002). Building an effective computer science student organization: The Carnegie Mellon Women@SCS action plan. *SIGCSE Bull.*, *34*(2), 74–78. http://doi.org/10.1145/543812.543835

Gasiewski, J. A., Eagan, M. K., Garcia, G. A., Hurtado, S., & Chang, M. J. (2011). From gatekeeping to engagement: A multicontextual, mixed method study of student academic engagement in introductory STEM courses. *Research in Higher Education*, *53*(2), 229–261. http://doi.org/10.1007/s11162-011-9247-y

Goode, J. (2007). If you build teachers, will students come? The role of teachers in broadening computer science learning for urban youth. *Journal of Educational Computing Research*, *36*(1), 65–88. http://doi.org/10.2190/2102-5G77-QL77-5506

Google Inc. & Gallup Inc. (2016). *Trends in the State of Computer Science in U.S. K-12 Schools.* Retrieved from http://goo.gl/j291E0.

Gordon, V. N. (2007). *The undecided college student: An academic and career advising challenge* (3rd ed). Springfield, Ill: Charles C Thomas.

Gordon, V., & Steele, G. (2003). Undecided first-year students: A 25-year longitudinal study. *Journal of The First-Year Experience & Students in Transition*, *15*(1), 19–38.

Green, A., & Sanderson, D. (2014). *Steps to success: An analysis of persistence and attainment in STEM majors* (SSRN Scholarly Paper No. ID 2451256). Rochester, NY: Social Science Research Network. Retrieved from http://papers.ssrn.com/abstract=2451256

Grites, T. J. (1981). Being “undecided” might be the best decision they could make. *The School Counselor*, *29*(1), 41–46.

Guay, F., Senécal, C., Gauthier, L., & Fernet, C. (2003). Predicting career indecision: A self-determination theory perspective. *Journal of Counseling Psychology*, *50*(2), 165.

Guerra, A. L., & Braungart-Rieker, J. M. (1999). Predicting career indecision in college students: The roles of identity formation and parental relationship factors. *The Career Development Quarterly*, *47*(3), 255–266.

Hartman, B. W., & Fuqua, D. R. (1983). Career indecision from a multidimensional perspective: A Reply to Grites. *The School Counselor*, *30*(5), 340–346.

Herling, L. (2011). *Hispanic women overcoming deterrents to computer science: A phenomenological study*. University of South Dakota. Retrieved from http://dl.acm.org/citation.cfm?id=2521982

Hewlett, S. A., Sherbin, L., Dieudonne, F., Fargnoli, C., & Fredman, C. (2014). *Athena factor 2.0: Accelerating female talent in science, engineering, and technology*. New York: Center for Talent Innovation.

Hoisch, T. D., & Bowie, J. I. (2010). Assessing factors that Influence the recruitment of majors from introductory geology classes at Northern Arizona University. *Journal of Geoscience Education*, *58*(3), 166–176. http://doi.org/10.5408/1.3544297

Holland, J. L. (1973). *Making vocational choices: A theory of careers*. Englewood Cliffs, NJ: Prentice-Hall.

Holland, J. L. (1997). *Making vocational choices: A theory of vocational personalities and work environments (3rd ed.)* Odessa, FL: Psychological Assessment Resources.

Holland, J. L., & Holland, J. E. (1977). Vocational indecision: More evidence and speculation. *Journal of Counseling Psychology*, *24*(5), 404.

Hu, S., & Kuh, G. D. (2002). Being (dis) engaged in educationally purposeful activities: The influences of student and institutional characteristics. *Research in Higher Education*, *43*(5), 555–575.

Hurtado, S., Hughes, B. E., Figueroa, T., Eagan, M. K., & Wilkins, A. (2015). Replenishing STEM pipelines: Factors that contribute to undecided students' completion of STEM bachelor's degrees. Presented at the 2015 Annual Meeting of the American Educational Research Association, Chicago, IL.

Hurtado, S., Saenz, V. B., Santos, J. L., & Cabrera, N. L. (2008). Advancing in higher education; A portrait of Latina/o college freshmen at four year institutions: 1975-2006. Los Angeles: Higher Education Research Institute, UCLA.

Hyde, J. S., & Mertz, J. E. (2009). Gender, culture, and mathematics performance. *Proceedings of the National Academy of Sciences*, *106*(22), 8801–8807. http://doi.org/10.1073/pnas.0901265106

Isaacson, B. (2014, July 31). Why most of this college's engineering students are women. Retrieved May 19, 2017, from http://www.huffingtonpost.com/2014/07/31/women-in-engineering_n_5631834.html.

John, E. P. S., Hu, S., Simmons, A., Carter, D. F., & Weber, J. (2004). What difference does a major make? The influence of college major field on persistence by African American and White students. *Research in Higher Education*, *45*(3), 209–232.

Kanny, M. A., Sax, L. J., & Riggers-Piehl, T. A. (2014). Investigating forty years of STEM research: How explanations for the gender gap have evolved over time. *Journal of Women and Minorities in Science and Engineering*, *20*(2), 127–148. http://doi.org/10.1615/JWomenMinorScienEng.2014007246

Kelly, K., & Lee, W. (2002). Mapping the domain of career decision problems. *Journal of Vocational Behavior*, *61*(2), 302–326.

Klawe, M. (2015, June 8). Closing the computer science gender gap: How one woman is making a difference in many lives. *The Conversation*. Retrieved from http://theconversation.com/closing-the-computer-science-gender-gap-how-one-woman-is-making-a-difference-in-many-lives-41422

Kodaseet, G. G., & Varma, R. (2012). In pursuit of a computing degree: Cultural implications for American Indians. *Journal of American Indian Education*, *51*(1), 67–88.

Koput, K. W., & Gutek, B. A. (2010). *Gender stratification in the IT industry: sex, status and social capital*. Cheltenham, UK; Northampton, Mass.: Edward Elgar.

Lehman, K. J., Sax, L. J., & Zimmerman, H. B. (2017). Women planning to major in computer science: Who are they and what makes them unique?. *Computer Science Education*, *26*(4), 277-298.

Lemons, M. A., & Parzinger, M. (2007). Gender schemas: A cognitive explanation of discrimination of women in technology. *Journal of Business and Psychology*, *22*(1), 91–98. http://doi.org/10.1007/s10869-007-9050-0

Leppel, K. (2001). The impact of major on college persistence among freshmen. *Higher Education*, *41*(3), 327–342.

Margolis, J., Estrella, R., Goode, J., Holme, J. J., & Nao, K. (2008). *Stuck in the shallow end: Education, race, and computing*. Cambridge, MA: The MIT Press.

Margolis, J., & Fisher, A. (2002). *Unlocking the clubhouse: Women in computing*. Cambridge, MA: The MIT Press.

Margolis, J., Fisher, A., & Miller, F. (2000). The anatomy of interest: Women in undergraduate computer science. *Women's Studies Quarterly*, *28*(1/2), 104–127.

McLachlan, G., & Krishnan, T. (2007). *The EM algorithm and extensions* (2nd ed.). New York: John Wiley & Sons.

Moustakas, C. E. (1994). *Phenomenological research methods*. Thousand Oaks, CA: Sage Publications.

National Center for Education Statistics. (2012). *Degrees in computer and information sciences conferred by degree-granting institutions, by level of degree and sex of student: 1970-71 through 2010-11*. Retrieved from https://nces.ed.gov/programs/digest/d12/tables/dt12_349.asp

National Center for Education Statistics. (2013). Digest of education statistics: Bachelor's degrees conferred by degree-grating institutions, by field of study. Retrieved November 13, 2013, from http://nces.ed.gov/programs/digest/d11/tables/dt11_286.asp

National Center for Education Statistics. (2014). *Digest of education statistics, 2014*. Washington, DC: National Center for Education Statistics. Retrieved from https://nces.ed.gov/programs/digest/d14/tables/dt14_318.30.asp

National Center for Education Statistics. (2015). Fast facts: Enrollment. Retrieved February 6, 2016, from http://nces.ed.gov/fastfacts/display.asp?id=98

National Center for Women and Information Technology. (2015). *Recruit strategically: A "High Yield in the Short Term" workbook for attracting women to undergraduate computing and engineering*. Boulder, CO: National Center for Women and Information Technology. Retrieved from https://www.ncwit.org/sites/default/files/resources/recruitstrategicallyworkbook_print.pdf

National Science Foundation. (2014). *Science and engineering indicators 2014*. Arlington, VA: National Science Foundation. Retrieved from http://www.nsf.gov/statistics/seind14/index.cfm/chapter-2/c2s2.htm#s2-2

National Science Foundation. (2015). *Women, minorities, and persons with disabilities in science and engineering* (No. NSF 15-311). Arlington, VA: National Science Foundation. Retrieved from http://www.nsf.gov/statistics/2015/nsf15311/digest/theme3.cfm#mindegrees

National Science Foundation & National Center for Education Statistics. (2012). *Special tabulations of U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey*. Washington, DC: U.S. Department of Education.

Nauta, M. M. (2012). Temporal stability, correlates, and longitudinal outcomes of career indecision factors. *Journal of Career Development*, *39*(6), 540–558.

Newhall, T., Meeden, L., Danner, A., Soni, A., Ruiz, F., & Wicentowski, R. (2014). A support program for introductory CS courses that improves student performance and retains students from underrepresented groups. In *Proceedings of the 45th ACM Technical Symposium on Computer Science Education* (pp. 433–438). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=2538923

Nyame-Mensah, A., Tamer, N. B., & Stout, J. G. (2015). *Understanding how summer research experiences can foster diversity in computing research*. Washington, D.C.: Computing Research Association. Retrieved from http://cra.org/cerp/wp-content/uploads/sites/4/2015/08/SURE_EvaluationReport.pdf

Ong, M., Wright, C., Espinosa, L. L., & Orfield, G. (2011). Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics. *Harvard Educational Review*, *81*(2), 172–209.

Orser, B., Riding, A., & Stanley, J. (2012). Perceived career challenges and response strategies of women in the advanced technology sector. *Entrepreneurship & Regional Development*, *24*(1-2), 73–93. http://doi.org/10.1080/08985626.2012.637355

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. Thousand Oaks, CA: Sage Publications.

Peduzzi, P., Concato, J., Kemper, E., Holford, T. R., & Feinstein, A. R. (1996). A simulation study of the number of events per variable in logistic regression analysis. *Journal of Clinical Epidemiology*, *49*(12), 1373–1379. http://doi.org/10.1016/S0895-4356(96)00236-3

Penner, A. M., & Paret, M. (2008). Gender differences in mathematics achievement: Exploring the early grades and the extremes. *Social Science Research*, *37*(1), 239–253.

Polkinghorne, D. E. (1989). Phenomenological research methods. In R. S. Valle & S. Halling (Eds.), *Existential-phenomenological perspectives in psychology* (pp. 41–60). Springer US. Retrieved from http://link.springer.com/chapter/10.1007/978-1-4615-6989-3_3

Porter, L., Bailey Lee, C., & Simon, B. (2013). Halving fail rates using peer instruction: A study of four computer science courses. In *Proceeding of the 44th ACM Technical Symposium on Computer Science Education* (pp. 177–182). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=2445250

Radermacher, A. D., & Walia, G. S. (2011). Investigating the effective implementation of pair programming: An empirical investigation. In *Proceedings of the 42nd ACM Technical Symposium on Computer Science Education* (pp. 655–660). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=1953346

Rhode Island School of Design. (2017). STEM to STEAM. Retrieved May 20, 2017, from http://www.risd.edu/about/stem_to_steam/

Rich, L., Perry, H., & Guzdial, M. (2004). A CS1 course designed to address interests of women. *SIGCSE Bull.*, *36*(1), 190–194. http://doi.org/10.1145/1028174.971370

Rosen, D., Holmberg, K., & Holland, J. L. (1987). *The College Major Finder: For Use with the Self-directed Search and Vocational Preference Inventory*. Psychological Assessment Resources.

Russell, D. W. (2002). In search of underlying dimensions: The use (and abuse) of factor analysis. *Personality and Social Psychology Bulletin*, *28*(12), 1629–1646. http://doi.org/10.1177/014616702237645

Salisbury University. (2014). College majors and the Holland codes. Retrieved November 19, 2015, from http://www.salisbury.edu/careerservices/Students/CareerInventories/Majors.html

Sax, L. J. (2008). *The gender gap in college: Maximizing the developmental potential of women and men*. San Francisco: Jossey-Bass.

Sax, L. J., Bryant, A. N., & Harper, C. E. (2005). The differential effects of student-faculty interaction on college outcomes for women and men. *Journal of College Student Development*, *46*(6), 642-657.

Sax, L. J., & Lehman, K. J. (2015, July). *The gender gap in computer science: Progress and challenges between 1971-2011*. Presented at the 2015 BRAID Summit, Harvey Mudd College, Claremont, CA.

Sax, L. J., Lehman, K. J., & Blaney, J. M. (2016). Building Recruiting and Inclusion for Diversity (BRAID): Emerging research on diversifying the CS major. *CRA-Women Newsletter*, *Winter/Spring 2016 Edition*.

Sax, L. J., Lehman, K., Jacobs, J.A., Kanny, A., Lim, K., Monje-Paulson, L. & Zimmerman, H. (2017). Anatomy of an Enduring Gender Gap: The Evolution of Women's Participation in Computer Science. *The Journal of Higher Education,* 88(2): 258-293

Sax, L. J., **Lehman, K. J.,** & Zavala, C. (2017). Examining the enrollment growth: Non-CS majors in CS1 courses. In SIGCSE '17: Proceedings of the 48th ACM Technical Symposium on Computing Science Education. New York, NY, USA: ACM.

Sax, L. J., Lim, K., Jacobs, J., Lehman, K., Paulson, L. & Maclennan, A. (2016). *Reversal of the gender gap: The biological sciences as a unique case within STEM.* Presented at the 2016 Annual Meeting, Association for the Study of Higher Education, Denver, CO.

Sax, L. J., Zimmerman, H., Blaney, J. M., Toven-Lindsey, B., & Lehman, K. J. (2015). Diversifying computer science departments: How department chairs become change agents for women and underrepresented minority students. Presented at the 2015 Annual Conference of the Association for the Study of Higher Education, Denver, CO.

Seidman, I. (2013). *Interviewing as qualitative research: A guide for researchers in education and the social sciences*. New York: Teachers College Press.

Servon, L. J., & Visser, M. A. (2011). Progress hindered: The retention and advancement of women in science, engineering and technology careers. *Human Resource Management Journal*, *21*(3), 272–284.

Settle, A. (2012). Turning the tables: Learning from students about teaching CS1. In *Proceedings of the 13th Annual Conference on Information Technology Education* (pp. 133–138). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=2380594

Seymour, E., & Hewitt. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO: Westview Press.

Smart, J. C., Feldman, K. A., & Ethington, C. A. (2000). *Academic disciplines: Holland's theory and the study of college students and faculty*. Nashville, TN: Vanderbilt University Press.

Smart, J. C., Feldman, K. A., & Ethington, C. A. (2006). Holland's theory and patterns of college student success. In *Commissioned Report for the National Symposium on Postsecondary Student Success: Spearheading a Dialog on Student Success*. Retrieved from http://web.ewu.edu/groups/academicaffairs/IR/NPEC_4_Smart_Team_Report.pdf

Strange, C. C., & Banning, J. H. (2001). *Education by design: Creating campus learning environments that work.* San Francisco, CA: Jossey-Bass.

St. Rose, A. (2010). STEM major choice and the gender pay gap. *On Campus with Women*, *39*(1). Retrieved from http://www.aacu.org/ocww/volume39_1/feature.cfm?section=1

Tashakkori, R., Wilkes, J. T., & Pekarek, E. G. (2005). A systemic mentoring model in computer science. In *Proceedings of the 43rd Annual Southeast Regional Conference-Volume 1* (pp. 371–375). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=1167453

The White House. (2016, January 30). Computer science for all. Retrieved February 2, 2016, from https://www.Whitehouse.gov/blog/2016/01/30/computer-science-all

Tobias, S. (1990). Stemming the science shortfall at college. In S. Tobias (Ed.), *They're not dumb, they're different*. Tuscon, AZ: Research Corporation.

University of North Florida. (2015). UNF Career Services: Holland codes and majors at UNF. Retrieved November 19, 2015, from https://www.unf.edu/careerservices/Holland_Codes_and_Majors_at_UNF.aspx

Varma, R. (2006). Making computer science minority-friendly. *Communications of the ACM*, *49*(2), 129–134.

Varma, R. (2010). Why so few women enroll in computing? Gender and ethnic differences in students' perception. *Computer Science Education*, *20*(4), 301–316.

Vittinghoff, E., & McCulloch, C. E. (2007). Relaxing the rule of ten events per variable in logistic and cox regression. *American Journal of Epidemiology*, *165*(6), 710–718. http://doi.org/10.1093/aje/kwk052

Wai, J., Cacchio, M., Putallaz, M., & Makel, M. C. (2010). Sex differences in the right tail of cognitive abilities: A 30 year examination. *Intelligence*, *38*(4), 412–423.

Waite, W. M., Jackson, M. H., Diwan, A., & Leonardi, P. M. (2004). Student culture vs group work in computer science. *SIGCSE Bull.*, *36*(1), 12–16. http://doi.org/10.1145/1028174.971308

Werner, L. L., Hanks, B., McDowell, C., Bullock, H., & Fernald, J. (2005). Want to increase retention of your female students. *Computing Research News*, *17*(2), 2.

Wilson, B. C. (2002). A study of factors promoting success in computer science including gender differences. *Computer Science Education*, *12*(1-2), 141–164.

Wilson, B. C., & Shrock, S. (2001). Contributing to success in an introductory computer science course: A study of twelve factors. In *Proceedings of the Thirty-Second SIGCSE Technical Symposium on Computer Science Education* (pp. 184–188). New York, NY, USA: ACM. http://doi.org/10.1145/364447.364581