Women in Computer Science: Two Studies on the Effects of Stereotypes

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Abstract

The goal of this honors thesis is to illuminate issues related to the systematic under-representation of females in computer science. It does so, first, through a review of research that addresses the existence of gender differences in computing ability, attitudes, and experiences, as well as factors potentially related to these differences, particularly stereotypes. Secondly, it expands on such research with two studies. The first study experimentally tests for the existence of stereotype threat effects for females with regard to computer competency. The second, qualitative, study collects and analyzes female computer scientists' experiences with and views about the effects of gender stereotypes for women in computer science.

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"Women never reason, and therefore they are (comparatively) seldom wrong."

William Hazlitt, *Characteristics*

"Man with the head and woman with the heart ...

All else confusion"

Alfred, Lord Tennyson, *The Princess*

"Computer Science is, simply put, the study of computation. Computer Science is practiced by mathematicians, scientists and engineers. Mathematics, the origins of Computer Science, provides reason and logic"

Valpariso University website, 2002

History is filled with instances of men (and sometimes women) characterizing woman by emotion and man by reason, and therefore, by intellect. These "superior" reasoning talents of man then also imply heightened mathematical and scientific abilities, including computer science abilities. The question of whether males and females actually differ in levels of various forms of intelligence, as well as the question regarding the sources of any such differences (e.g. "nature" vs. "nurture"), are topics of much discussion and debate. The belief, accurate or not, that women have a diminished reasoning ability has serious implications in various spheres of life. One such sphere is the realm of computer science. This honors thesis seeks to focus on this particular realm.

Today women are more likely to attend and equally likely to graduate from college as men. In 1999 women accounted for over half of undergraduate enrollment (56 percent) and graduate enrollment (53 percent) at American educational institutions (National Science

Foundation, 2000). Yet, female undergraduate enrollment in computer science (and mathematics and engineering) remains low. Furthermore, not only has the percentage of women in undergraduate computer science not increased in recent times, over the past two decades that percentage has been decreasing. In 1984 women accounted for 37 percent of bachelor's degrees in computer science; by 1996, that figure had dropped to 25 percent (National Science Foundation, 2000). Additionally, those undergraduate women who have enrolled in computer science have left the major at a higher rate than their male counterparts (Cohoon, 2001). Additionally, women still account for less than 25 percent of computer science graduate degrees, despite a dramatic overall increase in the percentage of women graduate students (National Science Foundation, 2000). Pearl, et al. (1990) elucidate why these systematically low numbers of women in computer science constitute a problem:

> It raises the disturbing possibility that the field of computer science functions in ways that prevent or hinder women from becoming part of it...Practices that exclude women are not only unethical, but they are likely to thwart the discipline's progress, as potential contributors to the field are discouraged from participation (p. 48)

This notable under-representation of women in computer science warrants an investigation of potentially relevant factors. Do gender differences in computing ability exist? Computing ability is also often referred to as computer aptitude, computer competency, and computer literacy. If such differences have been found, what are the relevant factors? How might gender differences in experience and attitudes be related? Are these factors motivated by biology ("nature"), by society ("nurture"), or by a combination thereof? These are among the questions this honors thesis will attempt to illuminate, by focusing on the existence and effects of stereotypes. For, if we can identify and understand any environmental factors or inequalities related to this systematic under-representation, we may be able to use that information to promote the numbers of interested women entering and staying in computer science.

Following a review of the relevant research seeking to respond to the above questions, this honors thesis will use two different approaches to examine further stereotypes, in particular gender stereotypes. In the first study I utilize a more empirical approach, conducting an experiment related to stereotypes' effects on computer testing performance. The theory of stereotype threat effects, as originally theorized by Claude Steele (1997), claims that persons about whom a stereotype exist will perform equally well as others in nonthreatening testing situations, but will underperform in threatening testing situations (i.e. situations in which the stereotype is made salient or relevant). Researchers have found stereotype threat effects for women and math test performance (Oswald & Harvey, 2000; Quinn & Spencer, 2001; Schmader, 2002; Spencer, Steele, & Quinn, 1999; Walsh, Hickey, & Duffy, 1999). As of yet, however, no studies have examined whether stereotype threat effects exist in related fields, such as computer science. Therefore, in addition to a more extensive review of the existing stereotypes and stereotype threat effects literature, in this thesis I will investigate the existence of stereotype threat effects for women and their performance on a computer ability test. Then, in the second study, I will utilize a more qualitative approach when analyzing the gender stereotype-related experiences of women in computer science. Therefore, in addition to a review of work examining the experiences of being a woman in the male-dominated computer science realm, this second study involves creating a dialogue with female computer scientists (or females considering computer science) in order to examine their views on the role stereotypes and perceptions play in their computer science lives and decisions. I will begin with examining the existence of (or lack of) gender differences in various computer-relevant variables.

Research has shown that males and females have varied in their past experiences with and current use of computers, both in quantity and in quality. Robin Kay (1992) conducted a review of research on gender and computer behavior, and she noted that one must be careful to distinguish what is meant by computer experience and/or use. Definitions of computer experience and use have included camp participation, course enrollment, game use, computer ownership, word processing skill, time spent, and other general extra-curricular activities (Kay, 1992). Despite the plethora of definitions, the research on computing experience and use has generally demonstrated consistent gender differences, with males "overwhelmingly use[ing] computers more often than females" (Kay, 1992, p. 278). These gender differences in computing experiences are typically greater when they concern the amount of computer programming and game-playing experience and use, and are typically less or nonexistent when they concern areas such as word processing use and skill (Busch, 1995; Chen, 1986; Shashaani, 1997). Arguably, programming experience is the most relevant (or influential) form of computing experience for a potential computer scientist. Another common gender gap involves the presence of a computer at home and amount of use of such a computer, particularly for high school students. Males more often had a computer at home and used these computers to a greater degree than females (Chen, 1986; Colley, Gale, & Harris, 1994; Shashaani, 1994, 1997). Taylor and

Mounfield (1994) found that while only certain prior computing experiences (high school programming course and computer ownership) were related to success for males, practically all prior computing experiences were related to success for females, and to a greater degree. Here, success was defined in terms of grades earned in an introductory college computer course. Beyond qualitative and quantitative computer experience and use, gender differences have also been found in the attitudes regarding computers.

As with prior computing experience, there is a considerable body of work on gender differences in computer-related attitudes. The most consistently documented gender differences include the following: females have expressed less interest and self-confidence (Chen, 1986; Colley, Gale, & Harris, 1994; Krendl, Broihier, & Fleetwood, 1989; Shashaani, 1993, 1997) and greater anxiety than males (Busch, 1995; Colley, Gale, & Harris, 1994; Todman, 2000). Busch (1995) found gender differences in self-efficacy for complex computer tasks but not for simple ones. Complicating matters, Koohang (1989) found no gender differences in interest, confidence, or anxiety, but found one in perceived usefulness of computer (males perceived computers as more useful), which is a gender difference not often found by other researchers (e.g. Shashaani, 1997).

Many of the studies on prior computing experience and attitudes, including some of those thus far discussed, measure these elements in order to examine the relationship between them. Many studies have found a positive correlation between computing experience, or at least certain aspects of it, and positive computer attitudes (e.g. Shashaani, 1994, 1997). Shashaani (1997) described the general relationship between computing experience and computer attitudes in the following way:

> The positive correlation between computer attitudes and experience revealed that students who knew more about the computer, used computers more, and had more access to home computers were also more interested in computers and had more confidence in working with them (p. 46).

Levin and Gordon (1989) found prior computing experience to have a stronger influence on computer attitudes than gender did. Baggagliacco (1990) also found that when prior computing experience was accounted for, the gender differences in attitudes, with males possessing more favorable attitudes about computers, disappeared. This balancing effect of prior computing experience suggests a strong environmental influence in promoting interest in computer science. Then again, some studies have found prior computing experience to be a less substantial factor than gender. Wilder, Mackie, and Cooper (1985) found gender differences in computer attitudes persisted regardless of controlling for computing experience and use. Likewise, Krendl, Brohier, and Fleetwood (1989) found that females with equivalent amounts of experience as males were still less interested and less self-confident. Another study found after controlling for prior computing experience, gender differences in computer interest disappeared, but that gender differences in confidence remained (Chen, 1986).

Although they involve key aspects of gender and computing, the examinations of gender differences in computer experience and use, as well as attitudes, do not provoke a debate in the same way that the question of whether there exists gender differences in computer aptitude does. Yet, for a topic which prompts such an important debate regarding nature versus nurture, the empirical research on possible gender differences in computer aptitude has not had a significant presence in the women and computing literature. Diane Halpern (1997), in her review of sex differences in intelligence, describes a potential inhibiting factor: “Those opposed to research on sex differences fear that it will increase prejudice and discrimination by legitimizing false stereotypes, obscuring similarities, and providing fuel for those who are determined to convince the world of the inferiority of females” (Halpern, 1997, p. 1091). On the other hand, research on gender differences in math aptitude is rather plentiful. Perhaps this lack of research is partly the result of the difficulty in defining and testing computer aptitude. In testing this ability, there are no commonly approved standardized tests as there are with math aptitude testing (e.g. SAT, GRE, etc.).

Kay’s (1992) review of research on gender and computer behaviors also examined the investigations of gender differences in computer aptitude. She reported that males outperformed females in approximately half of the experiments. The remainder of experiments generally showed the lack of gender difference, although a few did show females outperforming males. As with attitudes and computer experience, computer aptitude has been defined a multitude of ways, further limiting any generalizability. Researchers have defined aptitude in terms of experience, terminology, programming, word processing, computer games, and skill with certain computer application, among others (Kay, 1992). Dambrot, et al. (1985) and Ogletree and Williams (1990) both found a gender difference in aptitude favoring males undergraduate students, using the same Computer Aptitude Test. However, at times computer aptitude is defined and tested in primarily mathematical terms. Kramer and Lehman (1990) claim the Computer Aptitude Test used by Dambrot, et al. (1985) and others is one such incidence. Though the fields are closely related, they are not equivalent.

Given the existence of easily accessible standardized measures of math aptitude, it is not surprising that a considerable literature on the topic of gender differences in mathematical reasoning and achievement exists. A meta-analysis of one hundred studies on math performance found an overall gender difference that slightly favored males (Hyde, Fennema, & Lamon, 1990). On further analysis, these studies showed a slight female advantage in elementary and middle school, and a more considerable male advantage in high school and beyond. "It is important for us to know that females begin in high school to perform less well than males on mathematical problem-solving tasks. Problem solving is critical for success in many mathematics-related fields" (Hyde, Fennema, & Lamon, 1990, p. 151). These researchers and others (e.g. Hedges & Nowell, 1995) also found that the gender difference favoring males grew larger with increasingly selective (i.e. higher performing) samples. In commonly cited works, Benbow and Stanley (1980, 1983) examined very large samples of "intellectually gifted junior highers" and find large "sex differences" in SAT mathematics test performance. In 1980, this sample consisted of nearly 10,000 students, in 1983, of nearly 40,000 students. On the other hand, another study examining a similiar population used two other standardized math tests and obtained very different results; on one test the researchers found a gender difference favoring males, but on the other test they found no gender difference (Duffy, Gunther, & Walters, 1997). However, the effect of the intervening 15 years between these studies is unknown. Additionally, Kimball (1989) highlights the evidence that when math achievement is measured using grades (and not standardized mathematics test, as is generally the case) and any gender differences are found, these differences nearly always favor females. Conflicting results such as these lead us to question the source of any established gender differences.

As the Lord Tennyson and Andrew Hazlitt quotes that began this investigation imply, there are those who feel there are inherent sex (i.e. biological) gender differences in reasoning ability, particularly math-related reasoning ability. Benbow and Stanley (1980; 1983) use their research on gender differences in math ability in attempt to support "the hypothesis that sex differences in achievement and attitude towards mathematics result from superior male mathematical ability, which may in turn be related to greater male ability in spatial tasks" (1980, p. 1264). Research such as that of Duffy, Gunther, and Walters (1997), Kimball (1989) and others, have shown that there exist situational conditions under which females perform equally well as males. Thus, the majority of researchers prefer to view any gender differences from either a social/environmental viewpoint or, more popularly, a combined biological and social/environmental viewpoint (that is, nature *and* nurture) (e.g. Halpern, 1997; Halpern & LaMay, 2000). Halpern (1997) reviewed all three viewpoints and their proponents before describing her preference for what she calls a "psychobiosocial model":

> A psychobiosocial model offers an alternative conceptualization: It is based on the idea that some variables are both biological and social and therefore cannot be classified into one of these two categories...The model that is being advocated is predicated on an integral conceptualization of nature and nurture that cannot be broken into nature or nurture subcomponents (p. 1092)

Jacquelynne Eccles (1987, 1994) postulates a social learning model that connects expectations and motivation (according to subjective task values) to achievement-related choices; these expectations and motivations are in turn linked to, among other things, gender role socialization and identity. Gender role identity is also examined by gender and computing researchers. Using the Bem Sex-Role Inventory, researchers have found greater masculinity (i.e. more masculine gender role traits) to be coupled with more positive computer attitudes (Charlton, 1999; Colley, Gale, & Harris 1994). Charlton (1999) associated greater masculinity with increased comfort and engagement with computers, while Colley, Gale, and Harris (1994) associated greater masculinity with increased confidence, increased interest, and decreased anxiety with computers. Charlton (1999) also found greater femininity to be coupled with increased engagement and reduced obsessive use of computers. An important social/environmental factor that may manifest itself in gender differences in computer attitudes and ability is the presence and effects of stereotypes.

As is likely the case with members of other fields of study, there appear to be stereotypes of computer scientists in general, male or female ones. Matheson and Strickland (1986) found the stereotype of computer scientists, held by computer scientists and non-computer scientists alike, to fall along two dimensions, technological dedication and sociability. With computer scientists, their technological dedication refers to characteristics such as increased practicality, intelligence, perseverance, and achievement orientation. Sociability refers to increased dependability and modesty in social interactions, and introversion. The computer scientists did, however, generally view themselves as more sociable than the stereotypes (Matheson and Strickland, 1986). Margolis and Fisher (2002) found a common description by students, male and female, regarding their computer science peers,

> They described a person in love with computers, myopically focused on them to the neglect of all else, living and breathing the world of computing, “at the computer 24/7.” Computer scientists are said to emerge from being at their keyboards, just once in a while, with a “monitor tan” (p. 65)

In addition to general stereotypes, researchers have examined the presence and consequences of gendered stereotypes with regard to computer users. Gender stereotyping refers to idea that female computer users might be perceived differently than male computer users, either in a more negative or positive fashion. The evidence confirming the presence of gender stereotypes (in particular, negative stereotypes of female computer users) has been somewhat inconsistent. Some research has found that men possess more gender stereotyped views, including the belief in a male superiority in computer science ability (Levin & Gordon, 1989). Dryburgh (2002), in her classification of 1990s research on women in computing, found that high school males are more likely than females to have “sex-stereotyped attitudes” towards computing, and that these differences increased with greater amounts of computer experience and use. However, other recent research finds very limited or no evidence of negative stereotyping of female computer users (Colley, Hill, Hill, & Jones, 1995; Francis, 1994). However, the existence of stereotypes of greater male interest and ability in computers is evident in the realm of computerized toys and games, in which some children, mostly male, believe computers are only for boys (Kiesler, Sproull, & Eccles, 1985). Indeed, computer products for younger audiences are typically based on traditionally male fascinations (e.g. war and sports); and, they are generally marketed towards boys (Kiesler, Sproull, & Eccles, 1985). Some researchers also note the ‘We Can, I Can’t’ attitude, as termed by Collis (1985), which refers to a woman’s positive belief in the computer competence of women in general while having a negative belief in her personal abilities.

Whether or not gendered stereotypes of female computer scientists exist, women perceive such gendered stereotypes to exist, with considerable effects. Female students in computer science and other male-dominated fields are the most likely to report feeling threatened by negative gender stereotypes (Steele, James, & Barnett, 2002). The question then becomes, how does the perception of the presence of a negative stereotype affect measures of ability (performance)? Stereotype threat effects research deals with such a question.

Originally postulated by Claude Steele (Steele, 1997; Steele & Aronson, 1995), stereotype threat effects occur when a member of a particular group is prevented from performing to his or her potential when faced with risk of confirming (or being judged by) a stereotype about that group. Steele’s initial work found that African American students performed worse on an intelligence test than White students when that test was presented as a measure of their intellectual ability. If, however, that same test was presented as non-indicative of their ability, the African-American students’ performance matched that of the White students (Steele & Aronson, 1995). He describes the effect:

> Whenever African American students perform an explicitly scholastic or intellectual task, they face the threat of confirming or being judged by a negative societal stereotype – a suspicion – about their group’s intellectual ability and competence. This threat is not borne by people not stereotyped in this way. And the self-threat it causes – through a variety

> of mechanisms – may interfere with the intellectual functioning of these students (Steele & Aronson, 1995, p.797)

Research on stereotype threat effects has been expanded to other stigmatized groups and to other domains. Negative group stereotypes have been shown to decrease the performance of Latinos on intelligence tests (Aronson & Salinas, 1997, as cited in Aronson, Quinn, & Spencer, 1998), low socioeconomic students on intellectual tests (Croizet & Claire, 1998), women on negotiation and bargaining tasks (Kray, Thompson, & Galinsky, 2001) and women on math tests (Oswald & Harvey, 2000; Quinn & Spencer, 2001; Schmader, 2002; Spencer, Steele, & Quinn, 1999; Walsh, Hickey, & Duffy, 1999). Of particular relevance to this honors thesis are those studies examining the stereotype threat effects for women on math test performance. Spencer, Steele, and Quinn (1999) found that women with high mathematical ability performed worse on a difficult mathematical test than men with equally high ability did only when the gender stereotype was made pertinent (by describing the test as producing gender differences). Oswald and Harvey (2000) found similar stereotype threat effects. Though the research on stereotype threat has thus far not extended directly to computer science and women, it is proposed that similar effects may be found in this math-related field. Quinn and Spencer (2001) found that the stereotype threat interfered with women's ability to generate problem-solving strategies for a mathematics test; the researchers further mentioned the under-representation of women in fields such as engineering and computer science as an area in which these stereotypes may be having an effect.

Furthermore, there are several important features and facets of stereotype threat that should be considered, ones originally laid out by Steele (1997) and later confirmed and/or modified by other researchers. Counterintuitively, these effects of stereotype threat do not appear to depend on the individual's personal belief regarding the validity of the stereotype. Steele's original work describes the stereotype threat effects as the result of negative stereotypes (1997; Steele & Aronson, 1995). Indeed, some researchers maintain that negative stereotypes are necessary for stereotypes threat effects to result (Osborne, 2001; Shih, Pittinsky, & Ambady, 1999). Shih, Pittinsky, and Ambady (1999) found that for Asian American women's performance on math tests, the women for whom ethnicity was primed scored higher than women for whom it was not primed. The "Asian" identity is typically stereotyped as one where members are better at mathematics (i.e. a positive stereotype). Thus, the researchers claimed that making the positive Asian stereotype salient boosted mathematics test performance, having the reverse effect of negative stereotypes. Cheryan and Bodenhausen (2000), however, felt this previous study used ethnicity priming that was too subtle and indirect with regard the cultural stereotype of Asian superiority in mathematics. With modified ethnicity priming, these researchers found that when the positive Asian stereotypes were made salient, the Asian-American women's mathematics test performance was impaired (they refer to it as the "hazards of 'model minority' status"). Most research on stereotype threat effects deal with stereotypes regarding members of historically disadvantaged groups. However, a history of stigmatization is not necessary for stereotype threat effects to be relevant. One study found that White men performed worse than African American men on a golf task when that task was described as indicative of "natural athletic ability tasks," but performed equally well when that task was described as indicative of "sports intelligence" (Stone, Lynch, Sjomeling, & Darley, 1999). Though not an original stipulation of Steele’s (1997) theories, most research on stereotype threat effects has concerned various intelligence tests. This study involving athletic performance (Stone, Lynch, Sjomeling, & Darley, 1999), as well as a study on gender and negotiation (Kray, Thompson, & Galinsky, 2001) and a study on gender and affect tasks (Leyens, Desert, Croizet, & Darcis, 2000) confirm that stereotype threat effects also apply to areas outside the traditional academic domains. Another study found that White men threatened by a comparison with Asians, which induced a threatening condition, performed worse on a mathematics test that those men not threatened with such a comparison (Aronson, et al., 1999). Thus, the stereotype threat effect has the potential to be experienced by any group about whom stereotypes exist (also see Leyens, Desert, Croizet, & Darcis, 2000).

There appear to be two particularly important moderators with regard to stereotype threat effects. Steele (1997; Steele & Aronson, 1995) emphasized the first – domain identification. Individuals are more vulnerable to the effects of stereotype threat to the extent that they identify with the tested domain (further demonstrated by Aronson et al., 1999; Stone, Lynch, Sjomeling, & Darley, 1999). This domain identification continues to add an exasperating caveat to the concept of stereotype threat; it means that,

> At each level of schooling, it affects the vanguard of these groups, those with the skills and self-confidence to have identified with the domain. Ironically, their susceptibility to this threat derives not from internal doubts about their ability (e.g. internalization of the stereotype) but from their identification with the domain and the resulting concern they have about being stereotyped in it (Steele, 1997, p. 614)

Thus, unfortunately, those women motivated enough to continue in the male-dominated computer science environment, an environment perceived as full of gendered stereotypes, are those most likely to suffer from stereotype threat effects. The second important moderator concerns the centrality of one's given social identity, in that an individual who is more highly identified with a social group performs worse when threatened than one who is less strongly identified with this particular social group (assuming the stereotype concerns that particular social identity). Schmader (2002) confirmed gender identity's role as a moderator for women's math test performance. She describes the role of social identity:

> Social identity theory posits that individuals are motivated to maintain a positive sense of social identity. For any given social identity, however, this motivation is stronger among those who feel that identity is an important aspect of their self-definition. When that social identity is subject to scrutiny through the lens of a negative stereotype, those who are highly identified with their social group should experience the greatest degree of stereotype threat and resulting impairments to their performance (Schmader, 2002, p. 199)

Not only does stereotype threat effects damage performance in a particular situation (e.g., on a particular test), when these effects are repeated (that is, chronic), they may result in an individual's domain disidentification (Steele, 1997). Here, the domain is no longer as important in that individual's concept of self-identity. Major, et al. (1998) describe how negative stereotypes promote "disengagement" with a domain as the result of either devaluing the domain (akin to disidentification) or of discounting the validity of feedback regarding test performance, or both. For the individual, as a domain becomes less important and/or discounted, motivation to continue pursuing excellence in that domain is likely compromised. Thus, combined with the effects of gender identification, those women who identify the most strongly as female are also those women most likely to be susceptible to stereotype threat effects. Eventually disidentification with mathematics and computer science occurs, further ensuring that this environment will remain "male." Stereotype threat effects for women and computer ability testing, if found, may then also help explain the systematically low numbers of women in computer science.

Though stereotype threat effects likely has significant and important impacts on the loss of interest and decreased performance for members of certain stereotyped groups, many researchers also acknowledge the importance that other societal/environmental factors can have. These factors may include "socioeconomic disadvantage, segregating social practices, and restrictive cultural orientations, limits of both historical and ongoing effect" (Steele, 1997, p. 613). Therefore, the particular features of having to operate in a male-dominated environment such as math or computer science and the impact of such features on females should not be ignored. Thus, this honors thesis will also examine elements of the male-dominated field which may also play a role in the women's relative lack of interest and confidence in computing ability – with the ultimate result of systematically low numbers of women in computer science. The features of this environment include stereotypes, both actual and perceived.

As the phrase "male-dominated" implies, there are fewer females than males in computer science, which has then resulted in reduced numbers of female peers and faculty. In fact, one-third of computer science departments employ no women faculty (Andrews, 1994-1997). Peers and faculty, who may serve as mentors or role models, are important sources of advice, including advice on the particulars of being a woman in this field. Many females may feel more comfortable with a female advisor, in that they can talk to someone "like themselves." With the lack of female faculty, men should be assuming at least some of the mentoring roles. Unfortunately, it has been reported than women are more likely than men to be excluded from such mentoring relationships (Simeone, 1987). Cohoon (2001) found that computer science departments "with no female faculty lost female students at high rates relative to men" (p. 113), and that those "departments with higher female proportions of enrollment were more likely to retain women at comparable rates to men" (p. 112). The educational/institutional aspects of computer science departments possess certain qualities which may impede a woman's success in that department. Cohoon (2001) researched the various attributes of computer science departments. Those departments with higher support from the educational institution were more successful in retaining female enrollment.

At a more individual level, many females may experience harassment and discrimination of various forms. Spertus (1991) has an enlightening discussion of various women's encounters with sexual harassment, as well as with the more prevalent and often less intentional sexist humor or references. Simone (1987) examined the percentages of women in computer science encountering sexual harassment by a person in authority; she found that 34 percent of the undergraduate women and 41 percent of the graduate women had these experiences, most of whom did not officially report these incidents. Spertus (1991) also discusses the "locker room" atmosphere in which women in computer science may be exposed to more sexual displays and discussions than women in other academic areas. Females have varying degrees of comfort with this atmosphere, ranging from generally positive or neutral to highly negative. Many female computer scientists also feel the effects of gendered discrimination of various forms. Research has found that undergraduate women in male-dominated departments reported higher levels of discrimination than women in female-dominated departments (Steele, James, & Barnett, 2002). These women also reported that they anticipated further gender discrimination were they to remain in their male-dominated fields.

Another form of discrimination involves different expectations and standards of evaluation for men and women. Spertus (1991) reported that many people have lower expectations of computer interest and competency for women than for men. Her examples "illustrate how women are sometimes treated as less capable or interested in technology than men, instead of being treated as individuals" (p. 11). Additionally, the same action is often construed differently according to whether a man or woman executed it.

> The man scientist is aggressive; the woman scientist is pushy; He is careful about details; she is picky; He loses his temper because he's so involved in his job; she's bitchy; He follows through; she doesn't know when to quit; He makes wise judgments; she reveals her prejudices; He isn't afraid to say what he thinks; she's opinionated; He's discreet; she's secretive (Ramaley, 1978, as cited by Grant, 1995)

A female scientist is looked down upon if she acts "female," but is also looked down upon if she acts "male,"

> There is a catch-22 here, though. If a woman scientist behaves with traditional female behavior: quiet, non-competitive, suggesting instead of ordering subordinates,

> she is likely to be seen as ineffective, or even not intelligent. However, a woman who acts in traditional male ways: self confident, aggressive/assertive, competitive, vocal, is frequently labeled a "bitch" and hard to get along with. It is a fine line between these two, and an unfair burden placed on women (Grant, 1995, ¶ 19)

These double standards, as well as discrimination more generally, have negative implications for a female computer scientist's self-confidence and assertiveness, as well as their decision on whether to continue in the field (Steele, James, & Barnett, 2002). The stereotype in this environment is (or is perceived to be) that "men are better computer scientists than women." Herein lies a significant link with previously discussed research, the research that indicates the more female a computer scientist is, the less likely she is to succeed, either in terms of performance or in terms of attitudes (specifically, the research by Charlton (1999) and Colley, Gale, & Harris (1994) that found greater masculinity (i.e. more masculine gender role traits) to be coupled with more positive computer attitudes, and the research on stereotype threat effects with relation to domain identity and gender identity). These double standards further add to this dilemma.

The final features of the computer science environment that will be reviewed are some differences between men and women which are particularly salient and disadvantageous to women. For example, many women may have a different communication style than the male computer scientists (Spertus, 1991), and with men in the majority, this difference favors the males. Margolis and Fisher (2002) stress existence of the dissimilar interests of males and females regarding computers and computer science. Females appear to more often appreciate the versatility of the computing fields and its exciting, changing nature, as well as its secure employment than males do. Additionally, for many females, computers are more meaningful and compelling if they are able to link them with other fields and are able to keep computer science's social context in mind. Margolis and Fisher (2002) call this appeal "computing with a purpose." However, computer science curricula has traditionally been oriented on the basis of the fascinations of male students, and the aspects of computers that females find interesting may not be emphasized. This lack of emphasis on certain characteristics may discourage women, allowing them to feel computers "aren't for them." Closely related to different interests in computer science is the degree of these interests. There is an elite "hacker culture," as described in full by Levy (1984) in *Hackers: Heroes of the Computer Revolution,* which documents the history of the rise of computer culture. Pearl, et al. (1990) described the members of this subculture as ones who are "differentiated by special names (wizards, hackers, wheels), and are expected to have distinguishing characteristics, language, and behaviors" (p. 49). In particular, these behaviors include a sole focus of energy on computing, to the neglect of any other social or emotional needs. These "hackers" are often perceived as the paragons of computer science, and those not conforming to these standards are viewed as less competent. Female computer scientists have less often displayed the characteristics and behaviors related to this hacker culture, and they are aware of it, therefore feeling that perhaps that they do not belong in the field (Margolis and Fisher, 2002). Levy (1984) also portrayed this culture as one where women were distractions, not members. Some influential early hacker gurus viewed women as inherently less capable. Levy described the situation in the early 1960s at MIT:

> There were women *programmers* and some of them were good, but none seemed to take hacking as a holy calling the way Greenblatt, Gosper [early hacker gurus] did. Even the substantial cultural bias against women getting into serious computing does not explain the utter lack of female hackers. "Cultural things are strong, but not *that* strong," Gosper would later conclude, attributing the phenomenon to genetic, or "hardware," differences (1984, p. 84)

What was not mentioned, however, is that although MIT at that time admitted women, their admission rates were highly skewed. The class of 1963 included only about 20 women (Kaplan, online, accessed 2003). To be fair to MIT, the conditions for females in computer science there have since changed dramatically, not only in increased numbers of women students and faculty, but also in the support the institution has provided in examining women's position in the field. Spertus (1991) was a student at MIT when writing her extensive report of the conditions for women in computer science. Not only was the report encouraged by MIT, they later had a role in its distribution.

On the topic of "hacker" characteristics and women, Spertus (1991) wisely adds,

> It is important to remember that women who do not throw themselves into the computer world might not be inferior to men but that sacrificing everything to computers might not be something that a psychologically healthy human being does. Perhaps men and women alike would be better off if some jobs and hacker cultures did not require giving up the rest of their lives (p. 27)

Another priority that often has different degrees of importance for women and men in computer science is the priority of their families.

Many fewer women have a spouse at home willing to taking care of a family, and more often have to face the choice of sacrificing work for family or family for work. Additionally, any pregnancies could easily occur during the years in which they work to attain tenure, and institutions vary on their willingness to accommodate such situations (Cottell, 1992; Spertus, 1991). While these family-related issues may exist for females in other fields as well, in a male-dominated field such as computer science where very few others take a break for family, women may feel increased pressure not to do so. Furthermore, even if a woman chooses not to make family the priority, employers often assume that she has and will thus treat her differently.

Within the women in computer science literature, there is an issue that has been termed the "shrinking pipeline problem." The percentages of women earning computer science Master's Degrees and Ph.D.s in 1996 were 26.9 and 16.2 percent, respectively (National Science Foundation, 2000). The percentages of women continue to shrink throughout the academic ranks: women account for 15.9 percent of assistant professors, 9.4 percent of associate professors, and only 5.7 percent of full professors in computer science departments (Andrews, 1994-1997). These numbers have not changed significantly in recent times. This shrinking pipeline problem is a common subject for discussion within computer science's various journals (e.g. Camp, 1997; Leveson, 1990; Pearl, et al., 1990). The impact of the characteristics of male-dominated computer science is often detrimental to the well-being and computer interest and confidence of females attempting to navigate the realm of computer science; thus, these environmental characteristics are likely integrally connected with this issue of the "shrinking pipeline." Steele (1997), in describing the environment in which stereotype threat effects become a further barrier for women in mathematics, illuminates this world:

> To continue in math, for example, a woman might have to buck the low expectations of teachers, family, and societal gender roles in which math is seen as unfeminine as well as anticipate spending her entire professional life in a male-dominated world. These / realities, imposed on her by societal structure, could reduce her sense of good prospects in math as to make identifying with it difficult (p. 613-614)

"Computer science" can easily and appropriately be substituted for "math" in this description. For those women who have survived these obstacles, somehow managing to possess and retain a desire to pursue computer science, they must then face the possible effects of stereotype threat. The effects of this threat, which Steele refers to as "a threat in the air," may then lead to disidentification with computer science and the subsequent loss of that elusive desire to pursue computer science. Consequently, stereotype threat conceivably also contributes to the "shrinking pipeline" problem. Overall, the goal of promoting and maintaining female interest in computer science is not an easy task, but invaluable nonetheless, for "women must be part of the design teams who are reshaping the world, if the reshaped world is to fit women as well as men" (Margolis & Fisher, 2002, p. 3).

Method

Study 1

In this study, I examined the following hypothesis: When the gender stereotype of male superiority in computer competency is confirmed, female performance on a computer competency task among a group of women with a high interest in computers will be lower than the corresponding performance when that gender stereotype is refuted. I theorize that, by confirming this gender stereotype a threatening situation is created and the stereotype threat effects are introduced.

Participants

Twenty-eight undergraduate females from Macalester College participated in this study. Participants' mean age was 19.64 (*SD*=1.50). These participants were obtained in two ways. One set of participants consisted of 11 volunteers enrolled in an introductory psychology course, who by volunteering received partial fulfillment of course credit. The mean age of this set of participants was 18.64 (*SD*=.67). The second set of participants consisted of 17 volunteers from non-math/computer science courses. The mean age of this set of participants was 20.29 (*SD*=1.53). All participants were either non-math/computer science majors (*n*=18) or undeclared majors (*n*=10).

Materials

Demographic Information. Participants were asked to provide their age, year in school (e.g. "junior"), and major(s).

Computer Attitudes Pretest. For the Computer Attitudes Pretest, I used a short computer attitudes questionnaire, which consisted of five questions drawn from the 39-item Computer Attitude Scale created and used by Shashaani (1993, 1994, 1997). The questions chosen measured the participant's appeal for computers ("I enjoy working with computers" and "Computers do not interest me") and self-confidence in using computers ("I feel helpless around computers", "Given a little time and training, anybody could learn how to use a computer", and "I feel confident about my ability to use a computer"). Participants indicated the extent to which they agreed with each item using a Likert-type scale (5 = strongly agree to 1 = strongly disagree), with scales for negatively worded items reversed, for a maximum total of 25.

Higher scores indicate greater appeal and confidence in computers. The Alpha reliability coefficient was .77.

Computer Competency Test. For the Computer Competency Test I sought a test that measured knowledge of general computer concepts and terminology. I used five of the six 10-question matching sections from the Computer Literacy Competency Test, for a total of 50 questions (North American Office of Education, 2000). The matching section not used for test tested knowledge of historical persons related to the development of computers rather than concepts about the computers themselves. The other sections of the Computer Literacy Competency Test tested specific application abilities (e.g. Microsoft Word) by computer. See Appendix A for the Computer Competency Test.

Procedure

All potential participants are informed that they would be volunteering to participate in a study on “gender and computer aptitude.” Participants were tested either individually or in small groups (two to three). After completing a consent form, all participants first completed a Computer Attitudes Pretest, which when completed the participants returned to the experimenter after completion. Based on the answers provided on this Pretest, participants were classified as either possessing high computer interest or low computer interest. Participants who responded with a 4 or 5 (that is, they agreed or strongly agreed to positively worded statements and disagreed or strongly disagreed to negatively worded statements) on at least four of the five questions of the Computer Attitudes Pretest were placed in the high interest group (n=18), otherwise they were placed in the low interest group (n=10). In other words, those with a total score of 19 or higher on the Computer

Attitudes Pretest were placed in the high interest group, and those with a score 18 or lower in the low interest group.

After returning the Computer Attitudes Pretest, participants, within both the high interest group and the low interest group, were alternately assigned to one of two conditions: stereotype threatened or non-stereotype threatened. All participants received a packet that included a request for demographic information, an informational page, and the computer competency test. The instructional page contained a description of the test (as a "computer competency test"), instructions on the format of the test, and a statement on the relative performance of males and females on this test. For the stereotype threatened condition, the prevalent gender stereotype was confirmed, and the following statements: "This test has been found to show gender differences in computer competency. Overall, males have consistently obtained higher scores on this test." For the non-stereotype threatened condition, the prevalent gender stereotype was challenged, and the following statements: "The problems on this computer competency test have been found to be gender-fair. That is, overall, females and males have scored equally well on this test." The participants were given no time limit to complete the test. After the participants returned the competency test, they received a debriefing form, which described the true nature of the study, thanked them for their participation, and included contact information for further inquires.

Study 2

In the second study I sought to examine female computer scientists' views on the role stereotypes and perceptions play in their computer science lives and decisions. In particular, there are two goals of this study. The first goal is to obtain a picture of the current scope of experiences and perceptions of stereotypes for women in computer science, while also examining how these experiences corresponded with the recent research on the topic. The second goal is to use the results to help elucidate and formulate future possible areas of inquiry within this topic of stereotypes and gender in computer science, in particular through the development of a comprehensive set of more questions about the amount and nature of gender stereotype-related experiences in computer science.

Participants and Procedure

Thirty-seven participants responded, on a volunteer basis, to the request to share their experiences in computer science with regard gender stereotypes. Potential participants were recruited via two methods. First, I distributed requests to personal contacts in the field, either in person or via e-mail. Second, requests were distributed via the internet in two fashions. I posted requests on several internet newsgroups, newsgroups concerned with computer science and/or gender issues (comp.org.acm, comp.edu, and soc.women). Additionally, I posted requests to several gender and computer science mailing lists (SYSTERS, WIE3 - Women in Engineering IEEE, and Gender-Set through JISCmail). On occasion a response would include the name(s) of other potential participants; they were further contacted, via e-mail. Potential participants were told that if they volunteered, they would be participating in research on "the effects on women of stereotypes in computer science." The request was as follows, after providing my name:

> I am a psychology and computer science major at Macalester College (in St Paul, MN), and I am doing an honors thesis on the effects on women of stereotypes about women in computer science. For one portion of this project, I would like to include stories/anecdotes/etc. from individuals -- primarily women -- in

> computer science (or who were in computer science at one point). I'd like these stories to be related to gender stereotypes you've encountered and, particularly, their effects on women in computer science. I am interested in all kinds of stories and examples of stereotypes: pro-female, anti-female, or neutral.

All potential participants were informed of the confidentiality of their responses, were they to provide their name with the response. They were also provided with anonymous options for submission via the internet.

Results and Discussion

Study 1

Results

I hypothesized that female performance on a computer competency task would suffer when the gender stereotype of male superiority in computing was confirmed, in particular for those females who highly identified with the domain. The data did not support this hypothesis. For the Computer Competency Test, the top possible score was 50; for all participants, the range of scores was 18 to 44. In the high-interest group (n=18), though women in the stereotype threatened condition (M=34.60, SD=5.62) scored lower on the Computer Competency Test than those women in the non-stereotype threatened condition (M=35.75, SD=5.63) did, this difference was small and not statistically significant, $t(16)=-.43$, n.s. For the entire group of participants (n=28), the women in the stereotype threatened condition (M=33.64, SD=6.44) performed (exactly) equally well as the women in the non-stereotype threatened condition (M=33.64, SD=6.95).

One might expect that those who are more interested in the domain also are more competent in that domain. For all participants, there was a positive correlation between the Computer Attitudes Pretest and the Computer Competency Test that was not statistically significant, but was approaching significance, $r=.35$, $p=.07$.

I also looked at whether year in school was correlated with attitudes and/or competency, as greater amounts of education may be related to these variables. For the interest groups combined, as well as for both the low and high interest groups, more positive computer attitudes were positively correlated with year in school. However, only for the high interest group was this correlation statistically significant (both groups, $r=.36$, n.s.; low interest, $r=.099$, n.s.; high interest, $r=.48$, $p<.05$). For both interest groups combined and for the high interest group, greater computer competency and year in school were not significantly correlated (both groups, $r=.15$, n.s.; high interest, $r=-.03$, n.s.). The positive correlation between computer competency and year in school for the low interest group was also not statistically significant; however, it was a trend, and given the small size of the group ($n=10$), with a larger sample, this correlation might be significant ($r=.55$, $p=.10$).

Discussion

The primary purpose of this study was to examine the potential impact of stereotype threat on women's computer competency performance. The data from this small sample did not support the hypothesis that female performance on a computer competency task would decline when the gender stereotype of male superiority was confirmed, both for the high interest subgroup and for all participants. In research such as this, the desired result is usually the finding of a significant difference. However, if the existence of a negative gender stereotype does in actuality not depress performance for women with regard to computer performance as it does for women with regard to math performance, this would likely be a more significant result with regard to the real world applications. This would allow us to move the focus to other factors in the systematic under-representation of women in computer science. Based on an extensive review of the literature, this is the first attempt to test for stereotype threat effects for women and computing ability. To be confident that no stereotype threat effects exist, these results would need to be found in similar studies, ideally ones with larger sample sizes.

However, there are several possible reasons why, although not found in this study, stereotype threat effects are still highly possible for women with regard to computer performance. The two primary reasons concern the nature of the competency test and the nature of the stereotype threat condition manipulation.

Finding or creating an appropriate computer competency test is a significant barrier to the testing of stereotype threat effects. Beginning with the first stereotype threat studies (Steele & Aronson, 1995), researchers have stressed the importance of using an appropriately difficult exam. Spencer, Steele, and Quinn (1999) found that women would underperform on more difficult math tests while performing equally well on easier math tests. When they desire a test of math ability, researchers often rely on subsets of the math SAT or quantitative GRE exams. These are widely available, well studied standardized tests. Furthermore, these tests' high recognizability helps ensure that the takers of the test will consider it one diagnostic of their math ability. Additionally, and most importantly, these tests can be used with a relatively broad set of populations, including non-mathematics focused individuals. On the other hand, in computer science, the two of the most widely established standardized tests, the Computer Science AP (Advanced Placement) test and GRE subject exam, are not generally suitable for the many of the available populations. The AP test is heavily programming language-based (currently C++). Therefore, unless one ensures that all participants are (equally) proficient in this language, a daunting task in itself, there exists the possibility that a highly competent computer user could do poorly on this test. On the other hand, though not programming language dependent, the GRE subject test assumes the test-taker possesses knowledge and skills gained from an entire undergraduate computer science curriculum. The average test-taker is a computer science undergraduate considering graduate school, and this person has likely prepared specifically for this exam. Even with this preparation of test-takers, the percentage of correct answers on various questions ranges from 17 to 88 percent, with most between 50 and 80 percent (Education Testing Services, 2001). This test is fitting for a relatively small subset population. For many researchers, including those of this study, access to a sufficiently large sample from this selective population is likely limited.

Without a previously created standardized computer aptitude test, many researchers will have to create or search for and revise their own measures, as was done in this study. For this, computer aptitude must be defined. Computer aptitude has been defined a multitude of ways; researchers have defined aptitude in terms of ability in using certain software, experience, terminology, programming, word processing, and computer games, among others (Kay, 1992). In the creation of a computer competency test that can be used for a sufficiently broad population, one of the primary obstacles is creating a test that is difficult enough to make stereotype threat most relevant while not being so difficult as to result in a floor effect. Furthermore, these tests are not culturally accepted as diagnostic of ability in the way the SAT and GRE are; this means the researchers must be extra careful in ensuring the participants' perception of a diagnostic measure. For this study, I chose to use computer terminology and concepts as the basis for our Computer Competency Test. The range of scores (18 to 44 out of 50) seem to indicate an appropriate difficulty. However, the degree to which the participants believed that it was an actual measure of computer ability is unknown, despite our efforts to highlight the measure as one of computer aptitude. Quinn and Spencer (2001) found that stereotype threat interfered with women's problem-solving strategies on math tests. Therefore, since the test in this study was more related to background knowledge rather than the more important problem-solving aspects of computer science, the effects of stereotype threat might have been less relevant. The discussion of this difficulty in finding or creating an appropriate test is not to suggest, however, that it is not a worthwhile pursuit. Accurately testing for stereotype threat effects requires the formation of such a measure. There is also an additional category of reasons of why stereotype threat might still be relevant for women and computing ability despite not being shown in this study. This category concerns the nature of the stereotype threat condition manipulation.

As discussed, for the stereotype threat in a testing situation to be most relevant, the test-taker should believe that the measure is diagnostic of ability. If they do not feel it is a measure of their ability, the stereotype related to that ability is not connected with the situation, and thus has no effect. Therefore, one way in which to manipulate the stereotype threat relevance in a testing situation involves including instructions regarding the diagnosticity of the test. In the stereotype threat condition, the participants are told the test is highly indicative of their ability; while, in the non-stereotype threat condition, the test is presented as less indicative of their individual ability (e.g., the test is being used to develop questions). Steele and Aronson (1995) and Croizet and Claire (1998) found stereotype threat effects using this type of manipulation. Another potential way to manipulate the stereotype threat condition is through priming. Here, for the stereotype threat condition, the researchers attempt to make the relevant social identity (gender, race, etc.) salient to the participant (e.g., by having the participant indicate their gender, race, etc.). For the non-stereotype threat condition, no reference or questions are presented regarding this social identity. Steele and Aronson (1995) and Cheryan and Bodenhausen (2000) both found stereotype threat effects using priming of race/ethnicity.

On the other hand, in most research on stereotype threat effects for women and math, the experimenters manipulated the stereotype threat condition through references (or lack thereof) to the gender stereotype of male superiority in math. Some researchers, as in this study, manipulate the condition in the following way: In the stereotype threat condition, the participants are informed that the test has generally produced gender differences favoring males, while in the non-stereotype threat condition, the participants are informed that the test has not produced any gender differences (that is, it is "gender-fair") (Spencer, Steele, & Quinn, 1999, study 2; Stangor, Carr, & Kiang, 1998). A more common approach, however, was to manipulate the stereotype threat condition implicitly by creating a reduced-stereotype condition. Here, in the non-stereotype threat condition is again really a reduced stereotype threat, in which the participants are informed that the test is gender-fair, while in the stereotype threat condition, no mention of gender or gender differences is made (Oswald & Harvey, 2000; Quinn & Spencer, 2001; Spencer, Steele, & Quinn, 1999, study 3; Walsh, Hickey, & Duffy, 1999). In real-world normal test-taking situations, stereotype threat effects are the result of culturally present stereotypes, not of direct manipulations telling participants of those stereotypes. The future research on stereotype threat effects for women with regard to computing ability should take into considerations these possible different manipulations of stereotype threat.

The past research involving both male and female samples has generally found that women perform significantly worse than males in the stereotype threat condition, but perform equally well in the non-stereotype threat condition. Furthermore, it has generally been the case that the women in the stereotype threat condition perform more poorly than the women in the non-stereotype threat condition (Quinn & Spencer, 2001; Spencer, Steele, & Quinn, 1999). For the research that has studied only women, Oswald and Harvey (2000) also found that women in the stereotype threat conditioned performed worse than the women in the non-stereotype threat condition. On the other hand, Walsh, Hickey, and Duffy (1999) found that both males and females performed better in the stereotype threat condition than their male and female counterparts in the non-stereotype threat condition. They found a stereotype threat effect because, while men and women performed equally well in non-stereotype threat condition, women underperformed relative to men in stereotype threat condition. This comparison of relative performances between males and females can be important in determining stereotype threat effects.

Though no stereotype threat effects were found in this study, the procedure and results have highlighted several possible future variations and modifications. In order to determine whether the results of this study are actually indicative of the lack of stereotype threat effects for women with regard to computing ability, it needs to be replicated, preferably with larger sample sizes. Furthermore, a number of variations and/or modifications would also be beneficial. These variations might include varying the nature of the stereotype threat manipulation. Further work on creating an appropriate computer competency test, one that preferably would incorporate the use of problem-solving strategies more, would also be beneficial. Moreover, this test was not time-limited, in part due to its first-time use in this situation. Were this test time-limited, an additional stressor that may increase the effects of a stereotype threat would be introduced. Additionally, adding a time-limit would further simulate most actual test-taking situations. As stereotype threat effects have been shown to be most relevant for those that are most highly identified with the domain (Aronson et al., 1999; Schmader, 2002; Stone, Lynch, Sjomeling, & Darley, 1999), it would also be worthwhile to test for the presence of stereotype threat effects for those most highly identified, those women actually in computer science. However, given the underrepresentation of women in computer science, the original motivation for this research, attaining sufficient sample sizes becomes a more difficult task. For this population, a different competency test would be required as well.

Study 2

Results and Discussion

Thirty-seven individuals, primarily female, provided experiences with gender and stereotypes in computer science in response to our open-ended request. In order to allow for maximum participant confidentiality, I did not require participants to include demographic information; I did, however, request that they did, if they were comfortable doing so. Of the respondents whose gender was clear, 34 were female, either indicating it directly or implying it (e.g., "there were two other females," etc.) and one was male. Of the 29 participants who indicated their profession or student status, 19 indicated they are in academia. Of those 19 respondents, 5 are professors, 7 are undergraduate students, 4 are graduate students, and 3 participants did not indicate their position within academia. However, not all experiences occurred in the respondents' current positions. Twenty-four respondents wrote of experiences from academia; of these, one wrote of high-school experiences, 11 wrote of undergraduate school experiences, 3 wrote of graduate school experiences, 8 wrote of professor/faculty experiences, and 3 did not indicate their position during their academic experiences. Here, because many respondents included more than one experience, some respondents fall in more than one category. Additionally, 10 respondents wrote of experiences that occurred outside of the academic world, and 5 respondents did not indicate the setting of their experiences.

The request for individuals' experiences was intentionally very open-ended. Again, the request was as follows:

> I would like to include stories/anecdotes/etc. from individuals -- primarily women - in computer science (or who were in computer science at one point). I'd like these stories to be related to gender stereotypes you've encountered and, particularly, their effects on women in computer science.

I made this open-ended because of the goals of this study. The first goal was to get an impression of the range or scope of experiences and perceptions of stereotypes for women in computer science; furthermore, to see how these experiences correspond with the recent research on the topic, particularly the more empirical research. The second goal of this study was to help elucidate and formulate future possible areas of inquiry within this topic of stereotypes and gender in computer science. In order to more fully gauge the scope and prevalence of stereotypes (and perceptions of and their effects) it would be preferable to have a sufficiently representative sample of computer scientists, male and female, of varying ages and positions. Furthermore, to best use this sample, a comprehensive set of more specific important questions about the amount and nature of their experiences is also necessary. Such a set of questions would preferably be used in an interview-style study, for this allows the researcher to ask for clarifications to responses. Therefore, within this second goal, one particular aim was to use the participants' responses to develop a more comprehensive set of questions for use such future studies. In the remainder of this section, I will first describe and review the range of responses in the framework similar to the stereotype and computer science environment discussions from the introduction. Second, I will present our suggestions for future areas of inquiry, and a set of comprehensive questions, based on the results of the responses.

In the introduction, this thesis reviewed research on the existence of and perception of stereotypes of all computer scientists, as well as gender stereotypes. I will now consider the experiences obtained in this study with respect to these concepts. Matheson and Strickland (1986) found stereotypes of computer scientists, held by the male and female computer scientists themselves as well, related to increased dedication to technology, intelligence, perseverance, dependability, and introversion. Margolis and Fisher (2002) noted that their participants often gave similar descriptions of computer scientists in general. These descriptions closely paralleled those of "hackers," a title more often used with males (Levy, 1984). One female undergraduate in this study noted how she differed from other computer science students, "I don't fit the classic 'pale, sits in room all day playing diablo/ultima online and programming' stereotype for CS majors in general." In one sense, the stereotype of a computer scientist is as male; it is often considered the norm, that is, when one refers to a computer scientist, it is often assumed that this computer scientist is male. Those who deviate, females, may encounter disbelief. A couple of professors described that on occasion they had been mistaken for the departmental secretary. Several female respondents noted how others were surprised when others discovered their chosen field. Females at various levels in computer science remarked on comments from their peers. "When I said 'computer science,' his response was 'oh, you don't look like a computer scientist'" or "Most people don't picture me as a CS major...usually they are surprised when [I] tell them." These past examples, perhaps the result of "male as typical computer scientist" stereotype, may also be a result of a stereotype about what female computer scientists are supposed to be like.

The evidence confirming presence of gender stereotyping, where the typical female and male computer scientist are perceived differently, has been somewhat inconsistent in the literature. The particularly harmful gender stereotype is that concerning male superiority in computing ability. Some research has confirmed its existence, particularly in males (e.g. Dryburgh, 2002; Levin & Gordon, 1989). Other research has refuted gender stereotypes' existence, particularly negative gender stereotypes (e.g. Colley, Hill, Hill, & Jones, 1995; Francis, 1994). On the other hand, these studies generally use a college age population, whose views may differ from the older generation of computer scientists, who are those most likely to be in positions of authority and influence. Indeed, one female participant divulged that the "biggest thing I've noticed is that most of the weird sexist stuff comes from older folks." Additionally, although overall negative gender stereotypes of females by males may not exist, this "overall" is an average; there are males with particularly positive views on female computer scientists and males with particularly negative views on female computer scientists. Unfortunately, sometimes it only takes a few negative opinions of nearby males to affect and possibly discourage females. There are also some women, aware of the potentially negative stereotypes, who are ready for, and sometimes enjoy, the challenge of breaking these stereotypes. A female student claimed, "I like being an exception to normality. It's fun having people guess my major because they never have." Another female student stated, "I have encountered many gender stereotypes in my education but I think the best way to beat them is to prove them wrong."

The gender stereotype held by males of their superiority (or female inferiority) in computing ability was discussed by a significant number of respondents in this study. Sometimes this opinion was made clear through statements. One female described how it was at one of her jobs as a programmer: "I was repeatedly told that I didn't understand programming but that was okay [since] I was just a woman." Another female, who was a teaching assistant who asked about the possibility of being hired as a teacher, said,

> I was told that no woman was qualified enough in the field of technology to ever be allowed to teach for him and as soon as the only woman in his department retired (she was the only one he wasn't able to run off as soon as he became chair) his department wouldn't have a female teacher of any status.

A female student referred to a male peer who belittled her abilities: "He looked at me and said I quote 'There is no way that a girl knows more about Computer Science than I do.'" More often, however, this gender stereotype was implied in the way that many females felt they were not taken as seriously and/or underestimated based on their gender (and not the quality of their work). "I know some of the problem [of females getting bypassed for positions] obviously lies with their expectations of what men and women can achieve." These experiences included ones between student peers, professional peers, and between students and advisors/professors. Regardless of the debatable actual existence of negative gender stereotypes in computer science, Steele, James, and Barnett (2002) demonstrated that female students in computer science and other male-dominated fields perceive there to be gender stereotypes, and that they are the most likely to report feeling threatened by negative gender stereotypes. Stereotype threat effects, the focus of the first study, dealt with some of the possible repercussions of such perceived cultural stereotypes.

In the introduction this thesis also reviewed several elements of the male-dominated field of computer science that may play a role in women's relative lack of interest and resulting under-representation in computer science. Many of these elements are likely related to and/or caused by stereotypes. I first discussed the physical lack of women in computer science, at all levels. As of 1996, nationally only 25 percent of bachelor's degrees and graduate degrees in computer science were awarded to females (National Science Foundation, 2000). Additionally, the percentages of women continue to decline in the academic ranks (the "shrinking pipeline"). Fully one-third of computer science department employ no women faculty (Andrews, 1994-1997). Several respondents in this study specifically discussed how they were one of very few or the only female in their classes, majors, or jobs. Among the extreme cases are the following: students stated, "so far I have been in 2 classes, of 40 students, which only had one female in the class, and that was me," and, "I was 1 of about 6 women in my year level majoring in computer science and somehow we never had any classes together," and a professional female added that once, "I was the only woman in a group of 70 men." These low numbers have likely affected perceptions of the average computer scientists, as previously discussed. These low numbers of females also result in feelings of being more noticeable and, sometimes, "singled out" more. "In some ways, it's nice, because the teachers always remember you and know your name. [B]ut that's not always nice if your alarm clock didn't go off and you're trying to sneak into the back of the class unnoticed." Additionally, at times, males have been known to joke about these gender ratios, which may or may not make the females more uncomfortable. Some females in this study felt that this recurrent lack of women was isolating and often resulted in "boys' clubs," of which they felt left out, with negative aftereffects. One female student noted that she was "put at a significant disadvantage for not being one of the boys. They all talk to each other outside of class and help each other with labs and study together." Another student, who eventually left computer science for another (computer-related) major, said,

> All of the male students knew my name and knew a lot about me, however I didn't know their name and none of them would come up and talk to me. I found myself secluded from most of the class unless we were forced to work together in group projects...It seemed to me like they were "learning" more just by talking to

> each other about cool new things they found or built while I only learned things in the classroom.

In part as a result of stereotypes, females often face different sometimes degrading expectations and standards, often related to their abilities. The concept of the average computer scientist as male can lead to disbelief (e.g., the surprise of a female computer scientist's chosen field). As the result of gender stereotypes regarding females' inferior abilities, some males will expect that females do poorly, or at least, worse than them (e.g. "There is no way that a girl knows more about Computer Science than I do"). Then, when women perform equally well, some males will attribute their success to sources other than ability. This also includes the perception of preferential treatment (e.g. easier grading) favoring females. One female undergraduate wrote,

> Most of the time people treat me like I don't know anything, even professors. One time, when I got a very good grade in a very difficult class and some of the guys failed, they said it was only because the teacher was sexually attracted to me. Some males have such a hard time dealing with the fact that women can be more intelligent than them that they make up insulting excuses such as that.

Another female respondent told a colleague that both she and her husband had applied for the same job, but only she was made an offer. This colleague replied by saying that she was "probably filling a quota," despite the fact that she had more experience in the particular subfield about which company was concerned.

In the introduction, this thesis also discussed double standards, where different behaviors are construed differently according to whether a man or woman executed it (e.g. "aggressive" vs. "pushy," "discreet" vs. "secretive"). At times then, a female computer scientists is looked down upon if she acts "female" (e.g. quiet, non-competitive, emotional), but is also looked down upon if she acts "male" (e.g. self-confident, assertive, competitive, vocal), and is perhaps labeled a "bitch," creating a no-win situation for this female. Several respondents included experiences regarding this inability to "be female." A respondent described what happened to a highly competent female computer scientist he/she knew. She had gotten,

> A less-than-top review. The reason? The review said she was 'too emotional'. Given that women are more encouraged to express their emotions than men, you could say she was being compared against a male norm. Notice that this had nothing to say on whether her work was of high quality or whether she got it done on time or whether she documented it well or whether people found her easy to work with, all of which were without major flaw. It was her female style that was held against her.

A female student said, "I feel there is also a disdain in the classroom for anything girly." Another female student discussed a fellow female classmate, who,

> Calls it something like "being a girl" if she so much as does her hair. Dressing up or wearing a skirt will cause her to talk about how girly she feels all night... [but] I know she's as "girly" as she can be when the opportunity presents itself... it scares me that there's other girls like her, afraid to act, talk, or think like a girl because they'll be singled out even more.

Some of these disdained girly things are actions that females use to make themselves more visually desirable or attractive (e.g. dressing up, wearing makeup, etc.). At the same time, however, some respondents noted they had heard about complaints regarding the lack of attractive female computer scientists. One female undergraduate said,

> Last year, two male students, friends of mine, who were invited to meet faculty for lunch reported that the topic of the lack of attractive women in the department was aired. I'd heard this myself from male students on several occasions

This same student described the "rule of 11" that two male computer science professors had recently created at her school, where they "rate a 'girl' in the department twice, from 1-10, on aesthetics and intelligence and the sum won't exceed 11." She also noted that it was disconcerting that these were the people responsible for grading her. So, there are complaints about the lack of attractive, more "girly," but, when these women are there, they are taken less seriously. Indeed, a couple of respondents mentioned that they felt an extra burden in having to prove they could be pretty and female AND good at computer science. These different standards and expectations, and the associated stereotypes, sometimes has led to more overt harassment and discrimination based on gender.

Though many of the experiences discussed thus far could be considered harassment of a form, though perhaps more indirect or subtle, there are also instances of rather overt harassment based on gender within computer science (Simone, 1987; Spertus, 1991). One form of overt harassment is sexual harassment, which two female respondents specifically discussed. One of these respondents was a direct victim. This woman was told by a male co-worker that the reason she worked so much was not the result of her dedication but was that she "was obviously just a sexually frustrated woman and he, with his obvious prowess could assist me with that dysfunction." The more prevalent and often less intentional sexist humor or references can create a "locker room" atmosphere, of which many women do not feel a part (Spertus, 1991). "Many times I have overheard conversations of students about their girlfriends or girls in general that make me feel uncomfortable." Such incidences may further lead to feelings of isolation or "being left out," as previously discussed. Then there are also overt harassing incidents or comments by males that are based not only on gender, but on gender and ability. We have already seen a couple of these ("I was repeatedly told that I didn't understand programming but that was okay [since] I was just a woman" and "he...said I quote 'There is no way that a girl knows more about Computer Science than I do.'") One female participant described an experience from her college days,

> There were 24 students in the class, and I was the only woman. On the first day of class, looking directly at me, he said "I remember when they first admitted women to this (formerly all male Catholic) university. We flew the flag at half mast, that day.

Occurrences such as these are disrupting in the least. Furthermore, they will often affect a female's participation, concentration, interest, confidence, and performance regarding computer science. These changes will often affect decisions made regarding future in computer science (and whether to even continue in the field).

Unfortunately, there are also discriminatory practices based on gender that occur within computer science that add to the effects of these harassing occurrences. Undergraduate women in male-dominated departments have reported higher levels of discrimination than women in female-dominated departments (Steele, James, & Barnett, 2002). Additionally, these women have also reported that they anticipate further gender discrimination were they to remain in their male-dominated field. This discrimination concerns such areas as grading and pay policies, as well as ones concerning other evaluation policies (e.g. promotion, review, scholarship, award). Two respondents gave stories about experiences related to gender discrimination in grading policies. In the first, the respondent described an incident that took place during her undergraduate career, when she took a class with a professor rumored to discriminate against females. Both she and another female classmate each got a particular project working, yet, when comparing with other students found they both received the same grade as a male classmate who never got it working at all. Her female classmate went to the professor to argue for higher grade and had to "challenge the prof to prove how it could be made faster, and when he couldn't improve on it she was able to convince him to give her a better grade." The respondent, however, said, "at the time, I was intimidated and concerned about him grading me more harshly on other assignments, so I didn't pursue it." The other response regarding unfair grading policies happened with a female PhD student who said,

> At the end of the semester, a male student had the same numeric average I did...he got an A. I got a B. When I asked the TA about this, he said the professor believed women couldn't be in computer science and that the prof was attempting to lower the number of grads in the department.

This experience not only affected her grades, but as a result, she decided to switch areas within the department because she knew that if she stayed she would have to work with this particular professor on a regular basis.

A couple of female respondents also discussed salary discrimination, which they felt was gender-based. One woman described an experience from one of her first jobs. When she had gotten this job, she was paid only half her (male) predecessor's salary. Though she eventually got a small range, she said she was still "nowhere near my predecessor's salary." She argued, telling them she felt this was not a fair rate for the work she was doing. Later, she again made this clear, saying she would be looking for work elsewhere. Her employers responded by saying her salary was "good money for a young unmarried woman." She responded, saying, "I pointed out that my age, marital status, and gender were irrelevant items to take into account in determining a fair salary for the work being performed." She did find another job, with a significant raise; her former employers called her, who pleaded for her return, offering to match her current salary. She declined.

Other gender-based discrimination occurs with policies regarding reviews, scholarships, and promotions. One female student, after comparing her qualifications with the winners' qualifications, felt that the most probable reason she did not receive a particular scholarship was that her professor did not submit her nomination due to her gender. All his male students who asked for his nomination had won the scholarship. When she had asked for it, he agreed that she should receive it, but also commented, "he didn't know when he would 'get around' to completing his portion." One female respondent discussed how females with similar background and qualifications more often got bypassed for positions. The previously mentioned experience of a female computer scientists who received a "less-than-top review" because she was "too emotional" (that is, "her female style that was held against her"), is a case of gender discrimination applied to a review.

Some of these harassing and discriminatory experiences are more overt, where males have made explicit statements regarding their opinions on the competency of and their respect for female computer scientists. On the other hand, many of these experiences involve more subtle practices. Sometimes these practices are deduced or thought to be gender-based, including some the discriminatory practices just discussed. Here, it is hard to tell for certain if these truly practices are gender-based (and thus related to negative gender stereotypes). Most times, the accused practitioner does not directly say, "you're not getting this because you're female." One female respondent put it nicely, stating,

> The mechanics of prejudice are subtle. No practitioner will readily admit to engaging in behaviour that is detrimental to students based on some prejudice. It's difficult to distinguish this behaviour from politics, favouritism, or nepotism. Sometimes prejudice is just the sum of events...prejudice is being excluded from the best opportunities or being judged inferior in some respect that is irrelevant to academic considerations.

All the female respondents reported at least one experience that was linked to negative gender stereotypes. Some reported one or a couple of relatively isolated experiences, and others reported more regular experiences or trends. One respondent wrote of her career thus far,

> For the most part, I have had very positive experiences and have seldom been affected by negative stereotypes. I have worked with many intelligent, competent people - both men and women - and seldom feel I have been negatively judged because of my gender. Rather, most people I've worked with see me and others on our teams as people.

Others were less encouraging. Respondents wrote, "there is still a tremendous amount of it around," and "the odds, and culture..., are always against us." Another respondent wrote, "It's disappointing to know that this exists in the 21st century in science, which should by now know that the contributions by women are invaluable." For some women, the experiences were the result of the surrounding attitudes of several males, but, often, they were the result of just one person, and his prejudices. Unfortunately, though, the actions one person can result in far-reaching effects, especially if that person is one of authority or high status. One female respondent wrote of the results of her boss's attitudes, "It creates an environment of difference between me and my fellow co-workers." Some respondents described experiences which directly influenced decisions regarding their computer science path. A female respondent dropped a class as a result of the professors' negative comments about women; a different respondent changed her schedule to avoid a particular professor, rumored to be discriminatory. Another respondent changed subfields within her PhD program because had she stayed she knew she would have to work repeated with a particular "anti-woman" professor. Yet another respondent changed her major, in part because she felt left out of the circle. Finally, a respondent detailed how she changed her job-hunting strategies in order to avoid discriminatory practices she had encountered in the past. The more indirect results of these stereotypes and experiences, for example those dealing with confidence and interest in computer science, are much more difficult to assess, and consequently harder to successfully combat.

In this qualitative study, I attempted to open a dialogue with female computer scientists. In doing so, one of the goals was to obtain a picture of the current scope of experiences and perceptions of stereotypes for women in computer science, while also examining how these experiences corresponded with the recent research on the topic.

I found that the experiences of the respondents in this studied further emphasized the results of prior research on stereotypes and their potential effects.

The second goal of this study was to help elucidate and formulate future possible areas of inquiry within this topic of stereotypes and gender in computer science, in particular through the development of a comprehensive set of more questions about the amount and nature of gender stereotype-related experiences in computer science. The previous discussion of the stereotype threat study included a discussion of possible future variations/replications within that topic. Much of the research that deal, at least in part, with participants' gender stereotype experiences fall into one of two categories. The first includes the more empirical studies, which describe the prevalence and/or perception of the prevalence of gender stereotypes (e.g. Dryburgh, 2002; Francis, 1994; Levin & Gordon, 1989; Steele, James, & Barnett, 2002). These generally studies use surveys consisting of Likert-scale questions. The second category involves studies which allow participants to provide more individualized free-responses, either through interviews or sets of open-ended questions (e.g. Grant, 1995; Leveson, 1989; Spertus, 1991). However, generally, these studies have involved highly unrepresentative samples (of which the authors are aware). I feel a valuable tool in assessing would combine elements of both categories. By this, I mean, using representative samples of males and females in computer science, also employ a comprehensive set of open-ended questions. Using open-ended questions allows the participant to say more than whether or not they agree with the statement "I have encountered gender stereotypes." Having a sufficiently comprehensive set of questions helps assure that the researchers get from each participant their view of the overall picture, which may include anecdotes, but also is not just a couple of stories or experiences without any context. Additionally, this sort of study would ideally also be an interview oriented one, which allows the researchers to ask for clarifications or expansions to participant responses. To aid in the development of such a project, based on the experiences shared with us in this study, I developed such a set of questions. While ideally this would include participants of various ages, student status, professional status, ethnicity, sexuality, and other social identities, the initial scope of such a project would be enormous. To start, however, picking a particular age bracket or student status might be more appropriate and doable.

The entire list of questions is rather extensive and is included as an appendix (Appendix B). I tried to avoid phrasings that would suggest that gender stereotypes would be predominantly anti-female (e.g. instead of asking if they think stereotypes manifest in discrimination or harassment against women, omit the “against women”). Furthermore, generally questions that refer to females or males specifically had two versions (e.g. “In general, how do you feel your male/female counterparts feel about female/male computer science ability?”). The questions cover general stereotypes (“the typical computer scientist”) and gender stereotypes. The questions cover the participant’s perceptions of current stereotypes and whether they themselves fit the stereotypes. The questions cover the participant’s views on the *potential* results of stereotypes (including harassment, discrimination, different standards), as well as the participant’s *actual* experiences. The questions cover participant’s specific experiences, as well as their overall impressions.

General Discussion

I began this honors thesis by discussing my initial motivation for these studies, the systematic under-representation of women in computer science. Is this lack of women a result of inherent sex differences in computer attitudes and ability? And if some studies have found gender differences in attitudes and/or ability, are these truly indicative of the state of affairs, or do test-taking and other environmental factors play a role? Though biological differences should not automatically be dismissed, work such as Steele's (1997) and successors on stereotype threat effects, and others, suggest that situational factors can and do often play a significant role. Through examining the existence of and prevalence of environmental factors or inequalities we can gain an increased understanding of this under-representation. Furthermore, and more importantly, we can hopefully use this increased understanding to promote the numbers of interested women entering and staying in computer science. In this thesis, I chose to focus on one potential environmental factor, the existence and effects of stereotypes.

In the first study, I conducted an experiment related to stereotypes' effects on computer performance, in the form of stereotype threat effects. Claude Steele (1997) postulated that persons about whom a stereotype threat exists will perform equally well as others in nonthreatening situations, but will underperform in threatening situations (i.e. situations in which the stereotype is made relevant). There is a cultural stereotype about female inferiority in math and computing ability. Though researchers have consistently found stereotype threat effects with women and mathematics test performance (Oswald & Harvey, 2000; Quinn & Spencer, 2001; Schmader, 2002; Spencer, Steele, & Quinn, 1999; Walsh, Hickey, & Duffy, 1999), no studies as of yet have examine whether stereotype threat effects exist with women and computer aptitude testing. In the first study of this thesis, I examined the hypothesis that, when the gender stereotype of male superiority in computer competency is confirmed, female performance on a computer competency task among a group of women with a high interest in computers will be lower than the corresponding performance when that stereotype is refuted. Though the data from my small sample did not support this hypothesis, I also argued for several possibilities why stereotype threats are still highly possible for women with regard to computer performance. These reasons mainly concerned the difficulty of finding an appropriate competency test and the nature of the stereotype threat manipulation.

The support for the "on-average" existence of gender stereotypes of computing ability has been inconsistent. However, this research concerns averages, and individual encounters with gender stereotypes differ. There are males with particularly positive views on female computer scientists, but also, males with particularly negative views on female computer scientists. Sometimes it only takes a few negative harassing or discriminatory experiences to discourage certain females. Additionally, there is evidence for the belief in the existence of negative gender stereotypes (Steele, James, & Barnett, 2002). In the second study of this thesis, through opening a dialogue with mostly female computer scientists, I sought to examine the range of actual experiences and perceptions related to gender stereotypes, and the role these experiences and perceptions have played in their computer science lives and decisions. Where stereotype threat effects deal with an relatively unconscious effect of stereotypes, this study focused on aspects of stereotypes consciously accessible to the participants.

The overall results of both stereotype threat effects, and the types of experiences from the second study, may come in various forms.

The responses from the second study highlighted some of the possible results or reactions. For some, the existence of stereotypes makes them stronger, in the sense that they gain an increased desire to "prove them wrong." For others, the results manifested as changes in their decision making process, regarding their class schedules, their sub-field, or even their major. In these cases, the women made these choices consciously aware that they made them due to gender stereotype-related practices. However, for many, the results of gender stereotypes are more subtle, and these women are often unaware of the effects. Here, the gender stereotypes and negative attitudes towards women in the computer science environment are internalized, resulting in decreased interest and confidence. For some, this results in the decision to disidentify with computer science and leave the major (or never start it at all). Steele (1997) describes stereotype threat as "a threat that in the short run can depress their intellectual performance and, over the long run, undermine the identity itself, a predicament of serious consequence" (Steele, 1997, p.627). Margolis and Fisher (2002) found that,

> Many once-enthusiastic female college students find themselves in a descending spiral of eroding interest through the corrosive effects of lack of confidence, negative comparisons to peers, poor pedagogy, and biased environments (p. 77).

It seems then, that not only are women discouraged from developing an interest in computer science, those women who do become interested may lose that interest largely due to environmental factors.

The ultimate goal of identifying environmental factors detrimental to female participation in computer science is to use that gained understanding to promote increased numbers of interested women. Though the main purpose of this thesis was the identification and understanding of such factors, I will conclude with a brief discussion on some of the suggested improvements to the current state of affairs, as well as provide some further sources of more detailed reports. The scope of these "solutions" needs to be broad: "There are some things that can be done on an individual level, and there are others that must be implemented on an institutional, state, or federal level" (Leveson, 1989, p. 10). Possible activities on the multi-university or extramural level include conferences on women in science, committees on the status of women in computer science, regional workshops for women, networking activities, and providing research opportunities. Possible activities on a single university or departmental level include local workshops, study groups, summer institutes, university groups on women in science and mentoring activities. The availability of supportive mentors and role models is especially important, on all levels, preferably starting before high school. Mentoring can be on an individual level, through campus, local, or internet groups dedicated to the particular circumstances of women in computer science. These groups can also be important sources of peer support. At all levels, educating members of the academic community about of the existence of (or at least the perception of it) gender stereotypes and the resulting preferential treatment is also beneficial. Females often enter college with less prior computing experience than males; thus, it might be appropriate for college programs to offer different ways to enter the computer science curriculum, ones that take into account differing levels (Margolis & Fisher, 2002). Additionally, providing resources for interested or potentially interested younger females is also key.

Although there appear to be some specific problems that stand out at each stage of a woman's career, e.g., classroom discrimination as an undergraduate, advisor/mentor problems and learning

> opportunities in graduate school, funding and visibility problems as a professor, there are also some themes that are constant throughout - feelings of powerlessness, isolation, and invisibility, attacks on self-esteem, and exclusion leading to feelings of being an outsider and not belonging. None of these problems will be easy to solve, but there are things that can be done (Leveson, 1990, p.10).

Yes, there are issues regarding gender in computer science that need to be addressed, and making computer science increasingly gender-fair will not be an easy task, but it is definitely worthwhile...and possible.

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Appendix A

PART 1 (of 5)

_____ 1. An on-screen symbol consisting of a *letter* and > that indicates the operating system is ready for a command. It may indicate the current drive and directory.

_____ 2. A computer program that can prevent the infection of a computer by known viruses and detect when a virus is trying to copy itself onto a program.

_____ 3. Processes and controls the functions of the computer.

_____ 4. The numeric representation on the on and off electrical status in a computer.

_____ 5. Measurement used to state the internal clock speed of a computer.

_____ 6. Running two or more programs on a computer at once.

_____ 7. The smallest unit of data that a microcomputer can process.

_____ 8. The combined use of moving and still images, text, sound, or animation in communication.

_____ 9. A fixed number of adjacent bits, usually seven or eight, that operate as a unit, i.e., one character on the keyboard.

_____ 10. A measure of primary or secondary memory common to computers (1024 x 1024 bytes).

A. Binary number

B. Bit

C. Byte

D. CPU

E. Hard copy

F. Hard font

G. MB

H. Multimedia

I. Multitasking

J. Megahertz

K. System Prompt

L. Anti-virus/Vaccine

M. Watermark

Part 2 (of 5)

____ 1. The combination of text and graphics in the creation of a professional looking document.

____ 2. The operating system command which prepares a disk to receive data or programs.

____ 3. The primary program that runs the computer and gives the user control over hardware and software.

____ 4. A collection of related data fields that contain information about one subject.

____ 5. The main directory of a disk from which other directories branch.

____ 6. A subdivision of a record that holds a meaningful item of data.

____ 7. The act of preparing documents and manipulating text electronically.

____ 8. Software written primarily to organize, process, and retrieve items of data.

____ 9. Software written primarily to solve numeric problems using rows and columns.

____ 10. Programs written for solving a specific user problem or for performing a specific task.

A. Application software

B. Database

C. Desktop publishing

D. Operating system

E. Field

F. Format

G. Graphics

H. Integrated software

I. Record

J. Root

K. Sort

L. Spreadsheet

M. Word processing

Part 3 (of 5)

____ 1.	Copying computer programs without authorization from the creator for personal or commercial use.	A. Biomechanics
		B. CAD/CAM
____ 2.	Data that has been translated into a secret code for security reasons.	C. Computer vandalism
____ 3.	The activity of computer enthusiasts who are challenged by the practice of breaking computer security measures	D. Merging
		E. Encrypted
		F. Ethics
____ 4.	An individual's rights regarding the collection, processing, storage, distribution, and use of data about his or her personal traits or activities.	G. Hacking
		H. Piracy
		I. Privacy
____ 5.	The process of designing and drafting, as well as sometimes testing a product using computer graphics.	J. Downloading
		K. Vaccine
____ 6.	Crime directed against hardware or software which physically damages the equipment and requires no special expertise on the part of the criminal.	L. Virus
		M. WYSIWYG
____ 7.	The standards of moral conduct in computer use.	
____ 8.	A computer program that can destroy the contents of a hard or floppy disk.	
____ 9.	To receive into a computer an electronically transmitted file.	
____ 10.	Science that uses computers to study the movement of athletics.	

Part 4 (of 5)

_____ 1.	The smallest element on a video display screen.	A. 1.44 MB
		B. 64-bit
_____ 2.	A temporary memory storage in a printer.	C. Baud/ppm
_____ 3.	A measure of the resolution of characters displayed by a monitor or printer.	D. Boot
		E. Buffer
_____ 4.	The amount of data that can be stored on a high-density 3.5" floppy disk.	F. Disk drive
		G. Dpi
_____ 5.	A physical device, such as a computer or printer, that is connected to a network system.	H. Interface: parallel/serial
_____ 6.	An input device, output device, or secondary storage unit connected to a computer.	I. Node
		J. Peripheral device
_____ 7.	A form of primary computer memory into which instructions and data can be written to, read from, and easily erased.	K. Pixel
		L. RAM
_____ 8.	A computer which can process eight bytes of data at one time is a _____ computer.	M. ROM
_____ 9.	The process of loading the operating system into the main memory of a computer.	
_____ 10.	Hardware connections through which the components of the computer system talk to each other.	

Part 5 (of 5)

____ 1. The phone line signal which a modem translates to a signal the computer can process.

____ 2. A software that allows the user to connect to and navigate the Internet.

____ 3. A computer connection between an office and home that allows an employee to work at home.

____ 4. Data fed into the computer for processing.

____ 5. The electronic transmission of messages or pictures at high speeds between computers over communication channels.

____ 6. The measurement of the speed of data transmitted in one second.

____ 7. A device that modulates and demodulates signals transmitted over communication lines.

____ 8. The sending of an informal message electronically to one or several receivers.

____ 9. To gain access to a network system by dialing the telephone number and entering the identification number and password.

____ 10. A global network of networks.

A. Analog

B. Raw data

C. Bps/baud rate

D. Digital

E. Web browser

F. E-mail

G. Internet

H. Log on

I. Modem

J. Gateway

K. Telecommunica-tions

L. Telecommuting

M. Uploading

Appendix B

Ideally, to be asked of both genders, of all levels of study, various professions (and positions within), and ethnicities (even more ideal, of various regions and countries as well)

- What is your idea/concept of the typical computer scientist? Typical male computer scientist? Typical female computer scientists? Do you feel you fit these descriptions?
    - How do people generally respond when you tell them you are in computer science? If they were surprised, how could you tell (e.g. they said so, from their face, etc.)?
- What do you think is the general population's idea/concept of the typical computer scientist? Typical male computer scientist? Typical female computer scientists? Do you feel you fit these descriptions?
- What would you consider the most common stereotype within computer science? What would you consider the most common gender stereotype within computer science?
    - For both, how common believed is this stereotype? Do males or females or both subscribe to this stereotype?
    - For both, what might be the effects of these stereotypes?
    - Do you think these stereotypes ever manifest in blatant discrimination or harassment? If so, how?
    - How much of a role do any stereotypes play in your daily computer science life?
    - What interaction do you think other social identities, e.g. race/ethnicity, sexuality, have with any present gender stereotypes?
- In general, how do you feel your male/female counterparts feel about female/male computer science ability?

- How do you feel about "femininity" in computer science?
- If male, have you ever had a female superior? If female, have you ever held a position of authority? If so, how did you feel about this?
- Have you ever been in a very small gender minority in your classes/major/groups/jobs, etc.?
    - If so, how have you felt about that?
    - If so, do you think it has significantly changed your computer science experience?
    - If so, were you ever singled out? What might the advantages and disadvantages of this be?
- Have you ever experienced any overt harassment or discrimination based on your gender? If so, please describe, including the most recent occurrence.
- Have you ever experienced any differential treatment, different standards of evaluation and/or different expectations based on your gender?
    - If so, please describe.
        - What is the most recent occurrence?
        - At what time in your life did you most often have such experiences?
        - Do these experiences happen more in larger groups or in one-on-one interactions?
        - Do you see a pattern in the experiences?
    - If so, and if not overt, how did you know it was the result of gender and not some other stereotype or unrelated event?

- For both those with and without personal experiences with gender-related harassment, discrimination, differential treatment, etc., are you aware of others who have had such experiences?
    - Do you feel the standards for evaluation are in general different for male and female computer scientists?
    - Do you think the occurrence of such incidents has decreased over time, as attitudes and the times change?
    - In general, who are the “culprits”? Peers, superiors/authority figures, male/females/both, etc.?
- Have you ever made any major decisions regarding your computer science career based on gender?
- Overall, has your experiences in computer science with regard to gender been positive or negative?