COMPUTING-BASED SELF-ESTEEM:
THE INTERPLAY OF COMPETENCE AND WORTHINESS

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ABSTRACT

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This concurrent mixed methods study examined how the experiences of being a woman in computing affects her self-esteem over the course of her undergraduate career and into professional employment. Self-esteem was measured using the Rosenberg Self-esteem Scale that applies both competence and worthiness constructs. General (global) self-esteem was compared to self-esteem within the context of computing (computing-based self-esteem). Female attendees (*N*=546) of ACM-W celebrations of women in computing were invited to complete a Computing Experience Survey (CES). Quantitative and qualitative data were analyzed separately then mixed to validate findings. Quantitative results indicated that women reported significantly lower computing-based self-esteem than global self-esteem. Additionally, competence and worthiness significantly differed within computing-based self-esteem throughout one's college progression and into the profession. All measures of self-esteem (global, computing-based, competence, and worthiness) improve for professionals. Analysis of open-ended questions illustrated that competence and worthiness are intertwined in computing experiences, and positive and negative experiences often contained a social component. The following conclusions were presented: (1) context matters when measuring self-esteem; (2) competence and worthiness are separate but related dimensions of self-esteem; (3) computing-based self-esteem changes throughout a student's college career and into the profession; (4) experiences in computing provide explanations for these changes in computing-based self-esteem and shed light on persistence, career faithfulness, and leadership; and, (5) when worthiness is present, it is strongly tied to competence for women in computing.

Keywords: women in computing, computer science, self-esteem, competence, worthiness

For my mom who told me that I could do anything I put my mind to.

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CHAPTER I. INTRODUCTION

"Every girl deserves to take part in creating the technology that will change our world, and change who runs it." -- Malala Yousafzai, Nobel Peace Prize winner

Problem Statement

The Bureau of Labor Statistics projects 1.1 million computing-related job openings in the United States by 2024. Based on current trends in computing degree enrollments at colleges and universities in the United States, only 41% of these jobs could be filled by U.S. graduates (National Center for Women in IT [NCWIT], 2016). Unfortunately, women are not taking advantage of the opportunities in this high demand field. According to the Computing Research Association's (CRA) Taulbee Study, only 16.3% of undergraduate computer science recipients at major research universities were women (Zweben & Bizot, 2016). Similar numbers were reported by the Association of Computing Machinery's Non Doctoral-Granting Departments in Computing Study (NDC), finding that only 16.3% of computer science undergraduate degree recipients at non-doctoral-granting schools were women (Tims, Zweben, Timanovsky, Prey & 2016).

The low number of women receiving computing-related degrees is not just an issue of reaching an untapped demographic to help fill the projected job openings in economically crucial areas. Addressing the current inequity and lack of diversity is a critical step toward promoting a diverse workforce to create new technologies that will benefit a diverse population (NSF, 2013). Diverse teams are simply more creative and innovative (Barkema, Baum, & Mannix, 2002).

The American Association of University Women argues that society needs to enable women to take on roles "not simply as consumers and users of technology, but as designers, leaders, and shapers of the computer culture" (2000, p. 4). Fewer women completing computing degrees means fewer women working in computing-related jobs and therefore less women rising to leadership positions to influence the direction of research and development. According to the 2016 Harvey Nash survey of chief information officers (CIOs), 9% of senior IT leadership are female, up from 6% in 2015. However, they report a "bright spot" in these numbers that support efforts to retain women in computing:

> Compared to many other [business] disciplines such as HR, a greater proportion of women in IT [information technology] make it through to senior positions. This suggests that while we do not yet see enough young women entering the industry, if they do embark on a career in IT there is more chance that they could realize their full potential than in many other sectors. If more young women can be persuaded to enter the IT profession, it looks as though both they and the industry will benefit. (Harvey Nash Group, 2014, p. 33).

Background

The impact of women in computing has always been present (Abbate, 2012). In fact women were involved with computing from its inception. Ada Lovelace wrote programs for Charles Babbage's mechanical computer, and six women called "human computers" wrote programs for the ENIAC computer during World War II. Grace Hopper, a pioneer in computing and for whom the annual Celebration of Women in Computing conference is named, created the first compiler. She also laid out the specifications that led to the development of the COBOL programming language.

During the war, just as factory jobs were recast as appropriate and manageable for women (recall ads for "Rosie the Riveter"), so too were computer jobs. Since the computer programming job did not exist before WWII it could be more easily constructed as work women were capable of doing and it provided an exciting and well-paid option for women with a mathematics background beyond the traditional teaching and clerical positions. Ads during and after the war trumpeted that, if one has the patience for knitting or the attention to detail and ability to follow a recipe, one might be good at programing. Even *Cosmopolitan* magazine promoted programming as “women’s work”. In an article entitled “The Computer Girls”, the magazine encouraged readers to consider programming because it offered better job opportunities for women than other fields (1967, p. 52). Women’s participation increased through the 1970s, and peaked in the 1980s when women earned 37% of computer science degrees and held 35% of US professional computing jobs (Abbate, 2012, p. 3).

Despite women accounting for over one-third of the computing work force, the stereotype of a computer programmer became a nerdy man with poor social skills and questionable grooming habits. By the 1990s, a steady decline in the number of women in computing became too obvious to ignore. A report written in 1991 by Ellen Spertus entitled “Why Are There So Few Female Computer Scientists?” first put this issue in the spotlight. Soon to follow were papers such as “The Incredible Shrinking Pipeline” (Camp, 1997) and books such as *Unlocking the Clubhouse: Women in Computing* (Margolis & Fisher, 2003) that began to spur much discussion and debate. Along the way, computing had become “gendered”, leading to the dismal percent of women in computing today (Misa, 2010, Ensmenger, 2010).

Researchers have spent a considerable amount of time examining this development. Janet Abbate’s book, *Recoding Gender: Women’s Changing Participation in Computing* (2012), used extensive interviews with women in computing to explore why programming went from ‘women’s work’ to a ‘boys-only clubhouse’. Early programmers such as Elise Shutt (hired by Raytheon in 1953), Fran Allen (hired by IBM in 1957), and Paula Hawthorn (hired by Texaco in

1966) were surprised that men took over programming. Elise Shutt thought programming was "women's work"; Fran Allen said when she was hired, women were believed to be good at programming; and, Paula Hawthorn held that the mix of employees was half women (at least at the lower levels). But slowly, computing became professionalized and politics came into play. Nathan Ensmenger's book, *The Computer Boys Take Over: Computers, Programmers, and the Politics of Technical Expertise* (2010) more generally explains the history of computing and its separation from engineering, and touches upon the politics that made it difficult for women to succeed. The construction of expertise that favored a more masculine skill set, valued certain experiences over others. Advanced schooling was just one of these political changes. The creation of professional societies that only allowed men and work conditions that make it difficult for women to participate also limited women's opportunities to succeed in computing

All is not bleak though. Since the early 1990s, special interest groups have been formed and millions of dollars have been allocated to correct this issue. The flagship professional organization for computer science, the Association for Computing Machinery (ACM), tasked a committee to study the issue of women and computing in 1993. This committee made its first annual report at the ACM Council meeting in 1997 and by 2009 ACM-W became an official international council to focus on recruiting and retaining female college students and faculty in computing. Likewise, the flagship organization for engineering, the Institute for Electrical and Electronics Engineers (IEEE), created IEEE Women in Engineering. Other organizations such as the Anita Borg Institute (ABI), National Center for Women in Technology (NCWIT), the Association for Women in Science (AWIS), the Association of American Colleges & Universities (AACU), the Association of American University Women (AAUW), have been created with the purpose of promoting the impact of women in computing. The National Science

Foundation's (NSF) ADVANCE program was created to increasing the representation and advancement of women in science and engineering careers thereby contributing to a more diverse workforce. Between 2001 and 2016, NSF has invested over $130M to support ADVANCE projects. These types of initiatives can be categorized based upon the stage women are in their computing journey.

Initiatives focusing on the front end of the pipeline are devoted to introducing women to computing majors. Organizations such as the Computer Science Teachers Association (CSTA) and code.org have teamed up to support and promote the teaching of computer science in K-12 so that students are exposed to the discipline long before they must decide about what to study in college. Tools with simple drag-and-drop interfaces such as Alice, Scratch, Snap!, Tynker, and programmable Lego Mindstorms robots were created to make learning to program fun. Websites such as coderdojo.org, girlswhocode.org, techbridge.org, girldevelopit.org, and dotdiva.org were created to provide social forums for girls to meet other girls with similar interests in technology. Outreach efforts such as Women in STEM days, summer camps, CS Education Week, and Hour of Code build excitement for careers in technology through events that allow girls to develop their interest and skills in computing. For high school students, The College Board (2016) has created an alternate to the current Advanced Placement (AP) Computer Science exam that requires students to understand a very narrowly focused area of computing, software development. This new AP exam, Computer Science Principles (AP CSP), allows students to first build a broad understanding of the entire field of computing by organizing the curriculum around seven "big ideas" that are central to computing: creativity, abstraction, data and information, algorithms, programming, the internet, and global impacts, before jumping into a professional programming language such as Java. All these efforts provide groundwork for students, especially women, to help them have a better understanding of the field of computing.

For interested students who have selected a computing major, other initiatives are devoted to retaining women in computing majors. In a comprehensive literature review, Coohoon and Aspray (2006) categorized published research into ten categories: culture and image of computing, experience, entry barriers, curricula, role models, mentoring, student-faculty interactions, peer support, confidence and other personal characteristics, and pedagogy. Examples of research that focus on computing skills (i.e., competence) include entry barriers such as using prior programming experience as a determinant for success (Cassell & Jenkins, 1998; Jagacomski, Lebold, & Salvendy, 1988; Kersteen, Linn, Clancy, Hardyck, 1988; Taylor & Mounfield, 1994), curricula that "weeds out" beginner programmers too soon (Margolis & Fisher, 2002), and pedagogy (Arch & Cummins 1989; Chase & Okie 2000; Jagacinski, Lebold, Salvendy, 1988; McDowell, Werner, Bullock, & Fernald, 2003; McKenna, 2000; Ridley & Novak, 1983; Tobias, 1990; Turkle & Papert, 1990). Research on internal characteristics such as confidence and efficacy is also related to skill acquisition (Bandura, 1977; Beyer, 1990; Beyer, Rynes, Perrault, Hay, & Haller 2003; Eccles 1994; Gneezy, Niederle, & Rustichini, 2003; Lips, 2004; Lips & Temple, 1990; Seymour & Hewitt, 1997; Volet & Lund, 1994). Examples of research that focus on values and socially constructed worth (i.e., worthiness) include the lack of positive role models (Canes & Rosen 1995; Etzkowitz, Kemelgor, Neuschatz, Uzzi, & Alonzo, 1994; Haller & Fossum, 1998; Teague, 2002; Townsend, 1996), mentoring (Campbell & Campbell, 2000; Craig, 1998; Matyas & Dix, 1992; Ulku-Steiner, Kurtz-Costes, & Kinlaw, 2000), student-faculty interactions (Cohoon & Baylor 2003; Fox, 2001; Hearn & Olzak, 1981; Seymour & Hewitt 1997), peer support (Astin & Astin, 1992; Cohoon, 2006; McPherson, Smith-

Lovin, & Cook, 2001), and differences in personal values (Fisher, Margolis, & Miller, 1997; Marini, Fan, Finley, & Beutel, 1996; Wigfield & Eccles, 2000) that can help students find meaning in their work and a sense of belonging. Research on the culture and image of computing including stereotype threat (Ambady, Paik, Steele, Owen-Smith, & Mitchell, 2004; Correll, 2004; Frieze, Quesenberry, Kemp, & Velaz1uez, 2012; Kiesler, Sproull, & Eccles, 1985; Steele & Aronson, 1995; Wajcman, 1991) also falls under this category such that there is a sort of status afforded to the "computer geek" who is applauded for his obsession with all things related to computing.

Seeing the need to support and advocate for female college students in computing majors, ACM-W sponsors two major initiatives. Regional conferences, called "celebrations", bring together women in geographical locations, often by state or within a 4-6 hour driving distance. These celebrations create a community of technical women, provide role models, and break down feelings of isolation. Additionally, collegiate chapters of ACM-W, provide sustained support for women to share their experiences and collaborate on activities that they find to be meaningful such as events to encourage young girls to consider computing as a career.

Initiatives focusing on the tail of the pipeline are gaining attention. Research in this area is devoted to helping females enter the computing workforce and succeed there as professionals. For example, NSF funded a study that reached out to engineering graduates (Fouad, Singh, Fitzpatrick, & Liu, 2012) to understand factors related to women engineers' career decisions. They found that 10% of the over 5,500 women who responded did not even seek engineering jobs after graduation and 27% entered but then left the field. These women indicated that the workplace climate was a strong factor in their decision not to enter or to leave the profession. Freeman and Aspray (1999) called this phenomenon "career faithfulness" and found that women's career faithfulness was weaker than men's. In other words, a lower percentage of women earning computer science degrees entered the computing profession after graduation than men. Aware of these issues, organizations such as the Association for Women in Computing (AWC) provide support for professional industry women and the Computing Research Association Women's branch (CRA-W) provides support for academic women. The next section explains why more research needs to be conducted to address the problem of low numbers of women in computing.

Rationale

Despite these efforts to help recruit and retain women in computing, the number of women graduating with degrees in computer science has not increased (NCWIT, 2013). Cohoon and Aspray's literature review (2006) revealed two reasons for the lack of progress. First, they found that there is a lack of understanding of the underlying reasons and immediate causes for the low numbers of women in computing. They explain that much of what has been published is based on personal experience or observation, rather than "being grounded in empirical evidence that can be generalized" (p. 139). Second, they found "inadequate intervention efforts" because the efforts were rarely grounded in theory. For example, much has been written about mentoring interventions but as of their analysis, there was no comprehensive theory of how or why mentoring works. This study met their first concern (the need for empirical evidence that can be generalized) and lays the groundwork to meet their second concern (the need for intervention efforts based on empirical evidence), by carefully considering the over 100 years of self-esteem research to determine whether self-esteem is a factor that is being overlooked in research on women in computing.

There are many ways to define, describe, and measure self-esteem. One way to think of self-esteem is related to success or competence (i.e., skills, grades). Another way to think of self-esteem is related to values or worthiness (i.e., feelings of acceptance, belief that contributions are respected). This study considered both by applying a two-factor definition for self-esteem, to examine how competence and worthiness work together to describe self-esteem more completely than single factor definitions. This study also considered the differences between general (i.e. global) self-esteem and specific (i.e. based within a domain such as computing) self-esteem and show the importance of the context when measuring studying self-esteem. Additionally, self-esteem was examined as a dependent variable affected by precipitating experiences. And finally, this study showed that self-esteem is a developmental process that can be shaped and therefore should be measured over time. This empirical evidence can then provide the foundation for developing effective interventions. The next section explains how this study was structured.

Purpose of the Study

This concurrent mixed methods study examined how the experiences of being a woman in computing affect one's self-esteem over the course of her undergraduate career. Participants included women (*N*=546) at various stages in their computing-related career from freshmen in college to professionals working in the field. Participants' worthiness and competence dimensions of self-esteem as well as their global and computing-based self-esteem were investigated by analyzing survey data collected and administered by ACM-W. This survey was sent to participants of regional celebrations of women in computing events and included both closed and open-ended questions. Concurrent qualitative and quantitative methods were used for analysis. The relationships examined as specified in the quantitative research questions below were statistically analyzed using factorial multivariate analysis of variance (MANOVA). Participant experiences (i.e., self-esteem moments) explored through the qualitative research questions, were analyzed using various coding methods and validated through expert comparison to identify themes. The quantitative and qualitative data were then merged and analyzed using triangulation to build on the strengths of statistical analysis and the “voices” of individual participant responses. The next section states the research questions addressed by this study.

Research Questions

This study seeks to address the following research questions:

Q1: Do global self-esteem and computing-based self-esteem (CSE) differ by status (freshmen, sophomore, junior, senior, professional) among women in computing?

Q2: Do global competence, global worthiness, computing-based competence, and computing-based worthiness differ by status (freshmen, sophomore, junior, senior, professional) among women in computing?

Q3: What positive experiences in computing contribute to competence and worthiness among women?

Q4: What negative experiences in computing contribute to competence and worthiness among women?

The next section shows how self-esteem may be connected to persistence in computing and provides a framework in which to ground this study.

Theoretical Framework

This section shows how self-esteem may be connected to women and computing and provides a framework in which this study was grounded. With over 30,000 studies focusing on self-esteem, one should not be surprised to find that researchers have been examining self-esteem in both the educational and workplace settings for some time (Mruk, 2013). However, most of this research is based on only one of two single-factor definitions of self-esteem, namely in terms of success or competence (James, 1890/1983) *or* a feeling or attitude of worth as a person (Rosenberg, 1965). And, even though the value of focusing on self-esteem has been challenged, those who criticize the pursuit of high self-esteem (Baumeister, Smart, & Boden, 1996; Crocker & Park, 2004) admit that self-esteem does help buffer people during periods of stress, is strongly correlated to happiness, and facilitates persistence after failure (Baumeister, Campbell, Krueger, Vohs, 2003; Diener & Diener, 1995).

Although research based on a two-factor way of defining self-esteem as a relationship between competence *and* worth began in the 1970s, researchers are just beginning to apply it to academic research (Miller & Moran, 2006; Thoman, Arizaga, Smith, Story, & Soncuya, 2014). Thus, this study, which explores the effect of subtle (and sometimes not so subtle) challenges to competence (e.g., imposter syndrome) and worth (e.g., chilly climate) within the specific context of the computing field, will use a two-factor definition of self-esteem that is beginning to show promise in STEM education research (Thoman et al., 2014). Researchers have not yet previously applied this two-factor definition to understanding the specific phenomena of women in computing. This is what this study plans to do.

Self-esteem

Since there are three ways researchers approach self-esteem as noted above, operationalizing one's definition when researching this phenomenon is critical to understanding the procedure and results. This study will define self-esteem as the lived status of one's competence at dealing with the challenges of living in a worthy way over time (Mruk, 2006, 2013). Used as a model, this definition is supported by four critical components that work together to create healthy self-esteem. These components will provide the structure for this study: (1) competence, worthiness and the balance between them, (2) lived status (based within the specific domain of computing), (3) challenges of living (self-esteem moments), and (4) time (changes over the course of professional development).

Competence. Competence is one's set of skills or abilities and includes a sense of efficacy in how those skills may be used in a specific situation (Mruk, 2013). A sense of felt competence within computing is important for dealing with challenges because it not only provides the required computing aptitude but also provides a sense of individual responsibility for what is known and a level of authenticity in how to apply those skills. For example, a student earning high marks may appear to have competence however, if she doubts her knowledge or attributes her good grades to luck (e.g., imposter syndrome) her lack of confidence may prevent her from taking pride in a job well done and advancing her skills through seeking additional challenges.

Worthiness. Worthiness is an individual's attitude or feeling of being valued especially by one's social group or the value they themselves place on their own actions (Mruk, 2013). Within the domain of computing, this may relate to a student's sense of whether the social and intellectual challenges of being in computing is worth her while (e.g., chilly climate). Acceptance and being valued as a member of the class are directly related to one's sense of self-worth.

Balance between competence and worthiness. In the two-factor definition of self-esteem, worthiness and competence work together as a balance to create healthy self-esteem (Gecas, 1971; Mruk, 2006; Richardson, Ratner, & Zumbo, 2009; Tafarodi & Milne, 2002; Tafarodi & Swann, 1995; Tafarodi & Vu, 1997). Competence must be balanced by worthiness for actions to have merit. For instance, self-esteem is out of balance for a person who may be very good (competent) at morally offensive actions such as lying or stealing (lack of worthiness). On the other hand, worthiness needs competence to ensure that actions have meaning. For instance, narcissism is the result of self-esteem that is out of balance for a person who has a high self-opinion (worthiness) but has not earned it (lack of competence). In the context of computing, self-esteem may suffer for a person who is very good at programming (competence) but does not feel respected by their peers (lack of worthiness). Similarly, self-esteem is out of balance for a person who earns low marks on exams and assignments (lack of competence) but still acts superior to their classmates (worthiness).

Lived status. Mruk explains that he used the term “status” to represent something that is relatively stable but that can change under certain conditions. Harter referred to these different conditions as involving specific domains of self-esteem upon which one stakes their self-esteem (2012). Without context, self-esteem scores generally reflect one’s overall feelings and evaluation of oneself. However, self-esteem can vary widely within the specific context of academics, athletics, family, and relationships. Thus, larger gender differences have been revealed with domain-specific self-esteem than global self-esteem (Gentile, Grabe, Dolan-Pascoe, Twenge, Wells, Maitino, 2009, Sondhaus, Kurtz, & Strube, 2001; Tiggemann & Rothblum, 1997). Additionally, Crocker and Wolfe (2001) found that changes in self-esteem are “contingent” upon those domains or categories that mattered most to one’s self. This dual nature of self-esteem is known as trait vs. state dimensions (Mruk, 2013). Therefore, exploration of self-esteem *within the specific context of computing* may help explain the disengaging behavior of women in computing.

*Challenges of living***.** Although self-esteem is fairly stable for adults, it becomes more fluid during "transitions between major times of life or when it challenges us in particularly powerful ways" (Mruk, 2006, p. 94) as it might when under attack or scrutiny or when trying to achieve something meaningful such as mastery in computing. These moments that challenge one's self-esteem can be important turning points called "self-esteem moments" (Epstein, 1979; Mruk, 2006; Tafarodi & Milne 2002).

Time. Challenges are bound to arrive throughout life that either affirm or refute our sense of self (Harter, 2012; Mruk, 2013; Tafarodi & Vu, 1997). Mruk adds that challenges provide chances to act in ways that are *both competent and worthy* to help shape our self-esteem. Therefore, as with other areas of life, a student's self-esteem within computing is developed over years of study and through challenges that can harm or strengthen their sense of competence and fit. For example, repeatedly getting As in a course is not enough (competence) if the person does not feel as though his or her work has any value (worthiness). For self-esteem to be positively affected, confirmation of both continued increase in skill (competence) as well as confirmation of the importance of their contribution to the class (worth) must be achieved. A positive change in self-esteem only occurs as one continues to face and deal effectively with the challenges living presents.

In order to fully utilize the two-factor definition of self-esteem as a framework to explore the persistence of women in computing, all of these components were addressed. This study measured self-esteem within the context of computing (lived status), analyzed competence and worthiness and the interaction between them, highlighted the importance of self-esteem moments (challenges of living), and investigated self-esteem issues at different points during the college experience from freshmen through to professional employment (over time). The next section explains the context in which this self-esteem framework was applied.

ACM-W Celebrations of Women in Computing

This study was uniquely situated within an international retention initiative sponsored by ACM-W called “celebrations”. Primarily geared toward students, these celebrations are modeled after the national Grace Hopper Celebration of Women in Computing named in honor of Grace Hopper, one of the first female computer scientists. Each celebration brings together from 50 to 250 students and professional women in computing related fields for a one or two-day conference filled with national speakers, workshops, resume reviews, career fairs and time to network with other women in computing. This exposure to and time to socialize with role models of professional women in are important for students who are often the only female in their computing classes (NCWIT, 2013).

ACM-W administers a survey after every celebration. This study utilized the results from North America and Europe. This distinguishes this study from other studies because it included a broad range of data points. Whereas most studies that attempt to explain the experiences of women in computing are conducted at individual universities, this study has access to more women from diverse backgrounds across the undergraduate career into professional roles. This was a unique opportunity to learn from talented women who are persisting in computing by giving them a “voice” to make suggestions for better conferences and computer science education programs that could help women persist through graduation and into professional careers. This was also an opportunity to learn from students who are questioning their place in computing - considering whether to enter the field, or worse, deciding whether to leave it. By aggregating the survey data from the different celebrations, this study had access to a large enough population to utilize statistical methods that could not be conducted otherwise at individual colleges and universities (recall that based on national averages, if a computing program has 100 students, only 15 would be women). Additionally, this study had access to women at different stages of their career - academic through professional (freshmen, sophomore, junior, senior, professional) that allowed the exploration of issues at different points in their development.

This study also provides a service to the international organization (ACM-W) that oversees these conferences. Organizers have an economic and moral responsibility to ensure they are using their resources wisely. Hundreds of volunteer hours and hundreds of thousands of dollars from ACM, ACM-W, university, and corporate sponsors such as Microsoft, Google, and Intel, are spent delivering these regional celebrations. There is also the responsibility to the students who place their trust in the faculty to make these events worth their while to attend. Analysis of the survey data provided an empirical foundation on which to base recommendations for effective interventions in the future such as workshops that can be delivered at future conferences or academic settings such as during student club meetings.

As previously presented, this study explored whether there is empirical evidence to include self-esteem, defined in terms of two factors, in future research on women in computing – that self-esteem can be considered as a dependent variable affected by experiences in computing that could then act as an independent variable affecting persistence; that self-esteem has multiple dimensions (competence and worth) that need to be considered both separately and as a complement to each other; that the assessment tool used should measure self-esteem within the context of computing; and, that self-esteem is a developmental process that can be shaped and should be measured at different points - academic through professional employment. This empirical evidence can then provide the foundation for developing effective interventions in the future.

Significance of Study

Malala Yousafzai's quote at the beginning of this chapter presents a leadership challenge. She encourages women to take part in creating technology so they can change our world and change who runs it. However, to speak up and take the lead, women need a healthy self-esteem within the context of computing. Self-esteem has long been a part of teaching and learning (Harter, 2012; James, 1890/1993) as well as professional development and leadership (Burns, 1978; Pierce, Gardner, Cummings, Dunham, 1989). Therefore, this study adds to the literature on teaching and leadership by further demonstrating the importance of how these areas can affect self-esteem.

This study also has implications for college teaching and learning. Faculty desire for their students to succeed and there is empirical evidence that connects self-esteem to achievement and persistence (Harter, 2012). Our goal as educators is not so lofty to remove all negative experiences since students learn from both good and bad experiences (Mruk, 2013). Rather, what is important is making sure that when undesirable things happen, students not only endure but also prevail. Learning techniques that build resiliency can help students flourish under pressure. This is where interventions can help.

By grounding this study in the well-researched field of self-esteem, the questions are theoretically sound and backed by a century of exploration. Therefore, if self-esteem (competence, worthiness or both) is identified as a factor affecting women in computing, there are many theoretically sound, practically oriented, empirically supportable self-esteem enhancement programs that educators and business leaders can use as a starting point for intervention programs that will have persistent and significant results (Mruk, 2013, p. 119). Some interventions, such as judiciously providing positive feedback at appropriate times, require very little investment of resources and can be easily implemented.

Through using a freely available, valid, and reliable base for the survey, the Rosenberg Self-esteem Scale, this study may provide a short, cost-effective, survey tool that trained professionals can use to help departments identify student needs before they change their major (or worse, withdraw from school). Although tested within the context of computing majors, the procedure could be easily duplicated for other majors.

This study will aid in understanding the mixed results from other studies that have measured self-esteem and contribute to the literature on the following topics:

- using a **two-factor definition** of self-esteem so that both competence and worth are considered separately and together to achieve a comprehensive understanding of self-esteem;
- measuring both **global self-esteem (trait) and computing-based self-esteem (state)** to gain a better understanding of the behaviors associated with self-esteem within the specific situation of women in computing;
- measuring self-esteem **at different points** in the development of computing careers - academic through professional employment;
- considering the importance of experiences that constitute **self-esteem moments** that can create turning points in one's self-evaluation; and
- using a **mix of methods** to maximize the strengths and minimize the weaknesses of both quantitative and qualitative studies.

Definition of Terms

The key terms for this study are as follows:

Self-esteem. The lived status of one's competence at dealing with the challenges of living in a worthy way over time (Mruk, 2006, 2013). This is a two-factor definition for self-esteem including both competence and worthiness.

Competence. An individual's set of physical, cognitive, and social skills or abilities (Mruk, 2013). This is one factor of a two-factor definition of self-esteem. Used by itself, competence formed the basis for William James' (1890/1983) definition of self-esteem.

Worthiness. An individual's attitude or feeling of being valued especially by one's social group (Mruk, 2013) or the value they themselves place on their own actions. This is one factor of a two-factor definition of self-esteem. Used by itself, worthiness formed the basis for Morris Rosenberg's (1965) definition of self-esteem.

Healthy Self-esteem. Self-esteem that is a balance of high competence and high worthiness. This type of self-esteem can also be described as authentic, balanced, optimal, genuine, real, positive, secure, consistent, true, and stable. (Mruk, 2013).

Global Self-esteem (GSE). How one generally feels about his or herself on a day-to-day basis. The tendency for people to act in ways to maintain a sense of "self-sameness over time" through having enough "flexibility to adapt to new situations when they arise or to grow when circumstance favor furthering development" (Mruk, p. 92, 2013).

Domain-specific Self-esteem. Self-satisfaction in specific areas such as appearance, academics, social and may vary considerably from one domain to another (Gentile et al., 2009).

Organization-based Self-esteem (OBSE). This study uses this term to refer to one's self-esteem within the context of an organization. Positive correlations for persons with high

OBSE include feeling important, meaningful, effectual, and worthwhile within their employing organization (Pierce, Gardner, Cummings, & Dunham, 1989).

Computing-based Self-esteem (CSE). This study introduces this term to refer to one's self-esteem (defined as competence and worthiness) within the context their computing major or profession.

Computing. This study will use the term computing as an inclusive term to refer to the five sub-disciplines recognized by the Association for Computing Machinery (ACM): computer science (CS), software engineering (SE), information systems (IS), information technology (IT), and computer engineering (CE) (ACM, 2012).

Persistence. This study defines persistence as a person's resolve to complete a degree in a computing-related field.

Career Faithfulness. This study defines career faithfulness as a person's resolve to remain employed in a computing-field (Freeman & Aspray, 1999).

Attrition. This study defines attrition as a student leaving a computing major. This includes students who change majors or drop out of college entirely.

Self-esteem Experience. This study seeks to understand the meaningful experiences women have within their computing related major or profession and how they influence self-esteem. These poignant experiences are referred to as "self-esteem moments" (Mruk, 2013).

Status. This study will use the term status to categorize developmental times along a person's career: freshmen, sophomore, junior, senior, and academic or industry professional.

CS Education. Pedagogy and andragogy related to teaching computer science.

Delimitations and Limitations

Popular culture has brought attention to the low number of women reaching leadership positions. With books like *Lean In: Women, Work, and the Will to Lead* (Sandberg, 2013) and *Women Don't Ask* (Babcock & Laschever, 2007), authors highlight ways that women are prevented from and prevent themselves from getting ahead. For this reason, only women will be included in this study to allow an exploration of differences among women rather than defining women's experiences in relation to men's experiences. The hope is that women who read this study may be empowered by the stories that highlight the strengths and challenges of other women.

Gender inequity is even more pronounced in Silicon Valley where the top technology companies are located. Comprehensive studies such as "Gender Diversity in Silicon Valley" by Fenwick and West LLP (2013) showed that 45.3% of the top 150 technology companies (SV 150) do not have a female executive officer, compared to 16% of top 100 large public companies (S&P 100). Highly publicized articles such as the *New York Times'* "Out of the Loop in Silicon Valley" (Miller, 2010) further highlight the plight of women in technology. Interactive reports such as the *Wall Street Journal's* "Diversity in Tech" keep the public updated as the big tech companies publish their gender reports (Molla & Lightner, 2015). Although this is not just a pipeline issue, the number of women completing computing degrees is one piece of the puzzle. Women have earned about half of all science (including social sciences, mathematics, statistics, and economics) and engineering bachelor's degrees since the late 1990s, but the number of bachelor degrees earned is not evenly distributed across majors. Of the three with the lowest proportion of female majors (engineering, computer science, and physics) the lowest is computer science (NSF, 2015). For these reasons, only women in computing related fields (CS, SE, IS, IT, CE) will be included in this study. As a side note, gender diversity is not the only concern for technology companies. In 2015, only 3% of the female computing workforce were Black, 5% were Asian, and 1% were Hispanic. While this is a worthy line of research, combining the effects of gender plus ethnicity is beyond a reasonable scope for this study and will be left for future exploration.

Taking the study of women in computing one step further, this study focused on women who are currently persisting in computing, rather than focusing on those who leave. Intervention programs to improve student retention often, incorrectly, rely on research that documents why students leave (Tinto, 2012). Reasons for staying may not simply be the inverse of the reasons researchers have found for leaving. And, although they are related, understanding reasons for leaving does not necessarily translate into identifying ways to help students succeed (Padilla, 1999). Therefore, reasons for women staying in computing majors may not be simply the inverse of the reasons researchers have found that women leave the major (Kuhn & Joshi, 2006). By focusing on women who are currently in computing majors, this study allows for an exploration of what is working or not working for these women in order to help prevent their departure from the major.

Attendees of ACM celebrations of women in computing were selected for this study because of the unique research opportunity these conferences provide. In 2015-2016, twelve conferences were planned and each conference brought together between 50 and 200 women in computing at one time. This helps resolve the issue of small sample sizes that is typical with research on minority populations. These conferences also bring together women in computing from diverse work and school settings (public and private, different focus on research and teaching) from different geographic locations across the US.

Despite these strengths, several limitations warrant caution. First, this study used convenience sampling for data collection. There may be many reasons why a person may or may not attend a conference of this type; therefore, caution should be used if attempting to generalize the results of this study to the larger population of all women in computing. A second limitation of this study is the use of a survey to collect data. Since participants self-select to complete the survey, response bias is a concern. Although persons who complete surveys often tend to feel strongly one way or another leaving the middle ground unrepresented, this is not as much a concern for this particular study. Rather, a more relevant concern is that conference attendees may have felt obligated to participate due to the small, friendly environment of the conference. Another caution was the potential for socially desirable responses, whereby participants might have a perceived expectation that one should respond one way or another. A third limitation of this study is that it was cross-sectional rather than longitudinal. The results were collected at specific points in time to describe general trends. There is a possibility that a person may have taken the survey at different points in their academic career. This would not compromise the cross-sectional results of the study, however since longitudinal data was not collected this study cannot be used to determine cause and effect. A fourth limitation of this study is that the survey was administered in two different ways. Some participants received this study in paper format while attending the conference. Others completed the survey online after the conference as an addendum to a post-conference evaluation. Thus, consistency across surveys may compromise findings. This researcher considered these limitations while analyzing the data.

Organization of the Study

This chapter introduced the topic of women in computing and builds an argument for studying self-esteem, as a construct that may contribute to persistence in a computing major. This chapter also provided general definitions of key terms, statement of research questions, and a rationale for the study. Chapter 2 reviews the literature relevant to the topic of self-esteem and women in computing. Chapter 3 is an explanation of the research methodology used, data collection, and procedures of this study. Chapter 4 presents the descriptive narrative of the study's results and an analysis of the data. Finally, Chapter 5 summarizes this study's major findings and includes recommendations for future research and policy implications.

CHAPTER II. LITERATURE REVIEW

This chapter provides a review of literature related to self-esteem and women in computing. Included in this review are discussions of the different ways self-esteem is used in research studies and related examples from research on women and computing. The intent of this chapter is to examine and synthesize literature related to the topic, and further substantiate the need for self-esteem research to be conducted within the context of women's persistence in computing.

Before interpreting research that includes self-esteem, remember that 100 years of research on this topic has provided a rich and diverse pool of knowledge to draw upon. In fact, even after a century of research, the exact definition of self-esteem and how it should be properly assessed is still debated in the field of psychology (Mruk, 2013). Therefore, four points were considered while evaluating self-esteem findings on women in computing. First, the definition of self-esteem used by the researcher was identified. Some researchers use a competence-based definition (behavior/cognitive skills), some use a worthiness-based definition (meaning and values), and others use a two-factor definition (a balance between behavior/cognitive skills and the meaning or value one places on those skills). Second, the measurement of self-esteem was considered. Some research is more concerned with global (general, day to day) self-esteem while others are more interested in specific (within a certain situation or domain) self-esteem. Third, the use of self-esteem as an independent or dependent variable was determined. Some research situates self-esteem as an independent variable that is being shown to affect behavior, whereas others situate self-esteem as a dependent variable that can be affected or changed by experience. Fourth, the researcher's perspective of self-esteem as a fixed trait or a changeable state was considered. Research that considers self-esteem as a fixed trait will measure it once whereas research that considers self-esteem as a state that may change will measure it at various points over time to study developmental changes in self-esteem.

Literature related to these four points is highlighted below. Then, careful consideration of how self-esteem is being used in studies on women and computing is presented to help determine whether to compare, accept or challenge the findings. And finally, research related to self-esteem and leadership is discussed.

Four Facets of Self-esteem

Defining Self-esteem: Competence, Worthiness, and the Balance Between Them

Two major schools of thought on self-esteem have dominated the research over the years; however, in recent research a third definition has emerged. The oldest definition of self-esteem comes from William James (1890/1983) over a century ago. He defined self-esteem as the "ratio of our actualities to our supposed potentialities" (p. 296). Several things stand out in this definition. First, it focuses on the *behavior* or using one's *abilities*. However, James clarified that not all skills provide a source of self-esteem. Only those skills that involve "pretentions", for example those within one's aspirations, hopes, and dreams, provide a source of self-esteem (Mruk, 2013). James' definition also focuses on the effective use of one's abilities highlighting the importance of achievement and accomplishment. Therefore, based on James' definition, self-esteem is effectively using skills within domains that matter to one's identity. For instance, a person who identifies himself or herself as a computer programmer will feel an increased sense of self-esteem when they successfully complete a piece of software. However, they may not feel any change in self-esteem when they finish writing a history paper. This is where all **competence-based** definitions of self-esteem stem from. In fact, James writes of the "art of teaching" and the importance of helping students acquire skills in his *Talks to Teachers on*

Psychology: And to Students on Some of Life's Ideals (1906). The very nature of skill acquisition and the visible demonstration of those skills spurred research in areas of behavior, motivation, and self-efficacy (White, 1959).

Related to this competence-based school of thought is research on self-confidence. A phrase often heard related to women in computing is what some people call the "imposter phenomenon" or "imposter syndrome". Pauline Clance and Suzanne Imes (1978) explained that the imposter phenomenon describes the internal experience of feeling that one is an intellectual phony and seems to be prevalent among high achieving women (p. 1). This topic was brought to the attention of women in computing in 2010 at the national Grace Hopper Celebration of Women in Computing conference where a panel of highly respected women computer scientists shared their feelings of doubt about their competence. Even though their performance is the same as men, women tend to underestimate their abilities and will often turn down opportunities for personal and professional growth and promotion because of their self-doubt (Ehrlinger & Dunning, 2003). Although it takes more than just confidence to take action, a lack of confidence can be enough to prevent action even when one has the competence (Petty, Briñol, & Tormala, 2002). Having a minority status (as women do in computing) can further complicate feelings of confidence and self-validation because messages from minority sources tend to be perceived as less persuasive and therefore more often questioned (Horcajo, Briñol, & Petty, 2014). Related to science and engineering, Strenta, Elliott, Adair, Matier, and Scott (1994) found that women in these majors were distinctly less confident (questioning their own abilities) and more depressed about their academic progress than their male peers. However, a national study of women engineers (Fouad, et al., 2012) found that although self-confidence was the largest predictor of both intention to leave engineering as well as intention to stay in engineering, women who persisted and women who did not showed no difference in level of confidence. In addition and contrary to Strenta et al.'s study, Lewis, Smith, Belanger, Harrington (2008) found that satisfaction with the major (worthiness) was the most important factor in determining intention to leave the CS major and surprisingly, technical skill (competence) was the least important. These results demonstrate that perhaps more than just confidence in one's competence is needed to retain women in computing.

The second major school of thought in the study of self-esteem comes from Morris Rosenberg (1965). He defined self-esteem as a feeling of one's worth or value as a person. This definition differs from James' in that it is affective in nature rather than observable. But this definition grew in popularity among social scientists who were used to creating scales to measure attitudes, so a whole new body of research was established. Using self-report scales allowed researchers to create levels of self-esteem and use these levels to compare and predict behavior. For example, scales allowed researchers to compare the self-esteem of male and female elementary school students and to draw connections between self-esteem and depression, anxiety, neuroticism, happiness, academic success, and other characteristics. Today, some researchers in this school of thought see self-esteem as a process of evaluation and attitude formation but others see it as much more central to self and essential to one's identity (Epstein, 1985). Others also see self-esteem as a critical component in interpersonal relationships (Leary, Tambor, Terdal, & Downs, 1995). Mruk (2013) refers to self-esteem in this context as the "emotional glue that holds personal identity and social relationships together" (p. 16).

Related to this **worthiness-based** school of thought, is the idea of the "chilly climate". Roberta M. Hall and Bernice R. Sandler coined this phrase in 1982 to bring awareness to the frigid climate that women experienced on college campuses. Bernice Sandler fought tirelessly to help colleges recognize the importance of "institutional atmosphere, environment, or climate – both within and outside the classroom – in fostering or impeding women students' full personal, academic and professional development" and to help colleges understand that "females tend more than males to be attuned to the personal supportiveness of these environments" (p. 2, 1982). She argued that subtle and not-so-subtle faculty behaviors can have a critical and lasting effect on women, including the following:

- discouraging classroom participation;
- preventing students from seeking help outside of class;
- causing students to drop or avoid certain classes, to switch majors, and in some instances even to leave a given institution;
- minimizing the development of the individual collegial relationships with faculty are crucial for future professional development;
- dampening career aspirations; and
- undermining confidence.

As a result, she asserted that women may begin to question their self-worth and believe and act as though their:

- presence in a given class, department, program or institution is at best peripheral, or at worst an unwelcomed intrusion;
- participation in class discussion is not expected, and their contributions are not important;
- capacity for full intellectual development and professional success is limited; and

- academic and career goals are not matters for serious attention or concern (p. 3, 1982).

Research has shown that this "chilly climate" is prevalent in STEM, diminishing women's sense of belonging and leading to their lack of interest (Cheryan, Plaut, Davies, & Steele, 2009; Good, Rattan, & Dweck, 2012; Murphy, Steel, & Gross, 2007; Smith, Lewis, Hawthorne, & Hodges, 2013). Prevailing stereotypes about women's competence and worth in computing can cause uncomfortable psychological states for women which could hinder their abilities and behaviors that develop them (Appel, Kronberger, & Aronson, 2011). The culture of computing may not just be chilly; some women might find it to be outright alien (Kiesler, Sproull, & Eccles, 1985) and completely misaligned with their own values and interests (Eccles, 1994). Therefore, many women feel pushed away by the overall environment of science, technology and engineering and may seek situations in other majors where they experience greater social belonging (Chen, 2012, 2013; Thoman, Smith, Brown, Chase, & Lee, 2013).

Despite this chilly climate, however, some women persist. So perhaps a sense of worthiness is not the full picture of self-esteem. Simply believing that the study of computer science is worthy of their time and embracing the geek-culture of computer science is not going to be enough to help one pass skill-based exams and complete complex projects common to science-related disciplines.

The unidimensional definitions of self-esteem fall short in explaining women's choice not to persist in computing. The **competence-based** definition of self-esteem is contingent upon success and failure making it both an asset as well as a liability such as when the pursuit of self-esteem harms that person's reputation and relationships with others (Crocker & Park, 2004; Mruk, 2013). And, unfortunately, the **worthiness-based** definition of self-esteem comes up short defined as merely feeling good about oneself. On the one hand, this worthiness definition could be associated with dignity, honor, and conscientiousness, however, it could also be associated with negative characteristics such as egotism, narcissism, or aggression (Baumeister et al., 2003). For these reasons, research on self-esteem often provides conflicting results.

Although common sense tells us that our self-esteem matters, some researchers have been puzzled by the lack of strong empirical support for such a position (Baumeister et al., 2003; Emler, 2002; Smelser, 1989). Perhaps seemingly weak relationships between self-esteem and behavior (e.g., persistence in computing) may be a result of using one of the unidimensional definitions of self-esteem discussed above. Researchers have either used a competence-based definition that focused on behavior/cognitive skills (James, 1880/1983), or a worthiness-based definition, that focused on the participants' evaluation of the meaning or value of their actions (Rosenberg, 1965). However, there is a third definition that provides a more complete understanding of self-esteem. This two-factor definition considers both competence *and* worthiness and the balance between them (Mruk, 2006; Richardson, Ratner, & Zumbo, 2009; Tafarodi & Milne, 2002). Modern researchers of self-esteem who wish to be "empirically rigorous" are urged to use a dual, two-factor, or as some call it, a multidimensional approach (Mruk, 2006, p. 20). These two factors, competence and worthiness, intersect to create a comprehensive picture of self-esteem which may explain the effects of the chilly climate (worthiness) and imposter syndrome (competence).

For example, Tafarodi and Milne (2002) explain that using only one dimension of self-esteem is comparable to using only one measurement to describe a rectangle. To illustrate this point, consider a room. Although the length of a room is important, it does not provide a full understanding of the area of the room. Similarly, the same can be said for only knowing the width of a room. However, once the length *and* the width are known, the area that makes up the room can be realized. Analogously, only knowing how one feels about their competence or only knowing how one feels about their worth, provides at best only a partial understanding of their self-esteem. However, once their feelings of competence *and* worth are revealed, the relationship between them that makes up self-esteem can be more fully appreciated.

Mruk explains the interaction between competence and worth through the illustration of two perpendicular intersecting lines (2013). The horizontal line (the x-axis) represents a person's competence where a self-evaluation in the positive direction (to the right of the intersection of worth) indicates higher competence and a self-evaluation in the negative direction indicates lower competence. The vertical line (the y-axis) represents a person's sense of worth where an evaluation in the positive direction indicates higher self-worth and an evaluation in the negative direction (below the intersection of competence) indicates lower self-worth (see Figure 1).

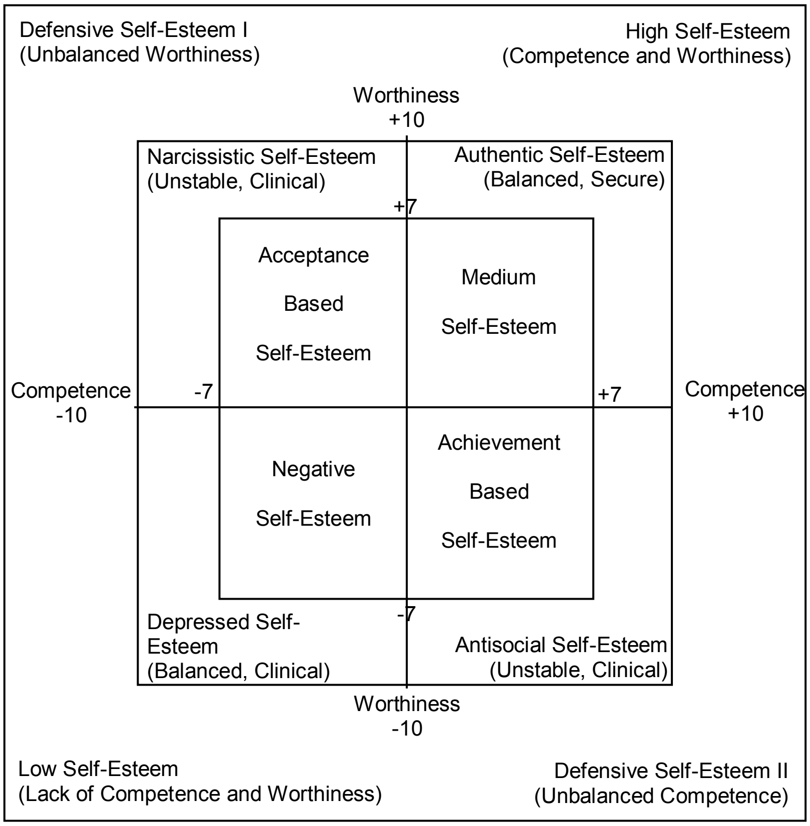

Figure 1. Self-esteem matrix. Adopted from Mruk (2013, p. 150).

High self-esteem is achieved when competence and worthiness are both extremely high. In this case, self-esteem is considered to be healthy and authentic. Unfortunately, this is difficult to sustain as lived experiences challenge worth, competence or both so people tend to bounce around in the medium self-esteem category. On the opposite end, low self-esteem happens when competence and worthiness are both extremely low. In this case, self-esteem is considered to be clinically depressed. Self-esteem that remains too long in this zone can manifest in dangerous symptoms. Fortunately, increases in competence, worth, or both can help bring persons through the area of negative self-esteem and into healthy self-esteem. When competence and worthiness are not balanced, self-esteem needs to be defended. For instance, if one bases all their self-esteem on worthiness (e.g., peer group approves), but competence is extremely low (e.g., poor grades are earned), behavior becomes narcissistic and unstable. If acceptance is challenged (e.g., a peer group shows disapproval), this self-esteem does not have enough competence to lean on and behavior can become defensive. Again, fortunately, increases in competence can help bring self-esteem into a healthy balance so that when acceptance is challenged, self-esteem can be protected by competence. On the opposite end, high competence (e.g., earning good grades) but low worthiness (e.g., a chilly climate) puts too much pressure on achievement. In the extreme case, behavior becomes antisocial and unstable. If achievement is challenged (e.g., a low mark is earned on an assignment), this self-esteem does not have enough worthiness to lean on and can result in defensive behavior. Fortunately, increases in worthiness can help bring self-esteem into a healthy balance so that when achievement is challenged, self-esteem can be protected by worthiness.

Global and Context Specific Self-esteem

Another reason weak relationships between self-esteem and behavior (e.g., persistence in computing) have been found may be a result of using a global measure of self-esteem rather than a context specific measure of self-esteem (Rosenberg, Schooler, Schoenbach, & Rosenberg, 1995). This is a paradox of self-esteem, that it can be both relatively stable over time, but also fluctuate within certain contexts and is not always considered when including self-esteem as a variable in research and therefore the tool used to measure self-esteem may not be measuring what researchers think it is measuring. This aspect of self-esteem has been called “trait versus state” self-esteem (Leary, et al., 1995), “stable versus unstable” self-esteem (Greenier, Kernis, & Waschull, 1995) and global versus situational self-esteem (Harter, 2012).

Marsh's (1986) research has shown that these two types of self-esteem cannot be used interchangeably. Although how one feels about themselves in general on a day-to-day basis (global self-esteem) has been shown to affect one's psychological well-being, researchers have shown how one feels about themselves in specific contexts or domains that have value to them has a greater effect on one's behavior (Harter, 2012; Rosenberg, Schooler, Schoenbach, & Rosenberg, 1995; Wells, 1988). Specific to academics, Harter (2012) found a relationship between motivation and academic specific self-esteem that may explain why excellent female students earning good grades decide not to continue past the first year of computer science coursework.

For example, Rosenberg et al. (1995) explain that if one wants to study the relationship between self-esteem and school marks, one must consider self-esteem within the specific context of academics. Studying general or global self-esteem will not explain specific behavior in school. A person may have a healthy self-esteem in general, but when it comes to schoolwork, their academic-specific self-esteem may be significantly different if grades are important to them. Their academic self-esteem would be more closely associated to related behaviors such as concept attainment than would their general self-esteem (Shrauger, 1972).

For example, related to computer science, Biggers, Brauer, and Yilmaz (2008) found five experiences to be important in student retention and offered the following suggestions for improvement. One suggestion was related to competence and the need to support students entering with less experience. Another suggestion was related to worthiness and the need for more social, welcoming, supportive environment. But the other three were related to the context of self-esteem. These suggestions focused on the *relevance* of computer science and the need to expose students to the "big picture", make coursework more relatable, and help students perceive the workload as worth their while. Tapping into this relevance is where measuring domain specific self-esteem (i.e., within the context of computer science) may be more useful to researchers interested in CS retention, rather than measuring global self-esteem (i.e., general feelings of self-esteem without a specific context).

Self-esteem as an Independent or Dependent Variable

Self-esteem has been studied as an independent and dependent variable. As an independent variable, self-esteem has been shown to affect behavior. For example, low self-esteem has been shown to result in avoidance and detachment behaviors and high self-esteem has been shown to result in openness to change and engaging behaviors (Mruk, 2013). Viewed this way, a person's self-esteem is considered important for handling the challenges faced on a day-to-day basis so some researchers use self-esteem to predict behavior. To investigate these external realities of behavior and their causes, researchers use methods such as observation, correlations such as surveys and tests, and experimentation. These quantitative approaches allow the researcher to control variables and reduce behavior to something that can be measured. Once measured, behavior can be explained using statistical interpretations.

As a dependent variable, self-esteem can be affected by situational experiences. Used this way, researchers study experiences to understand what causes changes to self-esteem (Mruk, 2013). Researchers then use these underlying causes to create interventions. To investigate these internal realities of human experiences and their meaning, researchers use methods such as introspection, case studies and interviews, and phenomenology. These qualitative approaches allow researchers to describe self-esteem as it happens in real life. Used together, qualitative and quantitative paradigms complement each other. Where quantitative measures translate human behavior into components so it can be measured, qualitative measures allow rich descriptions of personal experiences to provide meaning for human behavior.

Epstein (1997), Tafarodi and Milne (2002), and Mruk (2013) found that there are experiences that can be a turning point in a person's self-esteem. In a study titled, *Experiences that Produce Enduring Changes in Self-Concept*, Epstein asked 270 college students to complete forms describing the single most significant positive and the single most negative event in their past and their feelings before, during and after the experience. He found that experiences could be grouped in to three major categories – positive-positive, negative- positive, and negative-negative.

The positive-positive group described positive events that resulted in positive feelings. The positive events included new environment, success in a difficult undertaking, or gaining respect for admirable behavior, positive love relationship, new activity, affiliation with a new group, new social role, and being forced to assume greater autonomy. Positive feelings following these positive events included feeling alert, moral, competent, happy, spontaneous, secure, pleased with self, clear-minded, loveable, and kindly. Epstein found it particularly interesting that in addition to increases in positive feelings and self-esteem, participants reported spontaneous reactivity to the world, harmonious cognitive functioning, and positive regard for others. These feelings contributed to reported changes in behavior, attitudes, and goals such as social interest, increased positive self-regard, increased tolerance and openness to new experience, increased dedication to basic values and long-term goals, increased positive regard for others, and increased autonomy.

The negative-positive group described negative events that initially produced negative feelings but eventually resulted in positive feelings. These negative events included exposure to a new environment, new social role, being negatively evaluated, having an unsuccessful love relationship, affiliation with a new group, observing an example of another's antisocial or otherwise undesirable behavior, rejection by a group or loss of group affiliation, taking up a new activity, demonstration of inadequacy or immoral behavior, and forced autonomy. Epstein noted that although these experiences created inner conflict they resulted in increases in self-esteem and positive feelings such as reactive, happy, pleased with self, competent, loveable, and moral. These feelings contributed to reported changes in behavior, attitudes, and goals such as increased dedication to basic values and long-term goals, increased social interest, increased expansiveness and openness to new experience, increased positive self-regard, increased positive regard for others, and increased autonomy.

The negative-negative group described negative events that resulted in negative feelings. Negative events included exposure to a new environment, demonstration of inadequacy or immoral behavior, being negatively evaluated, being rejected by a loved one, death of a loved one or acquaintance, disturbed love relationship, loss of group affiliation, and introspective negative self. Negative feelings following these negative events included feeling threatened, tense, unhappy, unworthy, inhibited, confused, and conflicted. The end result was a more focused negative evaluation of the self. These feelings contributed to reported changes in behavior, attitudes, and goals such as personality constriction or reduced openness to new experience, increased negative self-regard, decreased concern with basic values and long-term goals, increased antisocial behavior, and decreased social interest. Surprisingly, these negative feelings also led to two positive effects in some people: increased dedication to basic values and long-term goals and increased expansiveness and openness to new experience. Thus, demonstrating that negative experiences were more complicated than positive experiences and tended to have mixed effects.

Epstein's study (1997) revealed a few experiences that created positive feelings in some people and negative feelings in other people. He explained that what mattered is "how the experience was perceived and how it related to the abilities and characteristics of the individual" (p. 75). Epstein suggested that it would be useful to learn more about what he called the assimilation processes that helped people turn bad experiences into valuable lessons.

Tafarodi and Milne (2002) studied the effects of negative events on self-esteem. They hypothesized that there are two different dimensions of self-esteem – self-liking and self-competence - and that different negative events would have different effects on these two dimensions of self-esteem. They asked 244 students to complete a self-esteem survey at two times four weeks apart. Between that time, students were asked to record personally important negative events that occurred during that time and to rate the intensity of the event's negative impact. They found no significant gender or racial differences. They did find as they hypothesized, that negative social events such as rejection, disapproval and interpersonal conflict not only negatively affected self-esteem but also more specifically affected the self-liking (worthiness) dimension of self-esteem. Likewise, negative achievement events such as failure and frustration not only negatively affected self-esteem, but also more specifically affected the self-competence (competence) dimension of self-esteem. They argue that a balanced understanding of the nature and importance of both dimensions may help explain the conceptual differences that seem to impede progress in understanding self-esteem and suggest that future research should investigate the impact of positive events as well as negative events.

Self-esteem as a Fixed Trait or State that Can Change Over Time

Much research has been conducted to determine whether self-esteem is stable over time similar to a personality trait or whether self-esteem is a developmental process. For more than four decades, Susan Harter has researched self-esteem from a developmental perspective. She and her colleagues have found that self-esteem changes over the lifespan and have created a suite of age appropriate assessment tools used to assess self-esteem within distinct domains such as scholastic competence, social competence, physical appearance, athletic competence, behavioral conduct, and self-worth over six stages of development: early childhood, middle to late childhood, adolescence, college years, middle through late adulthood, and late adulthood (Harter, 2012). Each stage has its set of challenges and developmental outcomes. Of specific concern during the college years, is depression. Four possible sources of depression are normative for this age group: separation from parents, breakups from romantic relationships, concerns about one's competence, and uncertainty about how to proceed with so many possibilities. Harter explains that this is a time when there is a greater need for social support from mature adults to help navigate these new challenges, however, now that students have graduated from high school, there is less structure, less social support, and the rules seem more ambiguous. Just as students are making important life decisions about their occupation and its impact on their identity, social support is changing from familiar parents and friends, to new unfamiliar and influential adults such as professors and coaches and new peers such as classmates and roommates. Besides learning how to get along with new people with vastly different backgrounds, college students need to establish their place in this new environment. In the past, it was always assumed that parents, teachers, and friends would be there for support. Now in college, new sources of support must be developed and earned. Harter identified that this "public" peer support is the primary source of self-esteem for college age students and that public peer support in the form of earned approval is the most critical to self-esteem across the lifespan (2012, p. 143).

To understand the role that social support might play to change or maintain self-esteem, Harter and Whitesell (2003) and her colleagues asked incoming students to take a questionnaire before they matriculated and then administered the same questionnaire two quarters later. She found three sub-groups of students: those whose self-esteem increased, those who decreased, and those that stayed the same. Those whose self-esteem increased showed dramatic increases in social support in their new university experiences compared to the experiences they had in high school. They found like-minded peers and supportive social groups, campus organizations, teachers and clergy. Those whose self-esteem stayed the same began their college experience with high self-esteem and found ways to maintain it during their first year. Like the group that increased in self-esteem, they found social support through connections with campus activities and social groups. Those whose self-esteem dropped were unable to make those connections that would offer social support. Not only did they experience a drop in self-esteem but they also reported an increase in feelings of depression.

To study gender differences in self-esteem over time, Kling, Shibley, Showers, and Buswell (1999) conducted a two-part meta-analysis. The first analysis included studies from a literature search, a dataset from the National Longitudinal Study of Youth (ages 14 to 22), and a dataset from the American Association of University Women (ages 9 to 15). They restricted the studies considered for the dataset to only those that measured global self-esteem defined as an overall evaluation of the self, and assessed by the following tools: the Rosenberg Self-esteem scale (Rosenberg, 1979), the Global Self-Worth subscale of Harter's Self-perception Profile for

Children scale (Harter, 1982) and the General Self subscale of Marsh's Self-description Questionnaire (Marsh, 1992). The final database included 44,394 males and 52,727 females. Analysis revealed a quadratic effect increasing from ages 7 to 10 (d = .16) through ages 11 to 14 (d = .23), peaking with ages 15-18 (d = .33), and decreasing with ages 19 to 22 (d = .18) through ages 23 to 59 (d = .10) and ages greater than 60 (d = -.03). The overall weighted mean effect size is considered small (d = .21).

The second analysis used data from four longitudinal studies conducted by the National Center for Educational Statistics (NCES) from 1972 to 1992: the NLS-72, the HS&B (senior cohort), the HS&B (sophomore cohort), and the NELS:88. The NCES uses four questions from the Rosenberg Self-esteem Scale to assess self-esteem. The final dataset included approximately 50,000 respondents. Data from the NCES was collected over a 20-year span starting in the 8^{th} grade with some studies going beyond high school. Analysis provided mixed results regarding self-esteem differences between males and females between age groups. However, focusing analysis on respondents who were 17 years old revealed a small gender difference that favored males. The effect sizes were smaller than .20 indicating that the means of males and females were less than one fifth of standard deviation apart (p. 485).

Robins, Trzesniewski, Tracy, Gosling, and Potter (2002) also studied global self-esteem over the lifespan. Analysis of 326,641 responses to an online survey revealed differences in self-esteem from ages 9 to 90 years. While Kling et al. had found a quadratic effect, Robins et al. found a cubic effect for global self-esteem with two high points. They found that self-esteem is high in childhood, falls in adolescence, levels out in college and remains steady until mid-adulthood where it rises until late adulthood taking a steep decline in old age. Although males and females in the 9 to 12 years old start with almost identical self-esteem, on average, across all ages, males reported higher self-esteem than females (Cohen's $d = .22$, $p < .01$). For females, self-esteem dropped almost twice as much as males during adolescence and although it increased in middle adulthood, it never recovers to the point of where it was in childhood. For males, while self-esteem drops in adolescence it does not do so as steeply as it does for women, and during adulthood it recovers more quickly than for women, and eventually surpasses the high self-esteem of childhood. In old age, the gap between male and female self-esteem begins to close with women's self-esteem eventually surpassing that of males.

To gain a better understanding of how self-esteem might differ between genders within specific domains, Gentile, Grabe, Dolan-Pascoe, Twenge, Wells, and Maitino (2009) conducted a meta-analysis that included 115 studies, 428 effect sizes, and 32,486 individuals. The scales used in these studies measured gender differences in self-esteem based on appearance, athletics, academics, social acceptance, family, behavioral conduct, affect, personal self, self-satisfaction, and moral-ethical self. Prior to analysis, the researchers used two theoretical frameworks to predict which gender might be favored in each domain. The first theoretical framework was based on competencies model (James, 1890) while the other was based on the reflected appraisals model (Cooley, 1902; Mead, 1934) that posits that our self-esteem is rooted with our relationship with others. As it turned out, the reflected appraisals model was correct more often than the competencies model. Males scored significantly higher than females in the domains of athletics ($d = .41$), personal self ($d = .28$) and self-satisfaction ($d = .33$). Gender difference favoring males for physical appearance ($d = .35$) was significant only after 1980 and was largest among adults. Females scored higher than males on behavioral conduct ($d = -.17$) and moral-ethical self-concept ($d = -.38$). No significant difference was found for academics ($d = .04$), social acceptance ($d = .04$), family ($d = .02$) and affect ($d = .11$). The research suggested that perhaps competencies and reflected appraisals canceled each other out for academics and social acceptance. When these domains are broken down by age groups, college age males scored higher than females in physical self-esteem (*d* = .27) and slightly higher for self-satisfaction (*d* = .05). College age females scored higher than males in behavior self-esteem (*d* = -.27) and only slightly higher for academic self-esteem (*d* = -.07).

Digging even deeper into the academic domain, Else-Quest, Hyde, and Linn (2010) conducted a meta-analysis of gender differences in mathematics. Aware of the underrepresentation of women in science, technology, engineering, and math (STEM) they analyzed two international datasets, the 2003 Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) to understand gender differences in achievement, attitudes and affect. Combined, the TIMSS and PISA represented 493,495 students 14-16 years of age, from 69 countries. The TIMSS primarily tests mastery of curriculum. The weighted mean effect size for achievement (math, algebra, data, geometry, measurement, number) was -.01 showing that boys and girls performed similarly. However, scores for self-confidence in math (*d* = .15) and valuing math (*d* = .10) were higher for boys than girls. The PISA primarily tests math literacy (using math to solve problems). Here the researchers reported a very small weighted mean effect size (*d* = .11) for achievement (math, quantity, space/shape, change/relationships, uncertainty) favoring boys. Even with similar scores, girls scored higher on anxiety (*d* = -.28) and boys scored higher in extrinsic motivation (d = .24), intrinsic motivation (*d* = .20), self-concept (*d* = .33), and self-efficacy (*d* = .33). In summary, analysis revealed that mean effect sizes in mathematics achievement were very small (*d* < .15). However, despite the gender similarities in mathematics achievement, boys reported more positive math attitudes and affect.

A point that needs to be considered related to these studies is that although they support the argument that self-esteem can change over time and that self-esteem may matter within the academic context, these studies report self-esteem as a single measure. It is possible that these overall self-esteem scores may be masking differences in worth, competence or both. For example, two people may score the same overall on a self-esteem scale. However, one may have scored high on the worthiness dimension but low on competence dimension and the other person may have scored low on the worthiness dimension but high on the competence dimension. In this case, these two individuals seem to have the same self-esteem but they are actually very different. A person with high worthiness and low competence may be fitting in well with his or her classmates but is not passing exams. A person with low worthiness and high competence may not feel a sense of belonging but is getting high marks on their exams. These individuals therefore would benefit from different types of interventions.

Self-esteem, Women, and Computing

Women and Computing: Competence Considered

One way to define self-esteem is as a measure of one's assessment of competence and achievement. Katz, Allbritton, Aronis, Wilson and Soffa (2006) explored why highly achieving students leave computer science majors. They found that women seemed to be more affected by a loss of confidence than were men and that lack of interest often accompanied loss of confidence, which resulted in their choice to leave the major. The researchers administered surveys throughout the four-course programming core to 200 computer science students and others such as Engineering students, required to take the four, core computer science programming courses at the University of Pittsburgh.

Katz et al. (2006) found that the same factors that predict achievement, such as math and verbal SAT score, the number of Calculus courses taken and prior computing experience also predict persistence beyond the first two courses. Home access to a computer and having a mentor or role model during high school also predicted achievement. However, several interactions between gender, achievement and persistence were also found. Male students who earned less than a B in the introductory computer science courses were more likely to take the next course than were women who earned less than a B. Findings support the argument that achievement (competence) was a factor in women's decision to leave CS, even for high-achieving students. Additionally, findings showed that loss of confidence in women's achievements (competence) was often accompanied by loss of interest. Surprisingly, women who reported more exposure to programming constructs before the introductory course, performed worse than women who had less programming experience. The researchers also found evidence to support their conjecture that substituting the development of math skill with programming skill development during high school may be detrimental to performance in an undergraduate computer science program, especially for women.

Katz et al. (2006) acknowledged the limitations of the study (small sample size and participants recruited from only one institution) and recognized the need for further research to test the validity and generalizability of their results. The researchers explain that two important questions remain: Why are male students who earn below a B in their computer courses more likely to persist than women at the same level? Furthermore, what can be done to sustain the confidence and sense of worth of promising students when their grades do not meet their expectations?

Crocker, Karpinski, Quinn, and Chase (2003) also studied self-esteem, grades and program persistence but instead of focusing on competence, they focused on the consequences of self-worth. For male and female engineering and psychology majors, the researchers found that poor grades had a stronger negative affect on female students' self-esteem than it did on men's self-esteem. However, unlike Katz et al. (2006) this negative affect on self-esteem did not create a stronger misidentification with the major. One hundred twenty-two students (32 men and 30 women majoring in engineering, 28 men and 32 women majoring in psychology) completed a pretest. Then for three weeks, participants completed a five-minute online questionnaire three times a week plus any additional days they took an exam or received a grade on an exam or paper. At the end of the semester, the students completed a posttest.

Crocker and her colleagues found several self-esteem related results. They found that students who based their self-worth on academic achievement (competence) had lower self-esteem when they did poorly on graded activities but did not have improved self-esteem when they did well on graded activities. Interestingly, women did not dis-identify with their major when they received poor grades, even though their self-esteem dropped. Most troubling however to the researchers was that *self-esteem instability* predicted greater depressive symptoms for students initially more depressed. The researchers explained that depression has high costs for learning, intrinsic motivation, stress and well-being and suggested that the combination of drops in self-esteem due to academic achievement (competence) and the prevailing negative stereotypes for women's abilities in engineering, might contribute to the high rate of attrition for women in engineering. Although this study did not find an interaction between gender, self-esteem and dis-identification with the major, the authors point out that this study included students at all stages of their career which may have obscured evidence of dis-identification that may occur earlier in a college career. The researchers conclude that their findings suggest that all students should be advised to find others sources for their self-esteem in addition to their academic competence.

Women and Computing: Worthiness Considered

Other sources of self-esteem can come from the environment. These sources are related to another way of defining self-esteem as a measure of one's feelings of worthiness, acceptance, and fit in within a setting. To show how group dynamics affect a persons' feeling of self-esteem, Crocker and McGraw (1984) studied the consequences of having *solo status* (being the only female or male in a group). Students (*N*=156) at Northwestern University were scheduled in groups of six. Three conditions were created for the groups: one male and five females, or one female and five males, or three males and three females. Participants ranked some items then joined a group to agree on the rankings. After the task, participants answered a questionnaire rating a male and female member of the group.

Crocker and McGraw found that males were almost twice likely to be identified as group leaders when they were the only male in the group. Females never identified themselves as leaders. Females in all male groups were more likely to indicate that they would have preferred to be placed in a different gender composition group. The participant's gender was mentioned only if the person they were rating was a solo and mentioned more often when the solo was a female. Men were rated more masculine but the magnitude of the difference depended on the group composition. A person's gender was invoked as an explanation for behavior for both sexes, but most often in the groups with only one female. In the solo female groups, all members thought that the men's behavior was related to the solo member being a female. Non-solo members perceived their own behavior to be due to the gender of the person they were rating in the solo female condition.

Although further research must be completed outside a controlled laboratory setting to study the consequences of these findings, Crocker and McGraw's study provides insight into group dynamics and the issues that might arise in a group or class where there is only one woman. Further studies might reveal that placing a solo women in a group of men may have adverse effects on that student's perception of their place in the group or class and therefore their place in a major. This perception may have then have an impact on self-esteem, especially on one's sense of worthiness as a valued colleague or team member, and affect a student's decision whether to stay in computer science.

Related to social acceptance, Cross and Vick (2001) researched social support and found that high levels of social support helped in some situations. High levels of social support involve a greater degree of acceptance, which is related to the worthiness dimension of self-esteem (Mruk, 2006). Cross and Vick studied self-esteem and persistence during the first two years of an undergraduate engineering program and found that students who desire close relationships felt a sense of misfit in their competitive engineering environment but that high levels of social support helped mitigate this effect. One hundred and twenty-five domestic (non-international), first semester engineering (i.e. non-transfer, non-repeating) students completed a first survey during the first few weeks of their first engineering course. A second survey was completed during the second semester of their engineering program. And, at the end of the student's second year, persistence information was obtained from the engineering college. Cross and Vick (2001) found that participants with high interdependent preferences, who are more often women, benefited from social support. They found greater increases in self-esteem, fewer thoughts of transferring, and greater likelihood of continued enrollment in engineering after two years. Interestingly, this study revealed very few gender differences. This could help move researchers away from examining gender as a predictor of success and look more to individual factors such as competence and worthiness. Both competence and worthiness are important to both genders, but males have a stronger sense of belonging, which may contribute to their development and competence in the major.

Although the study had a small sample size and all participants were from the same university, this research highlights the need to study the social aspects of self-esteem. Additionally, the researchers suggest results from this study demonstrate the need to develop support programs for students that are based on theoretical foundations such as self-esteem. Cross and Vick's research explained above, revealed that environmental factors do contribute to student retention. Jackson, von Eye, Fitzgerald, Zhao, and Witt (2009) also studied environmental factors but within the setting of middle school. They examined whether technology use is related to dimensions of self-concept and/or to self-esteem and whether there are any gender and/or race differences in self-concept, self-esteem, and technology use. They invited students and parents in the Detroit, Michigan area to complete a survey. Five hundred children (*M* age = 12.19, range 11-16 years) completed the Youth Survey and their parents completed the Parent/Guardian Survey.

Jackson et al., found that household income and gender positively predicted self-concept. With relation to self-concept, they found that girls had higher academic self-concepts and behavioral self-concepts whereas boys had higher physical appearance self-concepts and athletic self-concepts. Boys and girls had similar social self-concepts. They found no gender difference in overall self-esteem. However, the most robust finding was the gender difference in video gaming with boys playing more. The researchers were most concerned because video game playing was associated with a low behavioral self-concept and self-esteem.

Salminen-Karlsson (2009) also studied the gender-technology retention issue, but within the setting of community college students in Sweden. Her research sought to examine differences and similarities related to gender but her approach was different from most gender studies in that she examined both men and women and identified learning-clusters that did not follow a strictly male learning or female learning pattern. She found what she called *gender transgressors* - individuals or groups who have adopted some of the learning pattern of the opposite sex. One hundred forty-three women and 35 men completed a questionnaire about their computer courses, teacher, attitudes about computers, computer use, and themselves as computer learners. Twenty-six percent were under age 30, 20% were between 30-40, 29% were between 40-50, and 24% were over 50. She found that the results broke into three clusters: a typical male pattern, a typical female pattern, and a female pattern that resembled the male pattern. The distinguishing factor that separated the females into two groups was dissatisfaction with the way the course was taught.

Although this study had a small sample size, it might demonstrate why recommendations to meet female computer learning needs may not be serving a good portion of women. Salminen-Karlsson states, "These women refute the negative image of women being computer anxious, uninterested in, and left behind by the digital revolution – the image of women being different from and inferior to men" (p. 165). Through finding that not all women are the same she highlights the need to study similarities and differences among women and cautions against using oversimplified gender dichotomies. She suggests that researchers need to know more about these different groups of women and poses the following questions: Are some women more competent and interested than men but have differences in self-understanding that prevent them from continuing? What are these competencies and how did they learn these competencies? In addition, what is the role of adult education?

Continuing with the theme of self-esteem within different settings, LeRouge, Nelson, and Blanton (2006), explored the impact of role stress fit and self-esteem on the job attitudes of IT professionals. They surveyed IT developers from twelve Fortune 500 companies. One hundred twenty-four IT professionals (54% male, 43% female) completed the survey (*M* age = 36.80, *M* IT experience = 12.45, *M* tenure current position = 3.40, *M* tenure organization = 7.83). The survey included questions regarding job satisfaction, organizational commitment and self-esteem defined by the researchers as the extent that employees feel valued and taken seriously (worthiness). Role stress fit was measured as the difference between preferred and perceived role stress.

LeRouge and her colleagues found that role stress fit is positively related to job satisfaction and organizational commitment and that self-esteem significantly moderated the relationship between role stress fit and job satisfaction. Demographics such as age, experience, position, and gender were not significant. The researchers used behavioral plasticity, a theory suggesting that low self-esteem individuals are more influenced by social cues and more responsive to peer group interaction, job stress, and supervisor support, to explain why the low self-esteem IT developers in their study were less satisfied in situations of over- or under-role stress. The research team rationalized that high self-esteem individuals may be less susceptible to job environments that do not match their preferences. Therefore, they recommend including self-esteem enhancement techniques to coping interventions for IT workers experiencing role strain.

Women and Computing: Both Competence and Worthiness Considered

The studies explained thus far have shown that competence or worthiness may be a factor in persistence. However, another way to study self-esteem is to use a two-factor definition of self-esteem that includes both competence *and* worthiness. Using a two-factor definition, Thoman, Arizaga, Smith, Story, and Soncuya (2014) tested the theory that when women in STEM majors feel pushed away by the "chilly climate of science, technology, engineering, and math situations, they seek situations where they experience greater social belonging regardless of the grades they are earning. They tested this theory by asking STEM majors to submit diary entries related to their feelings of belonging and interest for two courses – one STEM course and one Humanities/Liberal Arts (H/LA) course. Through using a two-factor understanding of self-esteem when examining the diary entries of these women, they determined the impact of situational experiences on persistence. They found that a sense of belonging in STEM classes predicted interest in STEM classes. Additionally, they found that when women with a lower competence and higher self-liking (worthiness) felt a greater sense of belonging in their H/LA course than their STEM course, their interest in their STEM course diminished.

Thoman et al.'s (2014) study measured self-esteem just once at the beginning of the project so they could not show changes over time. However, by using a two-factor model for self-esteem, this study identified a significant connection between self-esteem and women in STEM courses that would have been missed if just a single-factor model had been used. The finding that *both* lower competence and higher self-liking (worthiness) had to be in place for belonging to influence class interest would have been missed if these two subscales were combined. Together, these two dimensions of self-esteem competence and self-liking (worthiness) moderated the effects of competing belonging on women's STEM interest. A composite score would not have revealed that one sub-score was low and the other was high (such as the area of a room does not give you information about the length and width). Therefore, this study urges researchers to consider both dimensions of self-esteem in future studies and when planning intervention strategies.

Thoman et al.'s study (2014) also suggests that the phenomenon of competing feelings of belonging (worth) is unique to a woman's experience in STEM courses. In other words, the authors suggest that because women must battle stigma daily in STEM, they are more vulnerable to low feelings of belonging that influence interest in STEM than they are in non-STEM classes. But they caution, that for some women, increasing STEM belonging is not enough. Therefore, they suggest supplementing strategies that boost both - women's feelings of their competence and of their worth in STEM.

Self-esteem and Leadership

Going Beyond Persistence – Organizational-based Self-esteem and Leadership

Success for women who persist in computing could be found in employment and leadership opportunities. Pierce, Gardner, Cummings, and Dunham (1989) introduced a construct called organizational-based self-esteem (OBSE) and its measurement. Borrowing from Coppersmith's (1967) work that persons use self-esteem as a way to shield or protect the self, from Deci and Ryan (2000) that people use self-esteem to help tolerate anxiety related to personal growth, and from Korman's (1970, 1971, 1976) work that people are motivated to maintain their self-esteem, they developed and tested a construct to help explain self-esteem within organizations. They posited that experiences within the organization shape one's organizational self-esteem and affects organizational attitudes and behaviors. For example, comments directed toward people and the types of tasks assigned to them communicate messages about their worth. They understood that self-esteem could be both the result and antecedent of behavior. Their definition for organizational-based self-esteem is a two-factor definition, "the degree to which organizational members believe that they can satisfy their needs by participating in the roles within the context of an organization" and as a result, "people with high OBSE should perceive themselves as important, meaningful, effectual, and worthwhile" (1989, p. 625). The ability to participate in roles such as team leader, requires *competence* and belief that a person can "satisfy their needs" such as meaningful work requires *worthiness*.

Pierce et al. (1989) also argued that organizational-based self-esteem should be measured using different tools than are used to measure global self-esteem. They explained that global measures of self-esteem frequently fail to demonstrate significant relationships with specific-task oriented behaviors and therefore the level of analysis should match the variables being studied. They also believed that if measured over time, they would find that organizational-based self-esteem was fairly stable.

Pierce et al. (1989) found that positive experiences with managerial respect, organizational structure, and job complexity, positively affected organizational-based self-esteem. In return, high levels of OBSE positively affected global self-esteem, job performance, intrinsic motivation, general satisfaction, citizenship behavior, organizational commitment, and, organizational satisfaction. Additionally, their study provides evidence that their measure of OBSE my yield better predictive efficacy than task-specific or global measures of self-esteem. They believe that the structural features of work environments can and do send strong messages that shape individuals' beliefs about their value within the organization and that employees develop organizational attitudes and engage in behaviors consistent with their organizational-based self-esteem.

The importance of self-esteem can be found throughout the leadership literature. James Burns, an authority on leadership studies, wrote that self-esteem has a powerful influence on people as early as adolescents, “drawing some of them into positions of potential leadership and keeping others out” (p. 94, 1978). And, even before Burns, Bernard Bass, credited with laying the foundation for transformational leadership, one of the most influential contemporary leadership theories, found that persons with high self-esteem appear more likely to change and lead others (p. 299, 1960).

More recently, Matzler, Bauer, and Mooradian (2013) investigated whether transformational leadership behavior is a function of the leader’s own self-esteem. They surveyed 411 entrepreneurs and managing directors of small- and medium-sized companies in Austria. Using Rosenberg’s Self-Esteem Scale (1965), Podsakoff, MacKenzie, Moorman, and Fetter’s Transformational Leadership Inventory (1990), and questions related to innovation success, Matzler et al. demonstrated empirical support that self-esteem is positively related to transformational leadership and transformational leadership is positively related to innovation success.

Li, Arvey, and Song (2011) also studied self-esteem and leadership. Their longitudinal study investigated the influence of self-esteem on what they referred to as leadership role occupancy and leader advancement. They found no gender differences. Self-esteem had a significant and positive influence on leadership role occupancy and advancement for both men and women. They suggest that managers consider leadership training programs or daily management practices that help enhance self-esteem for those employees on a leadership track.

These findings highlight the importance of developing leaders in the ever-changing field of computing where innovation or the lack of it can make or break a company over night.

Therefore, helping women to develop a healthy self-esteem within computing can lay the foundation for leadership development.

Summary

This chapter presented several definitions, models and measures of self-esteem and studies that explored the interaction between self-esteem, women, computing, and leadership. All studies on the retention of women in computing except one, used a one-dimensional definition (competence *or* worthiness), considered self-esteem as an independent variable (rather than one that could be changed through experience over time), and used a tool that measures global self-esteem (rather than one that could measure self-esteem within the context of computing). The one study that used a two-dimensional model of self-esteem (Thoman et. al, 2014), demonstrated the benefit of considering competence, worthiness and the interaction between them, as well as the importance of studying experiences over time and within specific contexts (STEM and non-STEM courses). Moving beyond persistence to employment and leadership, studies were presented that demonstrate the benefit of building self-esteem within organizations and that transformational leadership behavior (perhaps to change the status of women in computing) is a function of self-esteem.

Cohoon and Aspray's literature review (2006) revealed two reasons for the lack of progress to increase the number of women in computing: a lack of understanding of the underlying reasons and a lack of adequate intervention efforts. The current study will complement the studies above, paving the way for understanding self-esteem and the experiences that affect self-esteem as an underlying reason and immediate cause for the low numbers of women in computing that can then inform future intervention efforts. My study will address all four of the points explained above as important to studying self-esteem; use a two-dimensional definition of self-esteem (competence, worthiness and the interaction between them); measure both global and computing specific self-esteem; consider self-esteem as a variable dependent on experience in computing; and, demonstrate that self-esteem in computing may change over time.

The next chapter describes the methodology of this study. The design, participants, data collection instruments, variables, and materials, procedures used to collect the data, and data analysis procedures will be provided.

CHAPTER III. METHODOLOGY

This study examined how the experiences of being a woman in computing affect one's self-esteem. This chapter describes the research design, participants, instrumentation, procedures, research questions, data analysis, and assumptions and limitations for the study.

Research Design

Scheff and Fearon (2004) argue that much of the unconvincing results from self-esteem research are due to using quantitative methods alone. They, along with Mruk (2013) and Epstien (1979), recommended using a mix of quantitative and qualitative methods whereby the qualitative responses can provide an explanation of the quantitative results. Subsequently, this study used a convergent parallel mixed methods research design (Creswell & Plano Clark, 2011). Four data collections occurred over a span of three years. During each data collection, quantitative and qualitative data were collected concurrently via a survey. Quantitative survey data were used to examine differences (self-esteem) that exist among groups of individuals (freshmen, sophomore, junior, senior, and professional women in computing). Open-ended questions comprised the qualitative portion of the survey. The qualitative data was used to help explain the quantitative differences by providing examples of experiences that affect self-esteem. During analysis, the quantitative and qualitative data were analyzed separately before comparing to determine convergence, differences, or some combination of explanation between the two sets of data (Creswell, 2009; Creswell & Plano Clark, 2011). Figure 2 illustrates the timing of the data collections, analysis and interpretation phases for this study.

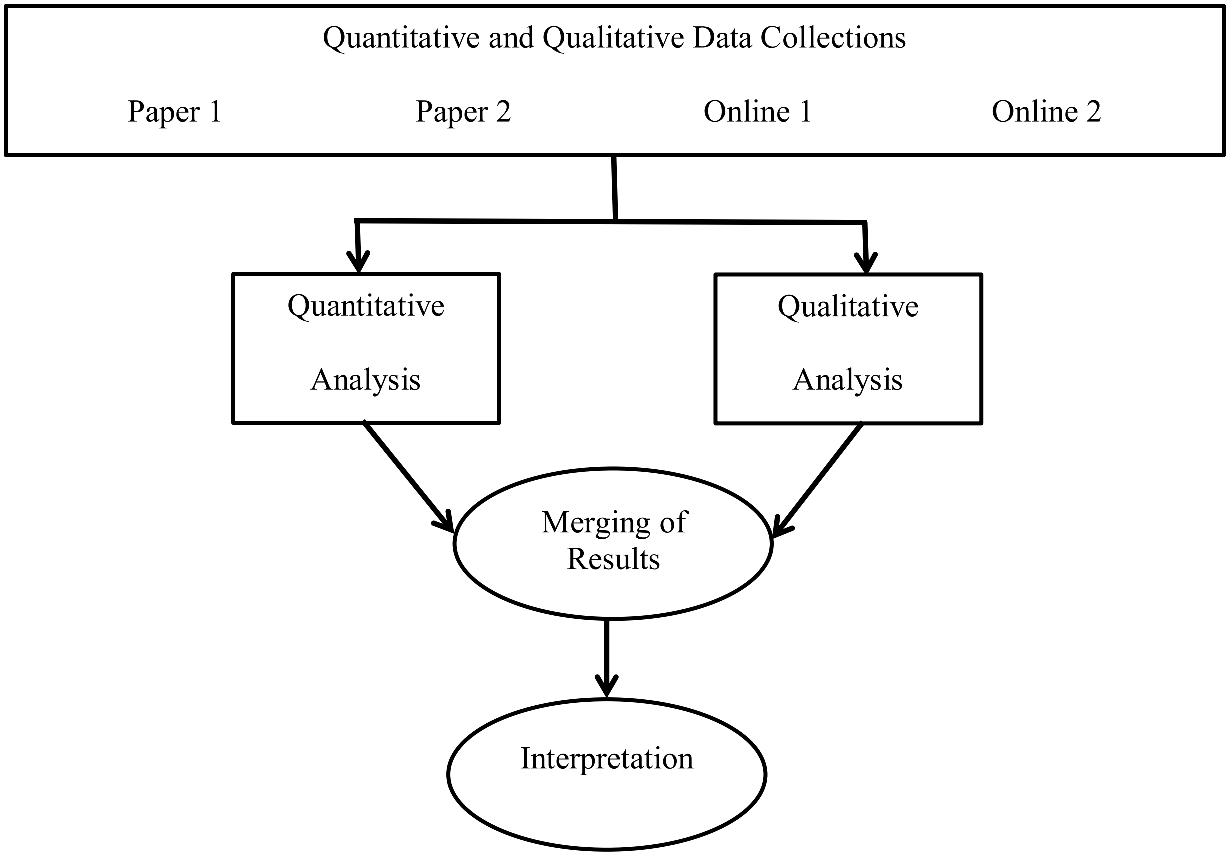

Figure 2. Convergent parallel research design used for this study. This figure illustrates the timing of the data collection, analysis and interpretation phases for this study.

Data Collection

The convenience sample used for this study includes undergraduates and professionals who attended ACM-W's celebration of women in computing conferences. These regional conferences usually last 1-2 days, providing opportunities for female computing students, faculty and industry professionals to attend educational sessions (e.g., research talks, workshops, roundtable discussions), career development sessions (e.g., resume review, career fair), and social time (e.g., games, party) to make connections with other computing students and professionals. The Ohio Celebration of Women in Computing (OCWIC) first administered two paper survey collections in 2013 and in 2015 during the OCWIC conference. Seeking to reach a geographically dispersed population, ACM-W adopted the paper survey, converted it to an online version, and administrated it as part of their international post-conference survey administered to all celebration participants – nationally and internationally. Participants may have taken this survey at different times throughout their career contributing to the cross-sectional nature of the study. A summary of data collections can be found in Table 1.

Table 1

Summary of Survey Participants by Survey Collection

Format	Collection	Date	*N*	Geographic Area
Paper	1	February 22-23, 2013	55	Ohio
	2	February 20-21, 2015	76	Ohio
Online	1	Fall 2014 - Spring 2015	147	US: Colorado, Minnesota, Virginia, Maryland, Washington, DC, Indiana, Michigan, Kentucky, Upstate New York; and, International: India, Canada, Cuba, United Arab Emirates
	2	Fall 2015 – Spring 2016	270	US: Missouri, Iowa, Nebraska, Kansas, Alabama, Georgia, Mississippi, Tennessee, North Carolina, South Carolina, Kentucky, Indiana, Ohio, Virginia, Maryland, Washington, DC, New York City, Upstate New York, Southern California; and, International: Europe, India, UK, Canada, Philippines, Puerto Rico, Azerbaijan

Participants

The convenience sample for this study was generated through the four data collections described above. The population from which this sample was derived includes female undergraduate students in computing majors (computer science, computer engineering, software engineering, information systems, and information technology) and female professionals working in computing related fields. Responses from participants not under study such as undergraduates not in computing majors (computer science, software engineering, computer engineering, information technology, information systems), graduate students, or males, were removed. Although age data were not collected, one can infer from the status of participants ranging from college freshmen to professionals (assumed to be still working) that attendees ranged in age from 18 to 65 years old. The following sections provide a more detailed description of each data collection and the respective participants.

Paper Collection 1

Attendees at the Ohio Celebration of Women in Computing (OCWIC) conference held on February 22-23, 2013, received the survey with their conference materials when they arrived at the conference. One hundred and seventy-three undergraduates, graduates and professionals in computing from 20 colleges and universities and 10 industries registered for this conference. Eighteen students were freshmen, 20 were sophomores, 38 were juniors, 26 were seniors, 16 were graduate students, 30 were faculty, 22 were industry representatives, and 3 were listed as other. Attendees were predominantly residents of the state of Ohio, and primarily of Caucasian and Asian descent. All attendees of this conference were invited to participate in the study. Of the 55 target participants (i.e., female, undergrad in CS, SE, CE, IS, or IT, or professionals in computing fields), who completed the survey, 5 were freshmen, 11 were sophomores, 14 were juniors, 11 were seniors, and 14 were professional faculty or industry representatives.

Paper Collection 2

Attendees at the Ohio Celebration of Women in Computing (OCWIC) conference held on February 20-21, 2015, received the survey with their conference materials when they arrived at the conference. One-hundred eighty-eight females from 20 colleges and universities and ten industries in Ohio attended this conference. Attendees were predominantly residents of the state of Ohio, and primarily of Caucasian and Asian descent. All attendees of this conference were invited to participate in the study. Of the 78 target participants (i.e., female, undergrad in CS, SE, CE, IS, or IT, or professionals in computing fields) who completed the survey, 8 were freshmen, 13 were sophomores, 21 were juniors, 13 were seniors, and 22 were professional faculty or industry representatives.

Online Collection 1

Attendees from Celebrations of Women in Computing held in the US, India, Canada, Cuba, and United Arab Emirates during the fall 2014 and spring 2015 semesters were invited to complete the survey online as an optional part of a post conference survey. Of the 147 target participants (i.e., female, undergrad in CS, SE, CE, IS, or IT, or professionals in computing fields), who completed the survey, 16 were freshmen, 19 were sophomores, 25 were juniors, 25 were seniors, and 62 were professional faculty or industry representatives.

Online Collection 2

Attendees from Celebrations of Women in Computing held in the US, Europe, India, UK, Canada, Philippines, Puerto Rico, Azerbaijan during the fall 2015 and spring 2016 semesters were invited to complete the survey online as an optional part of a post conference survey. Of the 272 target participants (i.e., female, undergrad in CS, SE, CE, IS, or IT, or professionals in computing fields) who completed the survey, 24 were freshmen, 54 were sophomores, 49 were juniors, 48 were seniors, and 95 were professional faculty or industry representatives. A summary the number of surveys completed by method of collection can be found in Table 2.

Table 2

Number of Surveys Completed by Method of Collection

Status	Paper Survey		Online Survey		Total
	Collection 1	Collection 2	Collection 1	Collection 2	
Freshmen	5	8	16	24	53
Sophomore	11	13	19	54	97
Junior	14	21	25	49	109
Senior	11	13	25	48	97
Professionals	14	22	62	95	193
Totals	55	77	147	270	549

Although all conference attendees were invited to complete the survey, only those undergraduate students who indicated CS, SE, CE, IS, or IT as their major were included for this study. All professionals (*N*=193) were assumed to be in computing fields and, therefore, included in the study; however, they were not classified as CS, SE, CE, IS, or IT. Of the 356 undergraduate, female participants in CS, SE, CE, IS, and IT who completed the survey, 250 were computer science, 11 were software engineering, 26 were computer engineering, 46 were information technology, and 23 were information systems. Table 3 provides a summary of the number of surveys completed by undergraduate major.

Table 3

Number of Surveys Completed by Undergraduate Students by Major

Status	Major					Total
	Computer Science	Software Engineering	Computer Engineering	Information Technology	Information Systems	
Freshmen	41	2	4	2	4	53
Sophomore	65	4	8	16	4	97
Junior	74	3	9	17	6	109
Senior	70	2	5	11	9	97
Totals	250	11	26	46	23	356

Instrumentation

A self-esteem instrument was created for this study to compare global self-esteem and computing-based self-esteem. This instrument, called the Computing Experience Survey (CES), contains both quantitative and qualitative questions. The quantitative questions were based on the Rosenberg Self-Esteem Scale (Rosenberg, 1965) considered the “gold standard” for self-esteem research (Mruk, 2013). Rosenberg’s Self-Esteem Scale is freely available for educational and research purposes. In return, the University of Maryland, where Dr. Rosenberg was a faculty member, requested a copy of any published works using the instrument.

The Rosenberg Self-Esteem Scale is comprised of ten questions measuring general (global) feelings about one’s self. Each question (five positively worded and five negatively worded) is answered using a 4-point Likert scale (strongly agree, agree, disagree or strongly disagree). Scores range from 0 to 30. For items 1, 2, 4, 6, and 7, the following scoring is applied: strongly agree = 3, agree = 2, disagree = 1, and strongly disagree = 0. Items 3, 5, 8, and 10, are reversed in valence, therefore the following scoring is applied: strongly agree = 0, agree = 1, disagree = 2, and strongly disagree = 3. Subscale scores were obtained by grouping the scores from items 1, 2, 3, 4, and 5 to study the competence dimension of self-esteem and grouping the scores from items 6, 7, 8, 9, and 10 to study the worthiness dimension of self-esteem (Rosenberg, 1995; Tafarodi & Milne, 2002).

Significant work has previously been done to assess the validity and reliability of the Rosenberg Self-esteem Scale. According to the University of Maryland, the scale generally has high reliability. Test-retest correlations are typically in the range of .82 to .88, and Cronbach's alpha for various samples are in the range of .77 to .88 (University of Maryland, 2004). Norms for different samples have been established.

The Computing Experience Survey (CES) used in this study has three sections. The first section contains the Rosenberg Self-esteem Scale – 10 questions to focus respondents on their general feelings of self-esteem (global self-esteem). The second section contains the Rosenberg Self-esteem Scale *slightly altered* to focus respondents on their feelings of self-esteem within their major or profession (computing-based self-esteem). For example, question 1 of the Rosenberg Self-esteem Scale is: “I feel that I am a person of worth, at least on an equal plane with others.” The matching question on the slightly altered Rosenberg Self-esteem Scale is: “I feel that I am a person of worth, at least on an equal plane with others, *within my major or profession*.” Researchers have found high validity when translating and applying Rosenberg’s Scale in various contexts (Bagley, Bolitho, & Bertrand, 1997; Hatcher & Hall, 2009; Schmitt & Allik, 2005). The third section contains open-ended questions to allow participants to share examples of their experiences in computing.

Paper Collection 1

Two forms of the CES were administered in 2013 to examine the influence of item ordering. The first version presented the questions as explained above. The second version of the survey presented the slightly altered Rosenberg Self-Esteem Scale questions first (computing-specific self-esteem), before presenting the Rosenberg Self-Esteem Scale (global self-esteem). Analysis revealed that there was no significant difference in the way responses were given based on the order of the questions. One open-ended question for Collection 1 was included: Tell me about a time (or times) that made you feel good about your abilities in computing.

Paper Collection 2

Based on the analysis from the first collection, only one form of the CES was deemed necessary for administration in 2015. Additionally, analysis revealed a need to add a second open-ended question: Tell me about a time (or times) that made you feel bad about your abilities in computing. This question was added to gain a better understanding of a negative trend that was identified during the examination of collection 1 data. Analysis revealed a continual decline in both worthiness and competence from freshmen to juniors. However, competence showed a promising recovery for seniors and continued to increase for professionals, but worthiness continued to decline for seniors only starting to recover for professionals.

Online Collections 1 and 2

The CES from Collection 2 was converted to an online format and added as an optional section to the ACM-W post conference survey. The online CES contained the quantitative questions from sections 1 (Rosenberg Self-esteem Scale) and 2 (slightly altered Rosenberg Self-esteem Scale), and the following two qualitative questions in section 3: (1) Tell me about a time (or times) that made you feel good about your abilities in computing, and (2) Tell me about a time (or times) that made you feel bad about your abilities in computing.

Procedures

Paper Collections 1 and 2

Participants of the OCWIC 2013 and 2015 conferences received the paper survey with their conference materials when they arrived at the conference (Appendix A). Attached to the survey was a cover letter/consent to participate (Appendix B) inviting them to complete the survey. Attached to the survey was a ticket (Appendix C) for a raffle organized by OCWIC to encourage participation. Two secured, closed boxes were made available in a central location of the conference (on a table in front of the main meeting space). Upon completing the survey, participants completed the raffle ticket (name and email) and detached it from the survey. They placed the raffle ticket in one closed box separate from the other closed box where they submitted the survey. Conference participants were reminded to complete the survey throughout the duration of the conference. Names were randomly drawn on the last day for miscellaneous OCWIC swag (i.e., t-shirts, glasses, etc.).

To maintain confidentiality of the content of the survey, all identifying data (name and email provided on the raffle ticket) was kept separate from the results of the survey referenced only by a unique participant ID for research purposes. All completed surveys were stored in a secure location in a locked office.

Online Collections 1 and 2

Conference participants received an email within a week of attending an ACM-W celebration conference. This email contained a link to a post conference survey. At the end of the survey, participants were invited to complete an optional section of the survey. If they responded "yes" to the question, "Would you be willing to share your experience as a woman in computing?" they received the CES questions used for this study. See Table 1 for a summary of data collections.

Quantitative Data Analysis

Quantitative Questions

This study examined the following quantitative research questions:

Q1: Do global self-esteem (GSE) and computing-based self-esteem (CSE) differ by status (freshmen, sophomore, junior, senior, or professional) among women in computing?

Q2: Do global competence (GSE-C), global worthiness (GSE-W), computing-based competence (CSE-C), and computing-based worthiness (CSE-W) differ by status (freshmen, sophomore, junior, senior, professional) among women in computing?

Data Preparation

Responses from the paper surveys were entered verbatim into an excel spreadsheet and merged with the responses from the online survey into one master set. The only identifying data associated with each response was the collection ID (paper or online), participant ID, participant status (freshmen, sophomore, junior, senior, professional).

The questions were first coded. The first 10 questions asked about the participants' global self-esteem using the exact wording from Rosenberg's Self-esteem Scale so these questions were coded G1, G2, G3, G4, G5, G6, G7, G8, G9, and G10. The next 10 questions asked about the participants' self-esteem within their computing major or profession so these questions were coded C1, C2, C3, C3, C4, C5, C6, C7, C8, C9, C10. Responses to the self-esteem questions were first coded (0-strongly disagree, 1-disagree, 2-agree, 3-strongly agree). Negatively worded questions were reverse coded so that a 3 in the final dataset indicated a most positive response and 0 indicated a least positive response.

Quantitative Variables

Sections 1 and 2 of the Computing Experience Survey (CES) contain questions that require statistical consideration. Rosenberg's Self-esteem Scale can be divided into two subscales, one to measure competence and one to measure worthiness (Rosenberg, 1995; Tafarodi & Milne, 2002); therefore, six scores were calculated by computing the sum of respective items. These six scores were utilized as dependent variables for this study and were calculated as follows. Three scores related to feelings of self-esteem in general (global self-esteem) were created from section 2 containing the Rosenberg Self-Esteem Scale questions: a total score for all 10 items, a subscale score for the competence items, and a subscale score for the worthiness items. And three scores related to feelings of self-esteem within computing (computing-based self-esteem) were calculated from section 3 containing a set of slightly altered Rosenberg Self-Esteem Scale questions: a total score for all 10 items, a subscale score for the competence items, and a subscale score for the worthiness items. The result was six scores for analysis: global self-esteem (GSE), global self-esteem competence subscale (GSE-C), global self-esteem worthiness subscale (GSE-W), computing-based self-esteem (CSE), computing-based self-esteem competence subscale (CSE-C), and computing-based self-esteem worthiness subscale (CSE-W). See Table 4. One categorical independent variable was used for this study: status (freshmen, sophomore, junior, senior, professional).

Table 4

Subscales and Calculations for the Six Dependent Variables

Subscale	Calculation
Global Self-esteem (GSE)	Sum of section 1 – all items (G1 – G10)
Global Self-esteem Competence (GSE-C)	Sum first five items (G1 – G5)
Global Self-esteem Worthiness (GSE-W)	Sum last five items (G6 – G10)
Computing-based Self-esteem (CSE)	Sum of section 2 – all items (C1 – C10)
Computing-based Competence (CSE-C)	Sum first five items (C1 – C5)
Computing-based Worthiness (CSE-W)	Sum last five items (C6 – C10)

Data Screening

Data were first screened for missing values. Analysis of the paper surveys revealed that one participant did not complete the survey so her submission was removed from analysis. Analysis of the online surveys revealed that in the computing-based self-esteem section of the survey, question #9 (C9) was missing from the collection of the data. Two options were explored to resolve this issue: 1) remove the question, or 2) use linear regression to predict the missing values (Mertler & Vannatta, 2010). Using the paper survey results, an oblique principal components factor analysis was conducted to examine the contribution of item 9 to the subscales of worthiness for both global and computing-based self-esteem. Results revealed that item 9 was the highest loading item for both competence subscales. Therefore, item removal was not deemed appropriate and replacement options were explored using paper results. First, Pearson correlation was conducted to examine the relationship of C9 with all remaining self-esteem items. Results indicated that multiple items were strongly related. Consequently, forward multiple regression was utilized to determine which self-esteem items (both global and computing-based) best predict C9, such that a regression equation could be used to generate a replacement value for C9. The analysis generated a four-factor model (C10, G9, C8, and G10) that significantly predicted C9, $R^2 = .684$, $R^2_{adj} = .676$, $F(4, 168) = 90.905$, $p < .001$. This model accounted for 68.40% of variance in C9 for the paper participants. Regression coefficients of the model predicting C9, presented in Table 5, were utilized to create the following regression equation: $C9 = .616X_{C10} + .307X_{G9} + .145X_{C8} - .160X_{G10} + .118$.

Table 5

Regression Coefficients for Final Model predicting C9

	B	β	*t*	*p*	Bivariate *r*	Partial *r*
1. C10	.616	.060	10.20	< .001	.773	.618
2. G9	.307	.065	4.69	< .001	.645	.340
3. C8	.145	.058	2.51	< .025	.575	.190
4. G10	-.160	.081	-1.98	< .050	.580	-.151

After C9 replacement values were computed for the online participants, subscale scores were calculated. Initial data screening of individual self-esteem scores did not reveal outliers and assumptions of normality, linearity and homoscedasticity were not violated. Multivariate screening of subscale scores, however, did reveal outliers. Outliers were identified by calculating Mahalanobis distance (Mertler & Vannatta, 2010). The newly generated Mahalanobis variable was explored to determine which cases exceeded the chi-square (χ^2) criteria. A chi-square table, showed the critical value of chi-square at $p < .001$ with $df = 6$ to be 22.458. Three cases exceeded this critical value and so were deleted from the analysis. Multivariate assumptions of normality and linearity were not violated.

Reliability

Reliability analysis confirmed the best approach to handling the missing data was to use the regression formula. Cronbach alpha coefficients for the global self-esteem and computing-based self-esteem subscales (using the regression formula to fill in missing values) were .880 and .895 respectively. This is similar to findings reported by the University of Maryland who maintain Rosenberg's webpages and report Cronbach's alphas for various samples are in the range of .77 to .88 (University of Maryland, 2004). In contrast, the removal of item 9 from both subscales generated a lower reliability coefficient for global self-esteem ($\alpha = .863$) and computing-based self-esteem ($\alpha = .873$). Table 6 presents the reliability coefficients for the different collections. The means and standard deviations for each of the Global self-esteem (GSE) questions are presented in Table 7. The means and standard deviations for each of the Computing-based self-esteem (CSE) questions are presented in Table 8.

Table 6

Cronbach Alpha Reliability Coefficients for Paper, Online, and Combined Self-esteem Subscale Sums

Subscales	Questions	Paper	Online	Combined
Global Self-esteem (GSE)	G1 - G10	.880	.880	.880
Global Competence (GSE-C)	G1 - G5	.737	.767	.761
Global Worthiness (GSE-W)	G6 - G10	.862	.822	.831
Computing-Based Self-esteem (CSE)	C1 - C10	.903	.893	.895
Computing-Based Competence (CSE-C)	C1 - C5	.792	.778	.781
Computing-Based Worthiness (CSE-W)	C6 - C10	.889	.853 [a]	.861

Note: [a] C9 for online collection was calculated using the regression formula: $C9 = .616X_{C10} + .307X_{G9} + .145X_{C8} - .160X_{G10} + .118$.

Table 7

Means and Standard Deviations for Global Self-esteem Questions and Subscale Sums

Questions [a]/Subscale	Paper Collection (*N* = 131)		Online Collection (*N* = 415)		Combined Collection (*N* = 546)	
	M	*SD*	*M*	*SD*	*M*	*SD*
G1: I feel that I am a person of worth, at least on an equal plane with others.	2.57	0.53	2.55	0.57	2.56	0.56
G2: I feel that I have a number of good qualities.	2.63	0.50	2.61	0.51	2.62	0.51
G3: All in all, I am inclined to feel that I am a failure. [b]	2.32	0.70	2.12	0.84	2.17	0.81
G4: I am able to do things as well as most other people.	2.37	0.57	2.34	0.64	2.35	0.63
G5: I feel I do not have much to be proud of. [b]	2.36	0.65	2.19	0.80	2.23	0.79
Global Competence (GSE-C)	12.24	2.16	11.81	2.46	11.92	2.39
G6: I take a positive attitude toward myself.	2.24	0.72	2.29	0.67	2.28	0.66
G7: On the whole, I am satisfied with myself.	2.25	0.90	2.15	0.73	2.18	0.73
G8: I wish I could have more respect for myself. [b]	1.74	0.90	1.66	0.97	1.68	0.96
G9: I certainly feel useless at times. [b]	1.85	0.79	1.62	0.94	1.68	0.94
G10: At times I think I am no good at all. [b]	2.11	0.67	1.90	0.95	1.95	0.92
Global Worthiness (GSE-W)	10.20	3.20	9.62	3.30	9.76	3.28
Global Self-esteem (GSE)	22.45	4.95	21.44	5.40	21.68	5.31

Notes: [a] Questions G1-G10 are the exact wording of Rosenberg's Self-esteem Scale (1965). [b] Each question was answered using a 4-point Likert-scale. After reverse scoring negatively worded questions, the resulting score for each question ranged from 0 to 3 with 0 indicating a strong negative feeling of self, and a 3 indicating a strong positive feeling of self.

Table 8

Means and Standard Deviations for Computing-based Self-esteem Questions and Subscale Sums

Questions [a]/Subscale	Paper Collection (*N* = 131)		Online Collection (*N* = 415)		Combined Collection (*N* = 546)	
	M	*SD*	*M*	*SD*	*M*	*SD*
C1: I feel that I am a person of worth, at least on an equal plane with others, within my major or profession.	2.20	0.67	2.26	0.70	2.24	0.69
C2: I feel that I have a number of good qualities, within my major or profession.	2.38	0.56	2.37	0.60	2.37	0.59
C3: All in all, I am inclined to feel that I am a failure, within my major or profession. [b]	2.19	0.76	2.10	0.81	2.12	0.80
C4: I am able to do things as well as most other people, within my major or profession.	2.17	0.66	2.14	0.67	2.14	0.67
C5: I feel I do not have much to be proud of, within my major or profession. [b]	2.14	0.81	2.00	0.86	2.03	0.85
Computing-based Competence (CSE-C)	11.07	2.58	10.86	2.67	10.91	2.65
C6: I take a positive attitude toward myself, within my major or profession.	2.24	0.62	2.26	0.69	2.26	0.68
C7: On the whole, I am satisfied with myself, within my major or profession.	2.14	0.71	2.05	0.75	2.07	0.74
C8: I wish I could have more respect for myself, within my major or profession. [b]	1.67	0.84	1.57	0.94	1.59	0.92
C9: I certainly feel useless at times, within my major or profession. [b]	1.79	0.92	1.63 [c]	0.78	1.67	0.82
C10: At times I think I am no good at all, within my major or profession. [b]	1.99	0.95	1.77	0.97	1.82	0.97
Computing-based Worthiness (CSE-W)	9.83	3.35	9.28	3.31	9.41	3.32
Computing-based Self-esteem (CSE)	20.90	5.51	20.14	5.60	20.32	5.58

Notes: [a] Questions C1-C10 are a slightly modified wording of Rosenberg's Self-esteem Scale (1965).
[b] Each question was answered using a 4-point Likert-scale. After reverse scoring negatively worded questions, the resulting score for each question ranged from 0 to 3 with 0 indicating a strong negative feeling of self, and a 3 indicating a strong positive feeling of self.
[c] C9 for online collection was calculated using the regression formula: $C9 = .616X_{C10} + .307X_{G9} + .145X_{C8} - .160X_{G10} + .118$.

Data Analysis

Lastly, inferential statistics were conducted to draw conclusions about the larger population of all women in computing. Since there were multiple dependent variables and linear combinations of those dependent variables were of interest, a factorial multivariate analysis of variance (MANOVA) was used. The following linear combinations of the dependent variables are of interest: global total and computing-specific total; global competence and computing-specific competence; and, global worthiness and computing-specific worthiness. In addition to MANOVA, a series of one-way analysis of variance (ANOVA) was used to identify which of the dependent variables were affected by the independent variables. Table 8 summaries the research questions, variables, and analysis for the quantitative part of this study.

Table 9

Variables and Data Analysis for Quantitative Research Questions

Research Questions	Independent Variable	Dependent Variables	Data Analysis
1. Do global self-esteem (GSE) and computing-based self-esteem (CSE) differ by status (freshmen, sophomore, junior, senior, professional) among women in computing?	Status (freshmen, sophomore, junior, senior, professional)	Global self-esteem score (GSE) Computing-based self-esteem score (CSE)	MANOVA
2. Do global competence (GSE-C), global worthiness (GSE-W), computing-based competence (CSE-C), and computing-based worthiness (CSE-W) differ by status (freshmen, sophomore, junior, senior, professional) among women in computing?	Status (freshmen, sophomore, junior, senior, professional)	Global self-esteem competence sub-scale score (GSE-C) Global self-esteem worthiness sub-scale score (GSE-W) Computing-based self-esteem competence sub-scale score (CSE-C) Computing-based self-esteem worthiness sub-scale score (CSE-W)	MANOVA

Qualitative Data Analysis

Qualitative Research Questions

This study addressed the following qualitative research questions:

Q3: What positive experiences in computing contribute to competence and worthiness among women?

Q4: What negative experiences in computing contribute to competence and worthiness among women?

Data Preparation

Section 3 of the Computing Experience Survey (CES) contained open-ended questions that require qualitative examination. The open-ended questions from the survey were transcribed, organized in a spreadsheet, read, coded and categorized into themes and descriptions. Then following a phenomenological research process (Creswell, 2009), analysis of significant statements, generation of meaning units, and development of essence descriptions followed.

Responses to the open-ended question, “Share a time or (times) that made you feel good about your abilities in computing” were analyzed to answer research question three. These are referred to as “Feel Good” responses. To examine research question four, responses to the following open-ended question were analyzed, “Share a time or (times) that made you feel bad about your abilities in computing”. These are referred to as “Feel Bad” responses.

Participants were not limited to providing only one response, because the intent was to collect examples to illustrate overall themes, not to identify one-to-one responses with the quantitative questions. For a similar reason, these questions were not required on the survey, and therefore participants were permitted to skip the question if they did not wish to reflect on it.

Preparation of the open-ended questions started with data entry of the responses from the paper survey. These responses were merged with the responses from the online survey into one master set. The only identifying data associated with each response was the collection ID (paper or online), participant ID, participant status (freshmen, sophomore, junior, senior, professional). Use of coding for each category helped minimize biases as responses were analyzed.

Identification of Meaning Unit Themes and Self-Esteem Categories

Two different techniques were used to identify a priori themes and emergent themes (Teddlie & Tashakkori, 2009). Deductive analysis of the open-ended questions was used to determine which self-esteem factor, competence or worthiness, was being enhanced or challenged by the self-esteem moment shared on the survey. This analysis resulted in classifying responses into self-esteem categories. Inductive analysis was used to allow common themes (meaning unit themes) to emerge while preserving unique responses. This resulted in classifying responses into meaning unit themes. To ensure consistency the meaning unit themes were crosschecked with the self-esteem categories. Member checking with experts the categorization of responses helped ensure reliability. During the last step of analysis, summary counts and percentages were calculated.

The first step of the analysis was to identify meaning unit themes. Based on the participant's response, short summary phrases were identified and marked in a separate column in a spreadsheet. In cases where participants provided more than one example, responses were split into different entries. After this initial review, a second pass through the responses was conducted to begin combining the responses into meaning units. For example, the following participant response, "when I am the only woman in the group, and when don't get as much responsibility or opportunity as the other group members (usually men)" was simplified to the meaning unit "group inequity". In the next pass, this meaning unit was combined with other similar examples into a theme called "low expectations from others". Data was crosschecked to make sure that categorization of responses was consistent.

The next step was to determine which self-esteem factor, competence or worthiness, was being enhanced or challenged by the self-esteem moment shared on the survey. Because respondents often do not provide enough detail to be certain of the intent of their comments and the overlapping nature of self-esteem factors, three categories were used: competence focus, worthiness focus, and balanced focus (competence and worthiness). Items were placed in the competence focused category if the wording of the response focused on enhancements or challenges to their abilities. Items were placed in the worthiness focused category if the wording of their responses focused on values or the “worthwhileness” of their actions. Items were placed in the balanced focus (competence and worthiness) category if the wording showed evidence of both competence and worthiness. Examples of competence-focused answers include responses such as “good grades” or “when I complete a programming project”. Examples of worthiness-focused answers include examples such as “receiving praise from my instructor” and “when other more experienced people tell me that the beginning is always difficult, and that it will get better”. Examples of balanced focus (competence and worthiness) answers include responses with a reference to competence (i.e., skills) and worthiness (i.e., valued actions). For example, the response “when someone thanks me for helping with a computer issue” includes the skill of resolving the computer issue as well as a value placed on that action because it was appreciated. Another example of balanced focus is shown in the following response that demonstrated both competence and recognition as an important team member, “a male colleague said to a junior developer to ask me for help. She knows more.” Careful attention was paid to categorizing responses based only on what was written. For example, “when I first developed my game” was categorized as competence focused because only the skill of programming was mentioned even though we might assume that if others played the game they might have provided a boost to the person’s feelings of self-worth. Whereas, “developing and publishing my own game” was categorized as balanced focus because both the skill of creating a game and acceptance from the publishing process (i.e., worthiness) are present in the response.

The third step in the data analysis was to confirm the self-esteem categorization. This was accomplished through a process called *member checking*. The researcher met with an expert in self-esteem and an expert in computer science education and, one by one, revisited each entry and confirmed the self-esteem categorization. When disagreements arose, discussion of items ensued to bring about final agreement of the categorization.

The fourth step was to cross-reference the self-esteem categorization with the meaning unit themes identified in the first step of analysis. A second meeting to *member check* categorization helped ensure consistency. For example, all responses related to the meaning unit themes programming, problem solving, grades and understanding concepts were crosschecked to make sure they were placed in the self-esteem category competence focus.

Summary counts and percentages were then calculated for each category. Random responses such as "N/A" or blank responses were not counted in total calculations. Summary counts and percentages were also calculated for each subset of the independent variables status (freshman, sophomore, junior, senior, professional). The resulting data set is displayed in Table 10.

Table 10

Number of Feel Good Responses and Feel Bad Responses by Status

Status	*f*	
	Feel Good	Feel Bad
Freshman	49	37
Sophomore	106	64
Junior	101	58
Senior	74	70
Professional	177	105

Meaning unit themes and self-esteem categories for Feel Good responses are displayed in Table 11. Meaning unit themes and self-esteem categories for Feel Bad responses are displayed in Table 12.

Table 11

Meaning Unit Themes and Self-esteem Categories for Feel Good Responses

Meaning Unit Themes	Self-esteem Categories		
	Competence Focus	Worthiness Focus	Balanced Focus (competence and worthiness)
Programming	x		
Problem Solving	x		
Grades	x		
Understanding concepts	x		
Encouragement, feedback, support		x	
Finding comfort in other's struggles (i.e., you are not alone) and success (i.e., success is possible) *		x	
Mentoring, coaching, inspiring others *		x	
Recognition, appreciation, winning scholarships/contests			x
Create useful software or solution *			x
Job/internship, promotion, invited to be on a team			x
Accomplishment, completing degree, reflecting on resume/vitae, publish paper, software, implement large project			x
Asked for help, known as the expert, invited to present paper/poster/work			x
Helped or fixed other's work *			x
Teaching, tutoring, presenting			x
Contributing to team *			x
Leadership or management role			x
Sense of belonging, interest, pride, comfort in field, respected as an equal			x

* Meaning unit themes not found in the "Feel Bad" responses.

Table 12

Meaning Unit Themes and Self-esteem Categories for Feel Bad Responses

Meaning Unit Themes	Self-esteem Categories		
	Competence Focus	Worthiness Focus	Balanced Focus (competence and worthiness)
Programming	x		
Problem solving	x		
Grades	x		
Understanding concepts	x		
Inexperience*	x		
Mistakes*	x		
Technical interview*	x		
Discouragement, negative feedback, lack of support		x	
Ridiculed, rude comments, judged, harassed, excluded *		x	
Having other interest outside computing – not accepted by peers *		x	
Lack of recognition, undervalued, underestimated, have to constantly "prove" skills			x
Overlooked for a job/internship, promotion, title, grant, award			x
Lack of personal accomplishment, research, publications of paper or software			x
Teaching/presenting			x
Ideas challenged or ignored			x
Leadership/management issues			x
Lack of belonging, "tech talk", feeling like an imposter			x

* Meaning unit themes not found in the "Feel Good" responses.

Reliability

These categories explain and provide a rich description of the quantitative results. Inner-coder agreement between committee members helped ensure reliability (Creswell & Plano Clark, 2011). The identification of discrepant evidence, negative cases, and explicit comparisons (Maxwell, 2013) will help verify findings, minimize researcher bias, and increase truthfulness.

Informed input from computer science faculty and self-esteem experts helped classify participant experiences that are typical and those that are exceptional, as well as provided insight into understanding their significance. Comparing the qualitative results from analyzing meaning unit themes and self-esteem categories helped verify findings. This comparison is often referred to as confirmation, disconfirmation, cross-validation, or corroboration (Green, Caracelli, & Graham, 1989; Morgan, 1998; Steckler, McLeroy, Goodman, Bird, & McCormick, 1992).

Mixed Data Analysis

After the quantitative and qualitative data were analyzed separately, the data were combined for further analysis. The combining and comparing of data from two different data sources is called triangulation (Creswell, 2009; Creswell & Plano Clark, 2011; Fraenkel, Wallen, & Hyun, 2009; Maxwell, 2013; Morgan, 1998; Teddlie & Tashakkori, 2009). Triangulation allows the inherent strengths of the quantitative and qualitative methods to support each other (Creswell, 2009). Whereas quantitative results can be generalized to a larger population and qualitative results may not, it is the rich responses from the qualitative data that will be used to explain and give life to the impersonal, quantitative statistics. Webb, Campbell, Schwartz, and Sechrest explain, “Once a proposition has been confirmed by two or more independent measurement processes, the uncertainty of its interpretation is greatly reduced. The most persuasive evidence comes through triangulation of measurement processes” (2000, p. 3).

A second way to combine and compare the quantitative and qualitative data is through transformation (Creswell, 2009; Creswell & Plano Clark, 2011; Fraenkel, Wallen, & Hyun, 2009, Morgan, 1998; Maxwell, 2013; Teddlie & Tashakkori, 2009). For example, once the qualitative data from open-ended questions have been categorized, frequencies and percentages can be calculated and compared to the results from the quantitative analysis. Similarly, the quantitative data from the Likert-scale questions can be converted into general themes that can be compared to the themes identified in the qualitative analysis (Creswell, 2009).

Assumptions

This research design relies on the honesty of the participants to complete the survey to the best of their ability, giving careful thought and reflection to their responses. For results to appropriately reflect the goals of the study, participants must be in computing majors or fields and must have a sincere interest in helping women in computing, having no other motives.

This chapter provided an explanation of the research methodology, data collection, and procedures of this study. Chapter 4 presents the descriptive narrative of the study's results and an analysis of the data.

CHAPTER IV. RESULTS

This study examined how the experiences of being a woman in computing affect one's self-esteem. A mixed methods study utilized qualitative and quantitative data sources to examine the experiences women have in computing. Experiences were evaluated using a two-factor model of self-esteem (competence, worthiness, and the interaction between them) (Gecas, 1971; Mruk, 2006; Richardson, Ratner, & Zumbo, 2009; Tafarodi & Milne, 2002; Tafarodi & Swann, 1995; Tafarodi & Vu, 1997). Scholars agree that a healthy self-esteem is achieved when both competence and worthiness are fairly high and well balanced. A healthy self-esteem is highly correlated with academic persistence (Harter, 1999). This study combined one of the oldest single-factor models of self-esteem focused on competence (James, 1890/1983) how one feels about their skills and abilities and one of the most widely used single-factor contemporary model of self-esteem focused on worthiness (Rosenberg, 1965) the value one places on their actions (i.e., "worthwhileness" of their work).

Conference attendees from women in computing celebrations were invited to complete a survey that included 20 Likert-scale closed-ended questions and two open-ended questions. Data from the two strands were gathered, analyzed separately, and then merged.

The 20 closed-ended questions were analyzed using a series of MANOVAs that compared responses of different groups of women in computing and their self-esteem. Narrative responses (self-esteem moments) to the two open-ended questions were examined using thematic analysis. Inductive analysis of these self-esteem moments allowed common themes (meaning unit themes) to emerge while preserving unique responses. Deductive analysis allowed classification of responses into self-esteem categories. Results from each independent analysis as well as the combined meta-analysis are explained in the next sections. This chapter describes the quantitative and qualitative results by research question.

Quantitative Results

Descriptive

After data screening, means and standard deviations for the subscales were calculated for the sample used for this study (*N*=546). The first 10 items (G1-G10) comprise the Global Self-esteem (GSE) measure. These ten items utilized the exact wording of Rosenberg's Self-esteem Scale (1965) and applied a 4-point Likert-scale. The second 10 items (C1-C10) comprise the Computing Self-esteem (CSE) measure. The Computing-based self-esteem items (C1-C10) utilized a slightly modified wording of Rosenberg's Self-esteem Scale (1965) to assess self-esteem within context of computing. Recall that online responses for item C9 were missing and subsequently replaced using the regression formula: $C9 = .616X_{C10} + .307X_{G9} + .145X_{C8} - .160X_{G10} + .118$. After reverse scoring negatively worded questions (G3, G5, G8, G9, G10 and C3, C5, C8, C9, C10), the resulting score for each question ranged from 0 to 3 with 0 indicating a strong negative feeling of self, and a 3 indicating a strong positive feeling of self. The different means indicate that participants felt better about themselves in general (global self-esteem) than they did within their computing major or profession (computing self-esteem). The GSE and CSE subscale means and standard deviations are presented in Table 13.

The Global and Computing Self-esteem questions were each further separated into four subscales to separately investigate competence and worthiness. Questions G1 through G5 comprise the Global Competence subscale (GSE-C), questions G6 through G10 comprise the Global Worthiness subscale (GSE-W), questions C1 through C5 comprise the Computing-based Competence subscale (CSE-C) and questions C6 through C10 comprise the Computing-based

Worthiness subscale (CSE-W). The mean for the global worthiness (GSE-W) subscale (*M*=9.76) is lower than the mean for the global competence (GSE-C) subscale (*M*=11.92) indicating that not only do they measure two different dimensions of self-esteem (i.e., global competence and global worthiness), but that in general these women felt worse about their worthiness than their competence. Similarly, the means for the computing-based worthiness (CSE-W) subscale (*M*=9.41) is lower than the mean for the computing-based competence (CSE-C) subscale (*M*=10.91) indicating not only do they measure two different dimensions of self-esteem (i.e., computing-based competence and computing-based worthiness), and that in general these women felt worse about their computing worthiness than their computing competence within their major or profession.

Table 13

Means and Standard Deviations for Global and Computing Self-esteem Subscale Sums (N=546)

Subscale	Questions	*M*	*SD*
Global Self-esteem (GSE)	G1-G10	21.68	5.31
Global Competence (GSE-C)	G1-G5	11.92	2.39
Global Worthiness (GSE-W)	G6-G10	9.76	3.28
Computing-Based Self-esteem (CSE)	C1-C10	20.32	5.58
Computing-Based Competence (CSE-C)	C1-C5	10.91	2.65
Computing-Based Worthiness (CSE-W)	C6-C10	9.41	3.32

Among the global items, the three lowest rated are worthiness questions: (G8) I wish I could have more respect for myself; (G9) I certainly feel useless at times; and (G10) At times I think I am no good at all. The three highest rated items are competence questions: (G2) I feel that I have a number of good qualities; (G1) I feel that am a person of worth, at least on an equal plane with others; and (G4) I am able to do things as well as most other people. The GSE items and subscale means and standard deviations are presented in Table 14.

Table 14

Means and Standard Deviations for Global Self-esteem Questions and Subscale Sums (N=546)

Question/Subscales	*M*	*SD*
G1: I feel that I am a person of worth, at least on an equal plane with others.	2.56	0.56
G2: I feel that I have a number of good qualities.	2.62	0.51
G3: All in all, I am inclined to feel that I am a failure. [a]	2.17	0.81
G4: I am able to do things as well as most other people.	2.35	0.63
G5: I feel I do not have much to be proud of. [a]	2.23	0.79
Global Competence (GSE-C)	11.92	2.39
G6: I take a positive attitude toward myself.	2.28	0.66
G7: On the whole, I am satisfied with myself.	2.18	0.73
G8: I wish I could have more respect for myself. [a]	1.68	0.96
G9: I certainly feel useless at times. [a]	1.68	0.94
G10: At times I think I am no good at all. [a]	1.95	0.92
Global Worthiness (GSE-W)	9.76	3.28
Global Self-esteem (GSE)	21.68	5.31

Notes: Each question was answered using a 4-point Likert-scale.
[a] After reverse scoring negatively worded questions, the resulting score for each question ranged from 0 to 3 with 0 indicating a strong negative feeling of self, and a 3 indicating a strong positive feeling of self.

Similar to the global self-esteem means, the three lowest rated computing-based self-esteem items are worthiness questions: (C8) I wish I could have more respect for myself; (C9) I certainly feel useless at times; and (C10) At times I think I am no good at all. However, there is a slight difference between global and computing-based self-esteem with regard to the three highest rated items. The top two are competence questions and are the same as the global self-esteem means: (C2) I feel that I have a number of good qualities and (C1) I feel that am a person of worth, at least on an equal plane with others. However, the third highest mean is a worthiness question: (C6) I take a positive attitude toward myself, within my major or profession. Given that worthiness mean is lower (*M*=9.41) than the competence mean (*M*=10.91), it is somewhat surprising that this worthiness question had a higher than average mean. The GSE questions and subscale means and standard deviations are presented in Table 15.

Table 15

Means and Standard Deviations for Computing-based Self-esteem Questions and Subscale Sums (N=546)

Question [a]/Subscale	*M*	*SD*
C1: I feel that I am a person of worth, at least on an equal plane with others, within my major or profession.	2.24	0.69
C2: I feel that I have a number of good qualities, within my major or profession.	2.37	0.59
C3: All in all, I am inclined to feel that I am a failure, within my major or profession. [b]	2.12	0.80
C4: I am able to do things as well as most other people, within my major or profession.	2.14	0.67
C5: I feel I do not have much to be proud of, within my major or profession. [b]	2.03	0.85
Computing-Based Competence (CSE-C)	10.91	2.65
C6: I take a positive attitude toward myself, within my major or profession.	2.26	0.68
C7: On the whole, I am satisfied with myself, within my major or profession.	2.07	0.74
C8: I wish I could have more respect for myself, within my major or profession. [b]	1.59	0.92
C9: I certainly feel useless at times, within my major or profession. [b]	1.67 [c]	0.82
C10: At times I think I am no good at all, within my major or profession. [b]	1.82	0.97
Computing-based Worthiness (CSE-W)	9.41	3.32
Computing-based Self-esteem (CSE)	20.32	5.58

Notes: Each question was answered using a 4-point Likert-scale.
[a] Questions C1-C10 are a slightly modified wording of Rosenberg's Self-esteem Scale (1965).
[b] After reverse scoring negatively worded questions, the resulting score for each question ranged from 0 to 3 with 0 indicating a strong negative feeling of self, and a 3 indicating a strong positive feeling of self.
[c] C9 for online collection was calculated using the regression formula: $C9 = .616X_{C10} + .307X_{G9} + .145X_{C8} - .160X_{G10} + .118$.

Inferential Results

Q1: Do global and computing-based self-esteem differ by status (freshmen, sophomore, junior, senior, professional) among women in computing?

Group status means and standard deviations for global and computing-based self-esteem by status were calculated (see Table 16). Figure 3 presents a visual comparison of the means. Computing-based self-esteem is lower than global self-esteem for all statuses. Although status groups differ, the means for the two subscales follow similar trends with a low point for juniors, a recovery for seniors, and a high point for professionals. A closer inspection of the trends reveal that compared to computing-based self-esteem, global self-esteem makes a steeper drop between sophomore and junior but a greater recovery between junior and senior. Additionally, the means for global and computing based self-esteem most closely converge for professionals.

Table 16

Means and Standard Deviations for Global and Computing-based Self-esteem by Status

Status	Global Self-esteem (GSE)		Computing-based Self-esteem (CSE)	
	M	*SD*	*M*	*SD*
Freshman	20.19	5.08	18.58	5.17
Sophomore	20.54	5.17	19.01	4.78
Junior	20.16	5.09	18.85	5.23
Senior	21.16	5.15	19.33	5.62
Professional	23.76	5.01	22.77	5.43

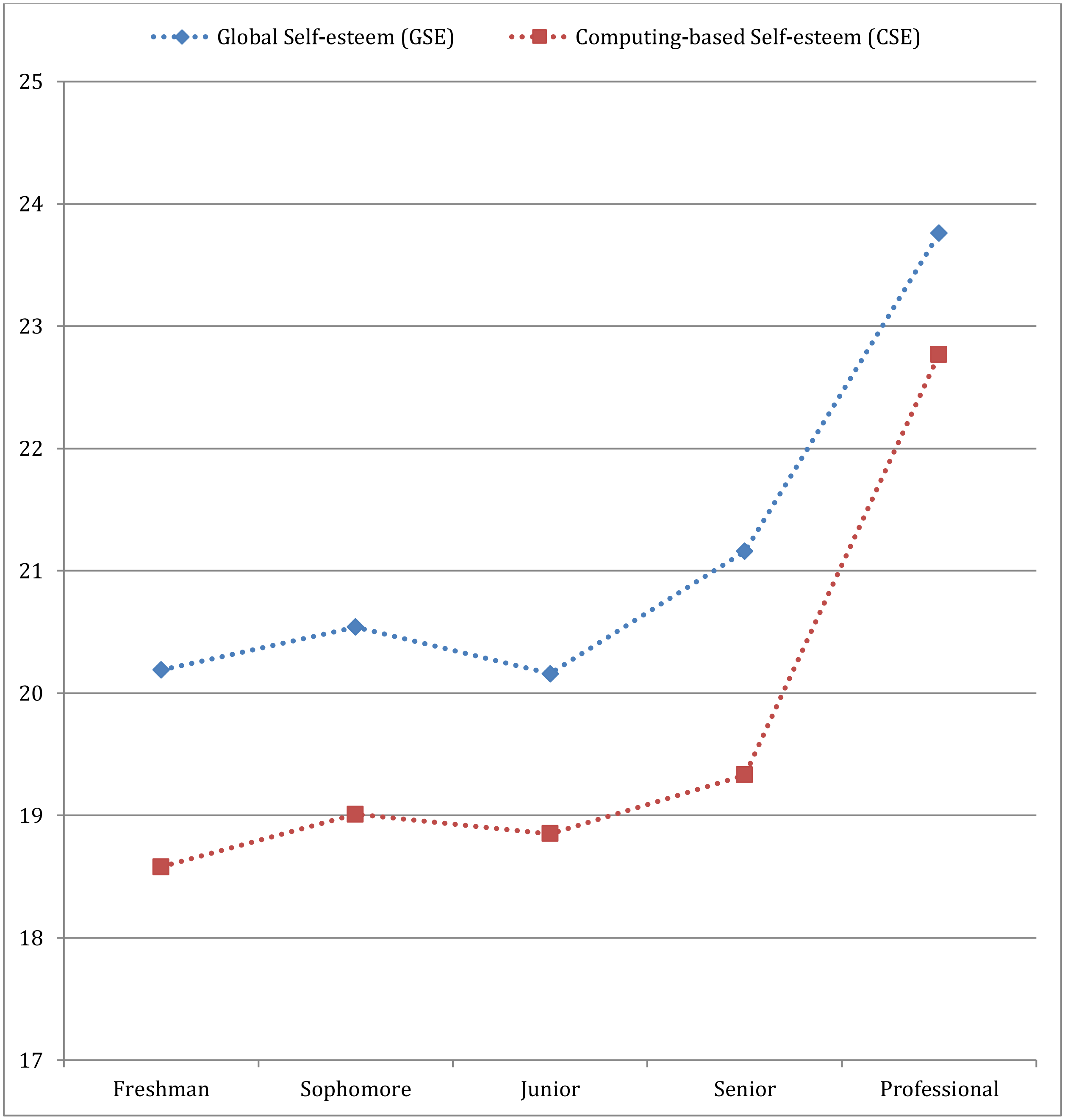

Figure 3. Comparison of means for global self-esteem (GSE) and computing-based self-esteem (CSE) subscales by status. Scores ranged from 0 (most negative feelings of self) to 30 (highest positive feelings of self).

A one-way multivariate analysis of variance (MANOVA) was conducted to determine differences in global and computing-based self-esteem scores by status (freshmen, sophomore, junior, senior, professional). Due to unequal group sizes for the independent variable status, a more robust MANOVA test statistic, Pillai's Trace, was utilized. MANOVA results revealed significant differences among status categories on the combined global and computing-based self-esteem score, Pillai's Trace = .112, $F(8, 1082) = 8.059$, $p < .001$, multivariate $\eta^2 = .056$. Analysis of variance (ANOVA) was conducted on each dependent variable as follow-up tests to MANOVA. Status differences were significant for global self-esteem, $F(4, 546) = 13.015$, $p < .001$, partial $\eta^2 = .088$ and computing-based self-esteem, $F(4, 546) = 16.131$, $p < .001$, partial $\eta^2 = .107$. The Scheffe post hoc analysis revealed that global and computing-based self-esteem scores for professionals was significantly higher than all undergraduate classes (freshmen, sophomores, juniors, seniors).

Q2: Do global competence, global worthiness, computing-based competence, and computing-based worthiness differ by status (freshmen, sophomore, junior, senior, professional) among women in computing?

Descriptive statistics were generated for the four self-esteem subscales by status (see Table 17). In addition, subscale means by groups are visually compared in Figure 4. Subscale scores may range 0 to 15. Subscale means are lower for global and computing-based worthiness than global and computing-based competence with computing-based worthiness being lowest and global competence being the highest. Global and Computing-based competence (GSE-C and CSE-C) means were higher than Global and Computing-based worthiness (GSE-W and CSE-W) means. Overall, Global competence means were highest and Computing-based worthiness means were lowest. Specifically, juniors showed the lowest mean for each of the subscales with one exception. Computing-based worthiness continued to decline for seniors before recovering. The promising trend however is that all four subscale means for professionals far exceed the means for all undergraduates.

Table 17

Means and Standard Deviations for Global Competence and Worthiness and Computing-based Competence and Worthiness Subscales of Self-esteem by Status

Subscale	Status	*M*	*SD*	*N*
Global Competence (GSE-C)	Freshman	11.17	2.43	52
	Sophomore	11.42	2.43	95
	Junior	11.32	2.21	109
	Senior	11.93	2.44	97
	Professional	12.69	2.23	193
	Total	11.92	2.39	546
Global Worthiness (GSE-W)	Freshman	9.02	3.03	52
	Sophomore	9.12	3.20	95
	Junior	8.84	3.23	109
	Senior	9.24	3.11	97
	Professional	11.06	3.12	193
	Total	9.76	3.28	546
Computing-based Competence (CSE-C)	Freshman	10.12	2.94	52
	Sophomore	10.23	2.23	95
	Junior	10.17	2.52	109
	Senior	10.81	2.71	97
	Professional	11.93	2.57	193
	Total	10.91	2.65	546
Computing-based Worthiness (CSE-W)	Freshman	8.45	3.33	52
	Sophomore	8.78	2.99	95
	Junior	8.68	3.08	109
	Senior	8.51	3.27	97
	Professional	10.84	3.21	193
	Total	9.41	3.32	546

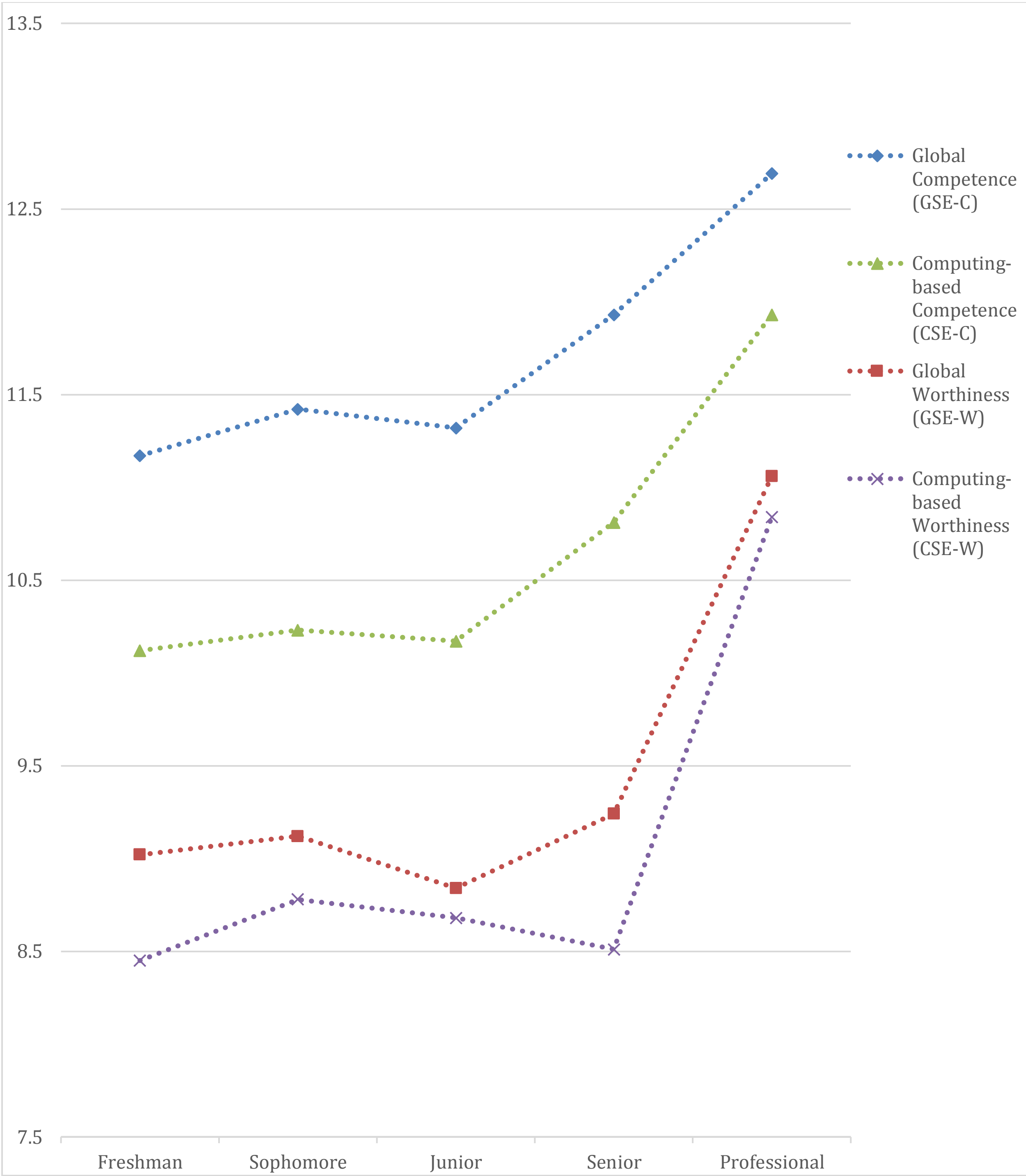

Figure 4. Comparison of means for global competence (GSE-C) and worthiness (GSE-W) and computing-based competence (CSE-C) and worthiness (CSE-W) subscales of self-esteem by status. Subscale scores ranged from 0 (most negative feelings of self) to 15 (highest positive feelings of self).

To examine status differences in competence and worthiness dimensions of self-esteem a one-way multivariate analysis of variance (MANOVA) was conducted on the four subscales: global competence, global worthiness, computing-based competence, and computing-based worthiness. Again, due to unequal group sizes for the independent a more robust MANOVA test statistic, Pillai's Trace, was utilized. MANOVA results revealed significant differences among status categories on the global and computing-based self-esteem scores, Pillai's Trace = .141, $F(16, 2164) = 4.931$, $p < .001$, multivariate $\eta^2 = .035$. Analysis of variance (ANOVA) was conducted on each dependent variable as follow-up tests to MANOVA. Status differences were significant for each of the four subscales with Computing-based Worthiness revealing the greatest effect due to status (partial $\eta^2 = .102$) (see Table 18).

Table 18

ANOVA Results for Self-Esteem Subscales by Status

Dependent Variable	*df*	*F*	*p*	Partial η^2
Global Competence (GSE-C)	4, 541	9.63	<.0001	.067
Global Worthiness (GSE-W)	4, 541	12.95	<.0001	.087
Computing-based Competence (CSE-C)	4, 541	13.19	<.0001	.089
Computing-based Worthiness (CSE-W)	4, 541	15.37	<.0001	.102

The Scheffe post hoc analysis revealed professionals significantly differ from all undergraduate statuses (freshmen, sophomores, juniors, seniors) for three of the self-esteem subscales: global worthiness, computing-based competence, computing-based worthiness. For global competence, seniors and professionals do not significantly differ from each other.

Qualitative Analysis

Q3: What positive experiences in computing contribute to competence and worthiness among women?

Responses to the open-ended question, "Share a time or (times) that made you feel good about your abilities in computing" were analyzed to answer research question three. These are referred to as "Feel Good" responses. Analyses revealed 507 positive self-esteem moments that were categorized into three foci: competence, worthiness, or balanced. Items were placed in the competence focused category if the wording of the response focused on enhancements or challenges to their abilities. For example, "Making a piece of code work before most of the other students" is a student response categorized as having a competence focus. Items were placed in the worthiness focused category if the wording of their responses focused on values or the "worthwhileness" of their actions. For example, "Having an amazing professor to mentor me in this field and support my decision to join it has been one of the most encouraging moments in my life" is a student response categorized as having a worthiness focus. Items were placed in the balanced focus (competence and worthiness) category if the wording showed evidence of both competence and worthiness. For example, "Being able to look at someone else's code and see what going wrong and leading them to find a solution by themselves" is a student response category having a balanced, competence and worthiness focus. Half of the responses illustrated a balance between competence and worthiness (54.44%). About a third (37.87%) of the responses demonstrated examples that were more focused on enhanced competence than on worthiness. Perhaps not too surprising in a field where women often do not feel welcomed, less than 8% of the examples illustrated examples that were more focused on enhanced worthiness than on competence (see Table 19).

Table 19

Comparison of Percent Feel Good Responses by Status

	Competence	Worthiness	Balanced
All Responses	37.87	7.69	54.44
All Students	43.94	6.67	49.39
Freshmen	61.22	6.12	32.65
Sophomores	48.11	9.43	42.45
Juniors	36.63	5.94	57.43
Seniors	36.49	4.05	59.46
Professionals	26.55	9.60	63.84

This lack of balance is more pronounced when considering the difference between student's responses and professional's responses. Compared to professionals, students supplied almost twice as many primarily competence responses and fewer primarily worthiness responses. Professionals shared a higher percentage of balanced competence and worthiness experiences than did the students. For example, professionals provided more examples of significant accomplishment, such as "When I publish a new computer interaction technique that gets colleagues excited."

Interesting trends emerge when considering the difference between student's responses by year in college. Freshmen showed the most dramatic contrast to professionals. Almost two-thirds of freshmen responses illustrated examples of competence and less than a third (32.65%) indicated a balance between competence and worthiness. Contrast this with almost the opposite for professionals who provided less than one-third (26.55%) competence-focused examples and almost two-thirds (63.84%) balanced competence and worthiness examples.

Fortunately, as the number of competence-focused responses decreased for each class from freshmen to seniors, the number of balanced responses likely impacting both competence and worthiness steadily increased from freshmen to seniors. Although not reaching the levels of professionals, this shifting of focus from reliance solely on skills to a blend of skills and value indicates a movement toward a more balanced self-esteem. Responses with a worthiness focus increased for sophomores but then dropped for juniors and again for seniors demonstrating that when worthiness is present for students, it is more often than not, coupled with competence (see Figure 5).

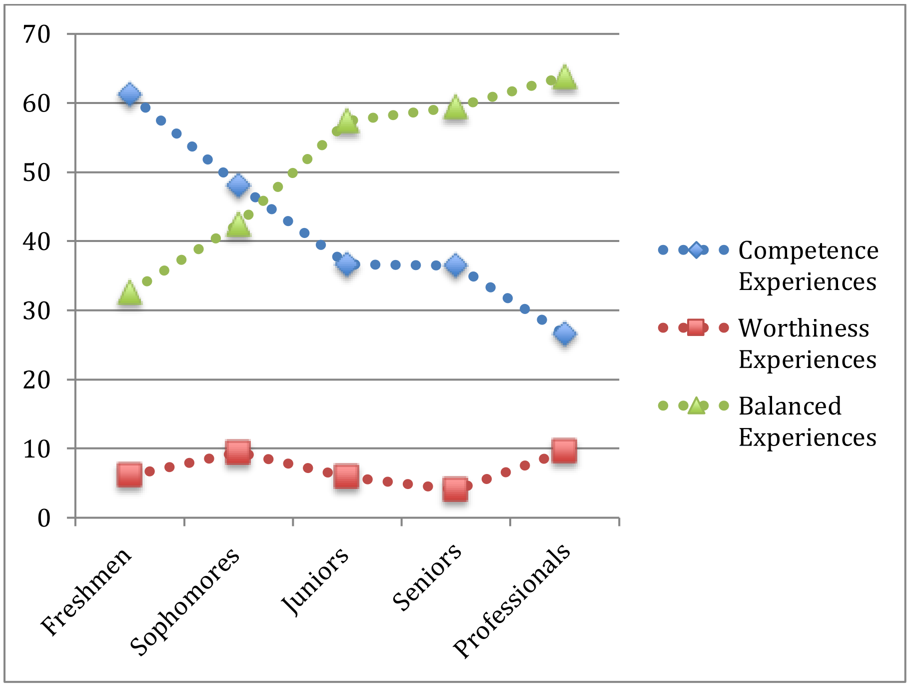

Figure 5. Comparison of percent Feel Good responses for undergraduate students by year in college compared to professionals. The decrease in competence focused responses is replaced by a healthier increase in balanced focus on both competence and worthiness.

Other Notable Feel Good Experiences

Throughout the qualitative results, an unexpected trend emerged. Responses referring to other people increased as the participants' status progressed over time. Over 70% of the examples from professionals included references to other people, whereas less than half of the freshmen responses included references to other people. In addition, professionals rarely cited gender, completion, or ability to complete a task without help in their references to other people. In contrast, the differences in references to gender, competition and ability to complete a task without help was lower for professionals than for students with one exception – juniors rarely mentioned the ability to complete a task without help (see Table 20).

Table 20

Comparison of Percent Feel Good Responses that Included a Reference to Other People, Gender, Competition, or Ability to Complete Task Without Help

	Freshmen	Sophomores	Juniors	Seniors	Professionals
References to other people	46.94	60.38	64.36	64.86	70.62
Gender	6.12	5.66	4.95	5.41	0.56
Competition	8.16	8.49	5.94	4.05	2.82
Ability to complete task without help	6.12	5.66	0.99	10.81	2.26

The difference between students and professionals and the imbalance between competence and worthiness is further demonstrated in the analysis of the negative self-esteem moments.

Q4: What negative experiences in computing contribute to competence and worthiness among women?

Responses to the open-ended question, "Share a time or (times) that made you feel bad about your abilities in computing" were analyzed to address research question four. These are referred to as "Feel Bad" responses. Participants shared 333 negative self-esteem moments. Items were placed in the competence focused category if the wording of the response focused on enhancements or challenges to their abilities. For example, "When I am unable to complete software projects without the help of m TA or professor" is a student response categorized as having a competence focus. Items were placed in the worthiness focused category if the wording of their responses focused on values or the "worthwhileness" of their actions. For example, "Sometimes the passive-aggressive/condescending comments guys can make" is a student response categorized as having a worthiness focus. Items were placed in the balanced focus (competence and worthiness) category if the wording showed evidence of both competence and worthiness. For example, "Having ideas I say repeated by men seconds later" is a student response category having a balanced, competence and worthiness focus. A little over 60% of the examples were categorized as competence focused, 12.31% of the examples were categorized as worthiness focused, and only a little over a quarter were categorized as having a balanced competence and worthiness focus (see Table 21). As such, participants provided more negative (12.31%) than positive (7.69%) examples with a worthiness focus. Additionally, competence focused negative responses (61.86%) far outweighed the positive responses (37.87%), indicating that challenges to one's competence are more salient for these women than challenges to both competence and worthiness.

Table 21

Percent Feel Bad Responses Compared to Percent Feel Good Responses

	Competence	Worthiness	Balanced
Feel Bad Responses	61.86	12.31	25.83
Feel Good Responses	37.87	7.69	54.44

This imbalance is more pronounced when considering the difference between student responses and professional responses. Compared to professionals, students supplied more competence focused responses but fewer worthiness focused responses. Professionals shared a higher percentage of balanced competence and worthiness experiences than did the students. For example, professionals provided more examples of their ideas being ignored, such as "Every day when I speak to male colleagues about things that I am working on. Either my accomplishments are considered small or I must be incorrect". See Table 22.

Table 22

Comparison of Percent Feel Bad Responses for Undergraduate Students and Professionals

	Competence	Worthiness	Balanced
All Students	69.74	10.09	20.18
Freshmen	78.38	8.11	13.51
Sophomores	82.81	6.25	10.94
Juniors	64.91	12.28	22.81
Seniors	57.14	12.86	30.00
Professionals	44.76	17.14	38.10

Trends continue to emerge when considering the difference between student's responses by year in college. Sophomores showed the most dramatic contrast to professionals. Sophomores offered almost twice (82.81%) as many competence-focused examples as professionals (44.76%), about a third (6.25%) as many worthiness-focused examples as professionals (17.14%), and about a fourth (10.94%) as many examples indicating a balance between competence and worthiness as professionals (38.10%).

The number of competence focused responses continually decreased for each rank from sophomores to seniors. Worthiness responses went down for sophomores but then up for juniors and seniors. Responses combining both competence and worthiness steadily increased from sophomores to seniors, demonstrating a trend toward a more balanced self-esteem (see Figure 6).

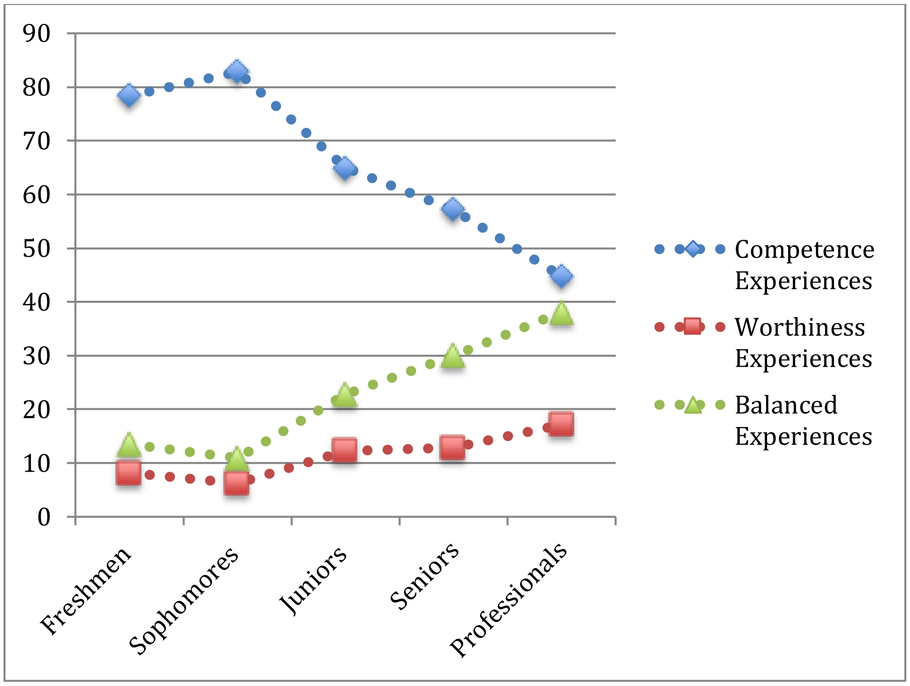

Figure 6. Comparison of percent Feel Bad responses for undergraduate students by year in college compared to professionals. The decrease in competence focused responses is replaced by a healthier increase in balanced focus on both competence and worthiness.

Other Notable Feel Bad Experiences

Similar to positive experience reports, references to other people within a negative experience increased as the participants' status progressed over time. For example, from Table 9, professionals more than students tended to include a reference to other people when sharing positive experiences. When reporting negative experiences, almost two-thirds of the examples from professionals (65.09%) included references to other people, where less than half (39.47%) of the freshmen examples included references to other people. In contrast, juniors and seniors mentioned gender as a component of their negative experience more often than freshmen, sophomores, and professionals. Seniors mentioned competition (i.e., pressure to answer questions, solve a problem, or write code as fast as their peers) more often than the other groups (see Table 23).

Table 23

Comparison of Percent Feel Bad Responses that Included a Reference to Other People, Gender, Competition, or Perceived Lack of Ability to Complete Task Without Help

	Freshmen	Sophomores	Juniors	Seniors	Professionals
Reference to other people	40.54	50.00	59.65	58.57	65.09
Gender	13.51	9.38	17.54	17.14	15.24
Competition	13.51	28.13	27.59	22.86	12.38
Perceived lack of ability to complete a task without help	0.00	4.69	5.17	1.43	0.00

Merged Analysis: Combining the Quantitative and Qualitative Analysis

The quantitative and qualitative data support each other when considering the self-esteem subscale scores and experiences over time (undergraduate years through to professionals). When the Feel Good and Feel Bad experiences are combined and compared with computing-based self-esteem, a relationship appears. As experiences become more balanced, the computing-based self-esteem subscale scores increase (see Table 24).

Quantitative and qualitative results were first converted to a common measurement. First, the Feel Good and Feel Bad percentages were combined. This allowed analysis of overall percent of responses that were focused on competence, worthiness, and balanced with respect to the two different response types (Feel Good and Feel Bad). For example, the percent Feel Good examples provided by freshmen that focused on competence (78.38) were combined with the percent Feel Bad examples (61.22) then averaged to calculate a percent for overall freshmen responses focusing on competence (69.80). Similar calculations were performed for the remaining categories (worthiness focus and balanced focus) for each of the student classes and professional. Worthiness-focused experiences stayed about the same for students, not increasing until professionals. However, the percent of competence-focused experiences declined from freshmen to professionals, replaced by an increase in balanced experiences (focused on both competence and worthiness).

Next, the computing-based self-esteem subscale mean scores were converted to a percentage of possible points. For example, the freshmen mean for computing-based self-esteem was 18.58. Since the total possible is a score of 30, the computed freshmen overall average is 61.93. When considered this way, freshmen scored in the third quartile (i.e., 61.93% of the possible total score). In a similar way, the computing-based competence subscale and computing-based worthiness scores were computed. The freshmen mean for CSE-C was 10.12 therefore, since the possible points for this subscale is 15, the overall average for CSE-C was 67.47. Likewise, the freshmen mean for CSE-W was 8.45, therefore since the possible points for this subscale is 15, the overall average for CSE-W was 56.33. All three averages fall into the third quartile. Averages for sophomores and juniors also fall into the third quartile, however seniors show an interesting transition. Although overall, senior total CSE average is in the third quartile, their CSE-C average comes close to the fourth quartile; however, the CSE-W drops close to the second quartile. Professionals scores recover into the fourth quartile.

Another way to interpret the average scores is to consider percentile ranks. Recall that the question response options were: 0-strongly disagree, 1-disagree, 2-agree, 3-strongly agree (i.e., 0s and 1s are negative responses, 2s and 3s are positive responses). Therefore, the following percentile ranks can be considered: low – under 33%, fluctuating – 33-66%, and healthy – above 66%. In other words, averages under 30.33 indicate that respondents have consistently negative feelings about their self-esteem (i.e., they are responding to the self-esteem scale with only 0s and 1s). Averages between 33.33 and 66.66, indicate that the respondents are having mixed feelings (they are responding with a mix of responses some positive and some negative). Averages above 66.66, indicate that the respondents are having consistently positive feelings about their self-esteem (i.e., they are responding to the self-esteem scale with only 2s and 3s). Considering percentile ranks, we see that competence seems to be in the healthy range for all participants. Of concern, is that worthiness fluctuates between positive and negative feelings for students throughout their academic career, not stabilizing the healthy range until professional status.

Table 24

Combined Overall Averages for Experiences and Computing-based Self-esteem Subscales

	% Experiences Overall [a]			Computing-based Self-esteem Subscale Averages [b]		
	Competence	Worthiness	Balanced	Competence (CSE-C)	Worthiness (CSE-W)	Total (CSE)
Freshmen	69.80	7.12	23.08	67.47	56.33	61.93
Sophomores	65.46	7.84	26.70	68.20	58.53	63.37
Juniors	50.77	9.11	40.12	67.80	57.87	62.83
Seniors	46.82	8.46	44.73	72.07	56.73	64.43
Professionals	35.66	13.37	50.97	79.53	72.27	75.90

Note: [a] Experience percentages combine both Feel Good and Feel Bad responses.
[b] Computing-based self-esteem scores have been converted to an average so they can be compared to the percent experiences.

Figure 7 combines both sets of data to make trends easier to identify. Self-esteem experiences are represented as a stacked bar graph to show that self-esteem moments were categorized into three types of experience (competence, worthiness, and balanced) and represent different percentages of the overall experiences reported. The area graph displayed behind the stacked bars, represents the computing-based self-esteem subscale (CSE) averages. The three line graphs represent the computing-based self-esteem subscale (CSE), computing-based competence subscale (CSE-C), and the computing-based worthiness subscale (CSE-W) averages.

This graph illustrates two important points. First, as overall computing-based self-esteem (CSE) increases, competence (CSE-C) and worthiness (CSE-W) subscale scores become more closely aligned, the percent of balanced self-esteem experiences increase. This could be an indication that as experiences become more balanced so too does self-esteem. And, as self-esteem becomes more balanced, it increases. Second, computing-based competence subscale (CSE-C) averages increased, even though the percent of reported competence-focused self-esteem moments decreased. The decrease in competence-focused experiences is replaced by an increase in worthiness and balanced experiences perhaps indicating that over time, competence is no longer as much a concern as is experiences that include worthiness.

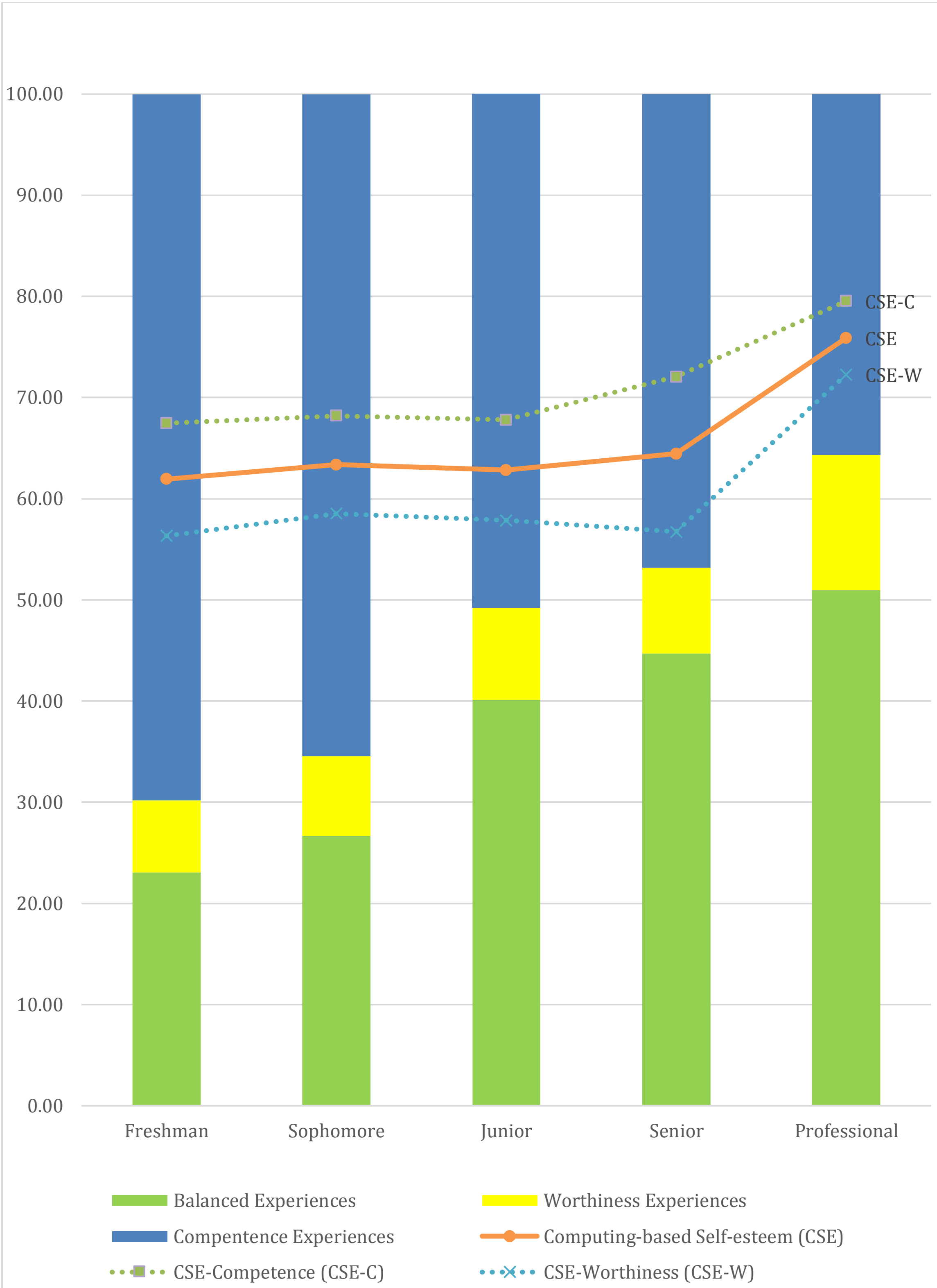

Figure 7. Comparison of experiences and computing-based self-esteem subscale averages.

CHAPTER V. FINDINGS

This study is based on the understanding that although self-esteem is considered a relatively stable global personality trait, it can be affected by situations or development training (Mruk, 2013). Based on this understanding, Mruk's definition of self-esteem provided a framework for this study to explore how the context of being in a computing major or profession may affect women's self-esteem. His definition provided four components that work together to create healthy self-esteem: context matters when measuring self-esteem in a specific domain of life, self-esteem has multiple dimensions, self-esteem may change over time, and experiences can affect self-esteem. Through a mixed methods approach, this study provided evidence that these components are important when exploring the experiences women have in computer science.

Discussion

Context matters

This study introduced the term computing-based self-esteem (CSE) to explore self-esteem within the context of a computing major or profession. Without context, self-esteem scores generally reflect one's overall feelings and evaluation of oneself. However, self-esteem can be different within the specific context of academics, athletics, family, and relationships (Greenier, Kernis, & Waschull, 1995; Harter, 2012; Marsh, 1986; Rosenberg, Schooler, Schoenbach, & Rosenberg, 1995; Shrauger, 1972; Wells, 1988). This dual nature of self-esteem is known as trait vs. state dimensions (Mruk, 2013). This study also introduced an instrument called the Computing Experience Survey (CES) to explore these differences. This study demonstrated that when the participants were asked to evaluate their self-esteem in general (global self-esteem) then asked to evaluate their self-esteem within the context of their computing-related course work (computing-based self-esteem) the scores were indeed different, which is consistent with the trait-state nature of self-esteem (Leary, et al., 1995). During preliminary screening for this study, the paired-samples t-test revealed a significant difference in scores for global self-esteem (*M* = 21.68, *SD* = 5.31) and computing-based self-esteem (*M* = 20.32, *SD* = 5.58); $t(545) = 9.516$, $p < .001$. These results indicate that participants felt worse about themselves within the context of computing compared to how they feel about themselves in general. Prior to this study, research on women and computing have not considered the difference between the fairly stable trait of global self-esteem and the potentially changing state of self-esteem within computing.

Self-esteem has multiple dimensions

The Computing Experience Survey (CES) used in this study also allowed exploration of a two-factor model of self-esteem – competence, worthiness, and the interaction between them (Gecas, 1971; Mruk, 2006; Richardson, Ratner, & Zumbo, 2009; Rosenberg, 1995; Tafarodi & Milne, 2002; Tafarodi & Swann, 1995; Tafarodi & Vu, 1997). The Computing Experience Survey based on Rosenberg's Self-esteem Scale, was separated during analysis into two subscales to measure competence and worthiness dimensions of self-esteem (Tafarodi & Milne, 2002). Analysis of these subscale scores revealed that competence and worthiness scores were indeed different. During preliminary screening of the global self-esteem scores, a paired-samples t-test revealed a significant difference in scores the competence dimension of self-esteem (*M* = 11.92, *SD* = 2.39) and worthiness dimension of self-esteem (*M* = 9.76, *SD* = 3.28); $t(545) = 22.89$, $p < .001$. Similar results were found when screening the computing-based self-esteem scores, revealing significant difference computing-based competence (*M* = 10.91, *SD* = 2.65) and computing-based worthiness (*M* = 9.41, *SD* = 3.32); $t(545) = 15.85$, $p < .001$. These results suggest that, although related, competence and worthiness are separate dimensions of self-esteem. Specifically, results suggest that within the context of computing, women's sense of worthiness is lower than their sense of competence. Prior to this study, research on women and computing have not considered the self-esteem factors of worthiness, competence, and the interaction between them.

Computing-based self-esteem changes over the course of a student's academic career

The third definition component applied during this study is that self-esteem can be considered a developmental state (rather than a fixed trait) that may change over time (Harter, 2012). The first research question asked whether global and computing-based self-esteem differ for freshmen, sophomores, juniors, seniors, and professionals. The minor fluctuations in self-esteem that were identified for freshmen, sophomores, and juniors might be explained by the leveling out of personal expectation and reality as students tackle increasingly more complex college-level concepts (Tinto, 2012). Although not statistically significant, the increase for seniors is interesting to note because this increase could be explained by the realization that internships and jobs are now possible (Robins, Norem & Cheek, 1990). Students are realizing that employers and graduate schools are interested in their computing skills. Not too surprising is the significant increase of self-esteem reported by computing professionals compared to computing students. Employers and graduate school interest in one's skills have become a reality.

Computing-based self-esteem remains lower than global self-esteem even into professional employment

The first research question asked how computing-based self-esteem changed over time in comparison to global self-esteem. Women's global self-esteem showed a slight fluctuation between freshmen, sophomore, and juniors and an increase for seniors and then again for professionals. However, their computing-based self-esteem remained lower than global self-esteem in all cases (students and professionals). This might demonstrate that the chilly climate of computing can be found both in collage and in the workplace as Bernice Sandler and her colleagues theorized (1982, 1996, 1999).

Competence and worthiness are different and most pronounced for seniors

The second research question asked how competence changes over the course of a student's academic career compared to worthiness. This is where more interesting results appear. By splitting out the competence subscale scores from the worthiness subscale scores, analysis revealed more detail about what was happening during each year. Table 25 shows the overall means for the competence and worthiness subscales in comparison to the computing-based score. Feelings of competence are similar for freshmen, sophomores, and juniors, but then increase for seniors and then increase again for professionals. However, fluctuations in worthiness are more pronounced. Figure 8 shows how the fluctuations in worthiness are masked when combined with competence to create the computing-based score. Worthiness increases from freshmen to sophomores but then decreases for sophomores to juniors and then *decreases* again from junior to senior. Recovery of worthiness does not occur until professional status is obtained. The continued decrease in feelings of worthiness would be obscured by the increase in feelings of competence if only the total computing-based self-esteem score was reported. This points out a potential opportunity to help students. If educators can help students feel the value of being in computing (i.e., increase their worthiness) earlier, they may be able to keep them interested in computing and thus improve retention. This finding supports the global impact goal the of the new AP CS Principles course/exam (College Board, 2016). Through exploring the global impact of computer science in an introductory course, students may begin to find personal satisfaction in the work they are doing earlier in their academic career, thereby increasing their feelings of worthiness within the field.

Table 25

Comparison of Computing-based Subscales After Converting to the Overall Mean

	Computing-based Self- esteem (CSE)	Computing-based Competence (CSE-C)	Computing-based Worthiness (CSE-W)
Freshman	61.93	67.47	56.33
Sophomore	63.37	68.20	58.53
Junior	62.83	67.80	57.87
Senior	64.43	72.07	56.73
Professionals	75.90	79.53	72.27

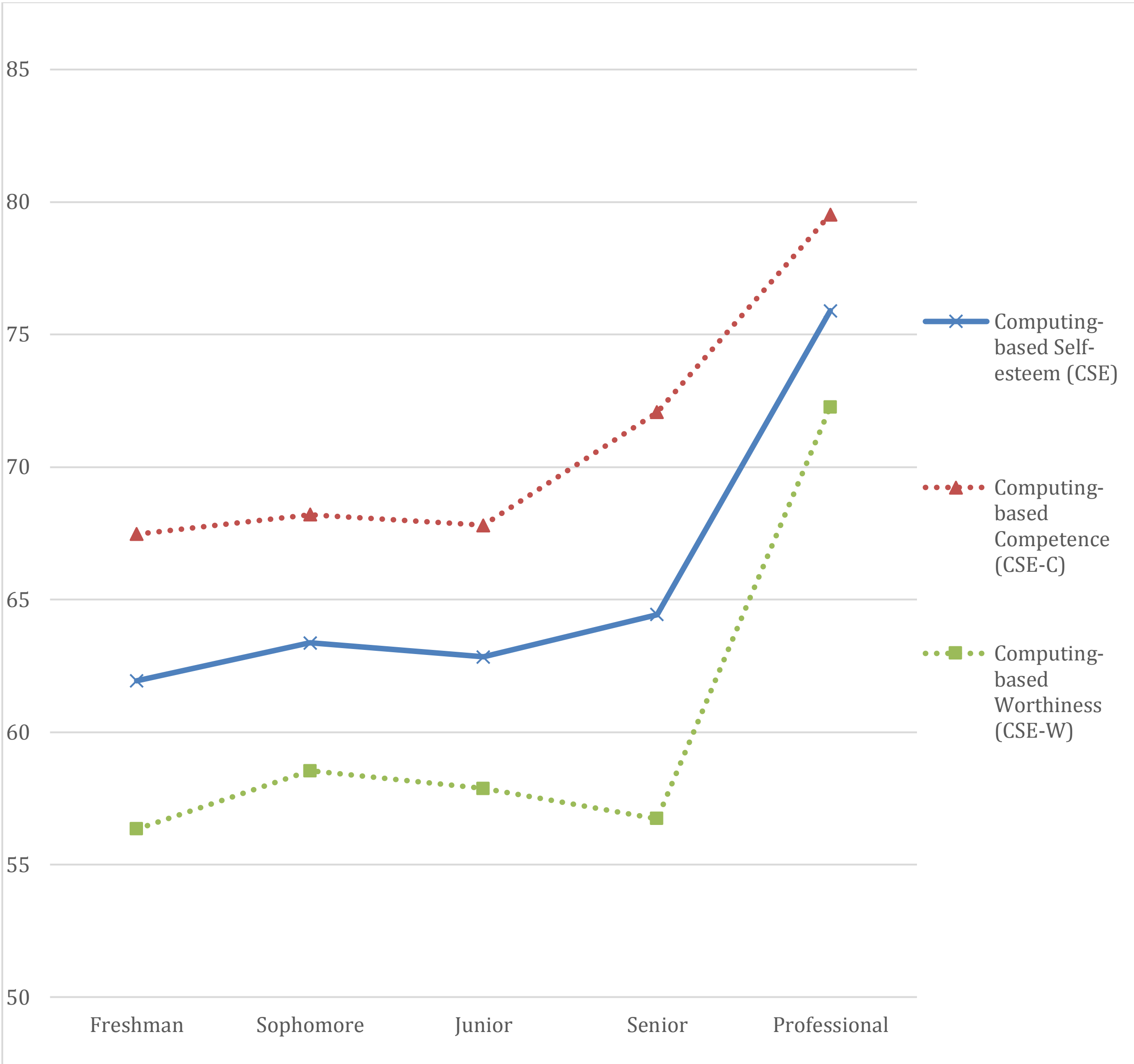

Figure 8. Comparison of the overall means of the computing-based subscales for undergraduate students by year in college compared to professionals.

Retention – competence and worthiness increases between freshmen and sophomores

The third and fourth research questions explored the experiences participants have in their computing major or profession. The qualitative data provide insight to the positive and negative experiences these women are facing in their computing majors and when combined with the quantitative data provide helpful insight. For example, the quantitative data show a slight increase in competence between freshmen and sophomores. More interesting, however, is the slight increase in worthiness. This could be an artifact of the confirmation received as students demonstrate their ability to complete college level work (Tinto, 2012). However, one might expect a larger increase in competence as well. The qualitative data assist in creating a more complete picture. Sophomores may have showed only a slight improvement in competence self-esteem scores because they experienced the highest percent of *negative* competence experiences. In fact, sophomore experiences both, positive and negative, were almost as strongly focused on competence as freshmen were. Although the quantitative data shows an increase for worthiness, the experiences indicate that this worthiness may be a result of their ability to demonstrate their competence. This is a possible retention concern for students who may be struggling to do so (e.g., within their introductory computing courses) and may shed some light on why even highly achieving students leave computer science majors (Katz, Allbritton, Aronis, Wilson & Soffa, 2006). Even students who earn good grades may not feel that they have had a chance to demonstrate their competence if they are in situations where their contributions are not valued. Recall that the sample for this study were engaged students who attended a conference for women in computing. Perhaps less engaged students who are struggling with their grades or struggling to find opportunities to apply their skills in meaningful ways feel even worse than the students who participated in this study. Helping these students acquire the computing skills they need to be successful as well as showing them how to handle experiences that challenge their sense of competence, worthiness, or both may help retain these students.

Persistence – even though competence and worthiness decline between sophomores and juniors

Although the decline for competence is slight between sophomores and juniors, considering it along with the decline in worthiness could provide an explanation for why students might leave the major at this point in their career. If a student does not feel that their competence is increasing (and perhaps even feel it is decreasing) and is questioning their self-worth within the computing field, she may choose to protect herself by leaving the major, seeking a place where she can feel more competent and worthy (Thoman, Arizaga, Smith, Story, & Soncuya, 2014). However, the students in this study are persisting even though their assessments of their competence and worthiness are slipping. Here again, the qualitative data becomes helpful. Although the quantitative data shows a slight decrease from sophomore to junior, the qualitative data shows an increase in worthiness experiences (either alone or combined with competence). Since these experiences may be positive or negative, they may not yet be positively affecting the self-esteem scores but this may be an indication that these students are developing the capacity to recover from difficulties. This might be thought of as a sort of computing-resilience that helps students learn from negative experiences and turn them into positive ones by demonstrating competence in an area perceived as worthwhile (Epstein, 1979). Again, recall that the participants for this study are engaged students who attended a conference for women in computing. Perhaps less engaged students who are struggling with their grades feel even worse than the students who participated in this study and may benefit even more from targeted intervention. These students may not be gaining the worthiness experiences that persisting students are or may need some help re-framing negative experiences into positive learning examples.

Career faithfulness - competence recovers but worthiness continues to drop for seniors

An explanation for the increase in competence from junior to senior could be due to successful demonstration of skills on larger team projects and internships. For example, juniors rarely mentioned the ability to complete a task without help which was a focus for freshmen and sophomores. One explanation could be that juniors are starting to have activities other than academics influencing their self-esteem, such as applying for internships which could have more influence on worthiness if the search is not going as well as expected. Another explanation for the continuing decrease in worthiness that starts with the junior year could be due to an increasing awareness of the chilly climate. Perhaps as students become more comfortable with their competence, their attention becomes more focused on their worthiness. Of concern would be a student who still after four or more years of study still feels they are not fitting in with the major and may choose not to pursue a job in the field. This could explain Freeman and Aspray's (1999) findings on "career faithfulness" who reported surprising numbers of students who completed computing or engineering degrees but never pursued jobs in their field. Career coaching during this transition between college and profession could help ensure students take the necessary steps to find a company or graduate program where they can find a worthy fit in which to apply their computing skills.

Light at the end of the tunnel - competence and worthiness recover for professionals

Although negative worthiness experiences increase, balanced positive experiences increase. The increase of balanced experiences may help professionals manage difficult situations that challenge their worthiness or competence. Many of these balanced experiences are related to opportunities they have for advancement and leadership within the workplace that may not be so available in college. This study's findings complement the findings of Pierce, Gardner, Cummings, and Dunham (1989) who introduced a construct called organizational-based self-esteem (OBSE). Using a two-factor model they showed experiences such as taking on the role of team leader, requires and builds *competence* and *worthiness* and that these competence-building and worthiness-building experiences contribute to overall job satisfaction.

The current study along with Pierce, et al.'s findings provide a different description of women's experiences in the workspace than is typically found in studies on confidence and self-efficacy. Often these research studies portray a bleak situation describing women filled with self-doubt (Eccles, 1994). The current study shows that there are other factors to consider (competence and worthiness) and that self-esteem is highest when they are in balance and may contribute to research on job satisfaction.

Caution is suggested, however, when considering the rebound that professionals reported in this study. These findings are based on students and professionals that are persisting in the field and are who are contributing to the dismal 16% of women who earn degrees in computing. Therefore, the light at the end of the tunnel *is for those that persist*. Faculty must not forget that many women are not persisting and intervention is required.

When worthiness is present, it is strongly tied to competence for women in computing

An explanation for the decrease in reported examples of competence examples, even though the subscale scores for competence were increasing, could be interpreted as indicating that as one begins to feel more competent, the less she is influenced by competence-only experiences and therefore would report less self-esteem moments that focus only on competence. It appears from this study that as a person progresses through their computing undergraduate career, self-esteem moments begin to focus less on competence experiences and more on balanced competence and worthiness experiences. This increase in experiences over the undergraduate career that combine competence and worthiness and the relative lack of change in experiences that are worthiness focused indicate that when worthiness is present, it is strongly tied to competence for women in computing. Prior to this study, research on women and computing have not considered the self-esteem factors of worthiness, competence, and the interaction between them. This study showed that self-esteem is highest when competence and worthiness are balanced and suggests that applications of this study and future research strive to intertwine these two important factors.

Implications

Implications for Leadership

Opportunities to be the expert. Results of this study can be applied to leadership in different ways. For example, leading outreach events can help students realize that they have skills in computing (competence) and feel that these skills are valued (worthiness) (Townsend, 2013). Women in STEM Days is one such outreach event. Local junior high and high school students are invited to participate in STEM activities presented by college faculty and students. These outreach events not only benefit the young students attending the event, but also benefit the college students who help plan and deliver the activities. In preparation of the event, the college students use their competence to design the activity and gain a feeling of worthiness as they feel part of the planning team. During the event, the college students use their competence to help the younger students trouble shoot their projects and grow their worthiness as they become the "experts" that the younger students look up to. However, the college students may need a little extra nudge to step out of their comfort zone. They have the competence, but may not feel worthy enough to stand in front of others as the expert. Their comfort level with public speaking may be complicated by their fear of being found out they are a fraud ("imposter syndrome") and fear that others will not respect what they say. This is where a little coaching can be helpful. Additionally, involving veteran students who have done this before can help lead the way for the newer students. Upper classmen are still close enough in age and experience for the new students to also see that it is possible to be successful. Veteran students benefit because their worthiness increases as the new helpers look to them as leaders. The veteran helpers become role models and in some cases peer mentors for the new helpers. Sharing "war stories" can illustrate that it is okay to take a risk, make a mistake, and lean on each other for help. The instructor benefits because her competence increases as she tries different projects with the students and realizes her worth as a teacher and computing professional.

Appointment of authority. Another leadership application of this study can be through appointing women to manage the computer lab or other common student space (Haller & Fossum, 1998). Granting the title of lab monitor or computer tech to a woman demonstrates that she is valued not only as a part of the community but as an authority within the community. This can be a subtle yet powerful message for peers to see their colleague in a leadership role. This simple gesture may be just enough to empower the women to speak up when changes need to be made to the lab or rules for its use. This is also a way for women to develop her technical skills as well as conflict management skills.

Assignment of roles. A third leadership application of this study can be through encouraging women to take on leadership roles. Team leader is not the only leadership role she can take. She might be good at time management and take the lead in making sure all the deadlines are met. She might be good at solving complex problems, so she might take the lead as solution architect. She might be good at understanding what the client needs (not just what they say they need) and therefore write the specifications. She might be good at helping people understand how to use technology and therefore take the lead on preparing the training materials. She may simply have a better idea and may take the lead in helping the rest of the group understand that another solution is the right way to go. She might even show leadership by encouraging someone else to try the lead role. Through taking on leadership roles, she learns how to take risks and begins to gain respect from team members thus increasing her competence and worthiness (Bass, 1960; Burns, 1978; Li, Arvey & Song, 2011). Good coaching and mentoring can help to make sure that these roles ae validated and experiences are internalized in a positive way.

Implications for Retention and Student Success

The results of this study support the four conditions of student success advocated by Vincent Tinto in his book Completing College Rethinking Institutional Action (2012). Tinto's research suggests that expectations, support, feedback and assessment, and involvement lead to student success. Related to the current study, each of these conditions support competence and worthiness. Expectations give students a reason (worthiness) for learning the concepts required (competence) and can be explained by the individual faculty member for a specific course or by academic advisors for the overall major. Assessing student needs will help identify how to effectively support students through giving them chances to enhance their competence and worthiness (e.g., tutoring, feedback). Involving students in the learning process through experiential activities inside or outside the classroom can help students find meaningful ways (worthy) to apply their skills (competence). Specific examples are provided below.

Academic advising and career coaching. Results from this study support best practice strategies for helping students identify the value (worthiness) of their education (Education Advisory Board [EAB], 2016). For computing students, besides the monetary investment, there is the investment of time and effort to complete projects. Therefore, helping them identify the return on their investment of their work can help with retention. One of these strategies is major maps. These diagrams show students that although choosing the right courses (competence) is important to success but so too is seeking out relevant experiences (worthiness) such as getting connected with the community (other students, professional organizations, role models), thinking globally (how to apply skills to affect the world), and getting ready for life after graduation. Advisors can help students identify the experiences that will have the most meaning for them. In fact, they can encourage students to change their thinking from being major-focused, "I am studying computer science" to mission-focused "I am studying computer science so I can help elderly persons live in their homes more safely". This type of thinking could help the student focus on the importance of gaining competence so they can meet the worthiness of their long-term goal. Some schools take the idea of getting ready for life after graduation a step further by requiring students to work with an advisor to create a transition plan. This last step may be particularly helpful for those students who are encountering doubt and perhaps for the first time, rejection from employers as they seek internships and jobs. Career coaching can help students navigate the challenges of deciding where to apply and turning negative experiences into learning opportunities.

Assessing student needs. This study utilized a low cost, easy to administer survey that trained professionals can use to obtain feedback from students either as a group or on an individual case by case basis. For example, to better understand a group of students, department chairs could ask a trained professional to administer the CSE survey to the students in their department. Based on the results of the CSE survey, the department would be better prepared to implement appropriate programming to meet their students' needs. To better understand an individual student's needs, a trained professional can use the survey as an interview tool. In the case of advising, the student could arrive ten minutes prior to the appointment to take the CSE survey. Then the interviewer could use the CSE survey questions as talking points, asking the student why she answered a quantitative question a particular way or what she meant by the words chosen to explain a self-esteem moment. These discussions could provide valuable insights to the successes and challenges this student is facing. Simply listening to the student's experiences and offering supportive feedback could go a long way to making the student feel valued and important.

Tutoring and feedback. Results from this study may inform intervention and feedback strategies. For instance, if a department determines that extra tutoring is needed to help with competence, some attention to worthiness should also be considered. Such a program would provide additional training for the tutors so they can better understand the importance of not only encouraging their tutees and welcoming questions and different ways of problem solving but also helping tutees see the value or worthwhileness of the activity. However, if tutors are only prepared to give encouragement without support for skill development, this becomes too heavily weighted on the side of worthiness. Too much "you can do it" without acknowledgement of the skills needed to succeed can make a student distrustful of the feedback they are receiving. *NCWIT Tips: 8 Ways to Give Students More Effective Feedback Using a Growth Mindset* (2016a) offers suggestions for how to give "wise feedback". For example, a balanced tutoring program might include one-on-one time with a mentor or coach after exams. These short meetings could be used to help the student validate their skills and identify action plans if needed (i.e., tutoring) as well as help the student find worthiness in their efforts to improve. Discussion could help the student turn negative experiences into positive learning experiences (Mruk, 2013).

ACM-W student chapters and social activities. ACM-W provides 101 ideas for how to engage women in educational, social, and outreach activities (Townsend, 2013). Results from this study may be used to inform the selection and implementation of these student activities. For example, if a department determines that a student organization could help students feel a sense of belonging (to increase worthiness), some attention is needed to ensure that skills are also nurtured (to balance the worthiness with competence). A club that meets to hang out may not help with competence or worthiness if the club becomes a "click" that pushes out those with different skills or interests. However, providing opportunities to connect with other women in computing as a source of academic as well as social support can help balance out the possible unbalanced experiences in the classroom. Additionally, providing opportunities to explore the profession and connect with female computing professionals can provide the role models (to increase worthiness, competence or both) that may be lacking in the classroom.

ACM-W celebrations of women in computing. Results from this study can inform the programming for the ACM-W celebrations of women in computing. This study showed that these engaged women, are having doubts about their competence and even more so about their worthiness. These celebrations have a unique opportunity to reach out to these women and provide ways to validate their competence and create an environment of inclusion and acceptance to validate their worthiness. Making sure that there is a balance of activities and presentations that appeal to their skills as well as to their worthiness can help to make sure the student has a positive experience. Reminding speakers to find ways to explain complicated content to novices could go a long way to helping students not take too hard of a hit to their competence during research talks. Additionally, encouraging speakers to add a Feel Good self-esteem moment to their talk could help balance competence with a message of worthiness (Barker & Cohoon, 2015; Mruk, 2013; Townsend, 1996).

Implications for Recruiting

K-12 outreach events. Although women under 18 were not included in this study, the importance of balanced experiences between competence and worthiness was illustrated. It may be that girls in K-12 are not low in either competence or worthiness or that they fluctuate quite a bit as they mature. But regardless of any changes or differences, providing experiences that enhance both competence and worthiness could lay the foundation for decisions to enter a computing major. For example, to enhance competence, these events could focus on making sure that the activities are challenging enough for the students to feel that they accomplished something, such as create an app for their cell phone. To enhance worthiness, session leaders can help participants understand that that activities are worthwhile so that participants see the value in doing them and see themselves as worthy participants, such as creating a software application that helps families locate lost pets (Barker & Aspray, 2006; Cohoon & Aspray, 2006).

Recruiting materials, including website messages. Again, presenting balanced messages may help women see that not only is competence valued, but also a sense of belonging and investment in worthwhile activities. *NCWIT Tips: 11 Ways to Build More Inclusive Academic Websites* (2016b) offers suggestions that illustrate the importance of presenting a balanced message. For example, instead of just promoting that the program requires a capstone project, the projects could be explained as one way of the university gives back to the community (i.e., a worthy use of one's computing skills). Another use of competence and worthiness related to recruiting, can be applied to information posted on websites. Often pictures show men and women working on a computer. This appeals to one who has computing competence and perhaps seeing that men and women work together may help one feel that this is a place she would fit in. However, a picture of students doing something worthwhile with their skills (i.e. helping young children get a robot to work or showcasing the software they built for a local not-for-profit organization) might show how one's computing skills can be used to help people. Even pictures that show comradery could be helpful. Rather than a picture of two students working on a computer, show them giving each other high-five to show the joy that comes from finally getting that piece of software to work.

Implications for Practice

In summary, this study provides evidence that experiences in computing can impact competence and worthiness and that competence and worthiness work together to create a balanced self-esteem. Recommendations for academic leaders include the following:

- Insist that faculty help students understand expectations, seek support, learn from assessment and feedback, and get involved in career related activities.
- Create opportunities for students gain leadership experience for example through ACM-W chapters and other prominent technical roles in the department.
- Send women to ACM-W Celebration conferences to help students experience a broader view of computing than they may get within their male-dominated classrooms.
- Add an introduction to computing course (e.g., CS Principles) to the curriculum to help students experience all the facets of computing and begin to explore how they might apply their computing skills in socially relevant ways.

- Encourage projects and undergraduate research to help students experience the application of their knowledge in ways that challenge them to step out of their comfort zone and discover the usefulness of their skills.
- Increase support for advising and mentoring to help students experience the major in a way that is valuable for them (e.g., major maps, graduation plans).
- Consider the meaningful attainment of skills when creating outreach/recruiting programs and materials.

Implications for Research

Research design. This study provides some insight as to why previous research was not able to identify self-esteem as a component of persistence. This study demonstrated that context matters and so encourages future studies that include self-esteem to focus participant attention on their experiences within the context of their computing major or profession. This study also demonstrated that competence and worthiness are two related but different dimensions of self-esteem and that these multiple dimensions reveal differences that can be lost if only total scores are reported. Therefore, this study encourages future researchers to use a self-esteem survey that can be separated into competence and worthiness subscales (e.g., Rosenberg Self-esteem scale) and carefully consider what the subscale scores for competence and worthiness may be revealing about the participants surveyed. This study also demonstrated that self-esteem changes over the course of a student's academic career so future researchers are encouraged to survey students at different times. This study reminds us that the needs of seniors may not be the same as the needs of freshmen. In summary, results of this study demonstrate that future studies on women and computing should consider:

- using a **two-factor definition** of self-esteem so that both competence and worth are considered separately and together to achieve a comprehensive understanding of self-esteem;
- measuring both **global self-esteem (trait) and computing-based self-esteem (state)** to gain a better understanding of the behaviors associated with self-esteem within the specific situation of women and computing;
- measuring self-esteem **at different points** in the development of computing careers - academic through professional employment;
- considering the importance of experiences that constitute **self-esteem moments** that can create turning points in one's self-evaluation; and
- using a **mix of methods** to maximize the strengths and minimize the weaknesses of both quantitative and qualitative studies.

Future directions for the Computing Experience Survey (CES). This researcher recommends that ACM-W continue to support self-esteem research as it relates to women in computing. Suggestions for future uses of the CES include the following: add a question to help identify what helps (or would) help a student stay in the field of computing; cross-referencing responses from the CES with feedback from the celebration they attended; compare scores between years to identify trends; conduct a longitudinal study to follow a cohort of students through their academic career and into the profession; provide "consulting" survey analysis for individual departments; provide support for at-risk students (i.e., those that score low on the CES); and, survey all computing students, including men.

Competence and Worthiness Training. There is no easy solution to retaining women in computing. However, the results of this study identified that self-esteem may be a factor that has been overlooked. Therefore, following Cohoon and Aspray's (1999) recommendations, the next step is to create and test an intervention program based on these empirical findings. This task is not quite as daunting as it might seem. As mentioned in chapter 1, there are many empirically supportable self-esteem enhancement programs that educators and business leaders can use as a starting point for intervention programs that will have persistent and significant results. One such program is the Competence and Worthiness Training (CWT) created by clinical psychologist, Christopher Mruk (2006). This five-week program can be conducted in a group setting or during one-on-one meetings making it flexible enough to adopt to an academic or work setting. Due to its brief and well-structured design, trainers and participants can easily learn and apply the techniques. The goals of the CWT are simple: teach participants how to appropriately reflect on and improve their feelings of competence and worth.

The program starts by first sharing the bad news that enhancing their self-esteem is not a magic bullet because self-esteem is only one factor affecting a situation or behavior. But, then it explains the good news that even small increases can have tremendous power over the course of time. This program could be adjusted to work with students or professionals and is inexpensive to deliver. In fact, the program has already been shown to be helpful for women and their self-esteem in a study conducted at Pennsylvania State University. For example, Hunt (2010) found that running the program for an all female group increased the psychological well-being of college women with varied majors. Using the same approach with women who share the same major and its values may even create additional synergies.

Leadership Training. Future studies may want to explore the connection between leadership and self-esteem for women and computing. Studies have shown that authentic leadership experiences can have a positive impact on psychological well-being and healthy self-esteem (Avolio & Gardner, 2005; Toor & Ofori, 2009). When asked to share a Feel Good self-esteem moment professionals in the current study offered more leadership experiences than did students. Perhaps providing female students with leadership opportunities could help increase their self-esteem, especially for the seniors who are suffering from self-doubt just as they are beginning to transition to the workforce. Professionals also offered more positive and negative worthiness focused responses than did students. Future research may consider investigating whether there is a connection between an increase in these experiences, persistence, and leadership. Perhaps these worthiness focused experiences, even the bad ones, are more meaningful motivators for persistence and leadership. If so, these women might be good role models for other women and be willing to share their suggestions to help other women. Or perhaps these worthiness experiences provide insight to where women need support. If so, this may be where business leaders should focus intervention and support programs.

Curriculum. Future studies may consider whether changes in the ACM Computing Curricula Recommendations (2013) over the years has had an impact on retention and self-esteem. Earlier versions of the ACM Curriculum guidelines focused on problem-solving where as more recent guidelines focus on skills (L. Leventhal, personal communication, March 24, 2017). This recent focus on skills (competence) rather than the applied usefulness of computing (worthiness) seems to be reflected in the qualitative responses from the participants in the current study, especially from freshmen and sophomores. Future studies may consider whether this shift in curricular focus could explain the drop in computing degrees by earned by women identified in the 80s.

Other suggestions. Other suggestions for future research include the following. Although the current study focused on women and computing, future studies might consider studying men and computing. Men may suffer the same feelings of the "imposter syndrome" and "chilly climate" and could benefit from learning techniques on how to handle situations when their competence or worth is being challenged. Indeed, it might even be found that some men, such as those who suffered low self-esteem in childhood or adolescence (so called "nerds") may experience a dramatic increase in competence and worthiness as their skills become valued in the computer setting, not just athletics or popularity. Another suggestion for future studies would be to follow up after the survey with interviews or focus groups. These interviews or focus groups could be used to help the researcher better understand the open-ended responses as well as better understand why participants answered the quantitative questions the way they did to better inform their interpretation. A third suggestion for future studies would be to compare the disciplines within computing CE, SE, CS, IS, IT. The current study did find differences between the disciplines but due to the small sample size for non-CS majors (i.e., CE, SE, IS, and IT) the results were not considered statistically reliable and therefore they were not reported.

One last suggestion for future studies would be to consider doing an item analysis of the separate questions. For instance, this study identified that the three lowest rated items for computing-based self-esteem are worthiness questions: (C8) I wish I could have more respect for myself, within my major or profession; (C9) I certainly feel useless at times, within my major or profession; and, (C10) At times I think I am no good at all, within my major or profession. However, only two of three highest rated items are competence questions: (C2) I feel that I have a number of good qualities, within my major or profession, and (C1) I feel that am a person of worth, at least on an equal plane with others, within my major or profession. The third highest mean is a worthiness question: (C6) I take a positive attitude toward myself, within my major or profession. This could indicate that although these participants have a lower overall mean for computing-based worthiness, they are deriving a bit of personal satisfaction from being in computing. Further investigation could reveal that the "geek culture" may not actually be a negative aspect of the field.

Closing Remarks

Through an interdisciplinary approach, bringing together leadership studies, computer science education, gender studies, and psychology, this study identified factors that contribute to student persistence in computing that may have otherwise not been identified. If we can help women stay in computing majors, they will have a chance to discover an enhanced sense of self-esteem once they get to the workplace. Here they will encounter challenges too, but because of the resilience they have built up over their college career they will be prepared to meet and overcome those challenges. Gaining a balanced self-esteem can embolden women to take on the leadership challenge presented by Malala Yousafzai earlier in this study, ensuring their part in creating the technology that will change our world, and change who runs it.

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APPENDIX A. COMPUTING EXPERIENCE SURVEY

First, tell me a little about yourself.

Below is a list of statements dealing with your general feelings about yourself. If you STRONGLY AGREE with the statement, circle SA. If you AGREE with the statement, circle A. If you DISAGREE, circle D. If you STRONGLY DISAGREE, circle SD.

	Question	Strongly Agree	Agree	Disagree	Strongly Disagree
1.	I feel that I am a person of worth, at least on an equal plane with others.	SA	A	D	SD
2.	I feel that I have a number of good qualities.	SA	A	D	SD
3.	All in all, I am inclined to feel that I am a failure.	SA	A	D	SD
4.	I am able to do things as well as most other people.	SA	A	D	SD
5.	I feel I do not have much to be proud of.	SA	A	D	SD
6.	I take a positive attitude toward myself.	SA	A	D	SD
7.	On the whole, I am satisfied with myself.	SA	A	D	SD
8.	I wish I could have more respect for myself.	SA	A	D	SD
9.	I certainly feel useless at times.	SA	A	D	SD
10.	At times I think I am no good at all.	SA	A	D	SD

Next, tell me about your major or profession.

Below is a list of statements dealing with your general feelings about yourself within your major or profession. If you STRONGLY AGREE with the statement, circle SA. If you AGREE with the statement, circle A. If you DISAGREE, circle D. If you STRONGLY DISAGREE, circle SD.

	Question	Strongly Agree	Agree	Disagree	Strongly Disagree
1.	I feel that I am a person of worth, at least on an equal plane with others, within my major or profession.	SA	A	D	SD
2.	I feel that I have a number of good qualities, within my major or profession.	SA	A	D	SD
3.	All in all, I am inclined to feel that I am a failure, within my major or profession.	SA	A	D	SD
4.	I am able to do things as well as most other people, within my major or profession.	SA	A	D	SD
5.	I feel I do not have much to be proud of, within my major or profession.	SA	A	D	SD
6.	I take a positive attitude toward myself, within my major or profession.	SA	A	D	SD
7.	On the whole, I am satisfied with myself, within my major or profession.	SA	A	D	SD
8.	I wish I could have more respect for myself, within my major or profession.	SA	A	D	SD
9.	I certainly feel useless at times, within my major or profession.	SA	A	D	SD
10.	At times I think I am no good at all, within my major or profession.	SA	A	D	SD

To wrap this up, tell me about your experiences.

1. Tell me about a time (or times) that made you feel good about your abilities in computing.

2. Tell me about a time (or times) that made you feel bad about your abilities in computing.

APPENDIX B. PAPER COLLECTION CONSENT

Greetings OCWIC! Can you help me out? I am trying to find out what helps women thrive in computing-related majors. Would you mind sharing your experiences with me? I will use your feedback to help other women find joy in computing.

About me: I am Rachelle Kristof Hippler and I teach computer science at BGSU Firelands. I am passionate about inspiring students stay in computing because I believe that there are tremendous opportunities and important work for those who enter the field.

Purpose: The purpose of the study is gain insight to what helps students succeed in computing. You benefit from participating in this study by knowing that your responses will help inform teaching and contribute to overall improvements in computing education. If this study leads to better teaching, students may benefit from more welcoming environments and stronger academics. To thank you for your time, I invite you to enter a raffle for fun OCWIC swag.

Procedure: You will be asked to complete a short survey containing 23 questions. The entire survey should take you about 8 minutes to complete. Once completed, tear off the raffle ticket. Outside the main conference room you will find two separate boxes, one for the completed surveys and one for raffle tickets. Place the survey and the raffle ticket in the corresponding box. Names will be drawn periodically throughout the conference.

Voluntary nature: I have obtained permission from OCWIC to ask you complete this questionnaire. Your participation is completely voluntary. Deciding to participate or not will not affect your relationship with Bowling Green State University or the Ohio Celebration of Women in Computing (OCWIC).

Confidentiality/Anonymity Protection: To maintain confidentiality, all identifying data will be kept separate from the results of the survey and will be stored on a password-protected computer. I will be the only one who will have access to the data.

Risks: There are no risks associated with this study.

Contact information: If you have any questions, you may contact me at 419-372-0670 or rkristo@bgsu.edu. You may also contact the Chair of the BGSU Human Subjects Review Board at 419-372-7716 or hsrb@bgsu.edu, if you have any questions about your rights as a participant in this research.

Thank you so much for your time!

By completing and returning this survey you are indicating your consent to participate in the study. You must be 18 years or older to participate.

APPENDIX C. PAPER COLLECTION RAFFLE TICKET

Thank you so much for sharing your experiences!

Please place this ticket for a raffle into the designated box outside the main conference room.

Name: ____

Email: ____

Participant ID: __________________________________