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Diversity or Difference? New Research Supports the Case for a Cultural Perspective on Women in Computing

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Abstract Gender difference approaches to the participation of women in computing have not provided adequate explanations for women's declining interest in computer science (CS) and related technical fields. Indeed, the search for gender differences can work against diversity which we define as a cross-gender spectrum of characteristics, interests, abilities, experiences, beliefs and identities. Our ongoing case studies at Carnegie Mellon University (CMU) provide evidence to show that a focus on *culture* offers the most insightful and effective approach for investigating women's participation in CS. In this paper, we illustrate this approach and show the significance of cultural factors by describing a new case study which examines the attitudes of CS majors at CMU. Our analysis found that most men and women felt comfortable in the school, believed they could be successful in the CS environment at CMU, and thought they fit in socially and academically. In brief, we did not see any evidence of a strong gender divide in student attitudes towards fitting in or feeling like they could be successful; indeed we found that the Women-CS fit remained strong from prior years. Hence, our research demonstrates that women, alongside their male peers, can fit successfully into a CS environment and help shape that environment and computing culture, for the benefit of everyone, without accommodating presumed gender differences or any compromises to academic integrity.

Keywords Culture · Environment · Computer science education · Women-CS fit · Diversity · Gender · Women · Recruitment · Retention

Introduction

Gender difference approaches to the participation of women in computing have not provided adequate explanations for women's declining interest in computer science (CS) and related technical fields (e.g., Blum et al. 2007; Frieze et al. 2006; Adams et al. 2003; Trauth 2006; Wajcman 1991). We propose that new approaches, and in particular taking a cultural approach, are not only helpful but necessary at this critical time in the history of computing in the USA when "among *all* occupations in *all* fields of science and engineering, computer science occupations are projected to account for nearly 60% of *all* job growth between now and 2018" (Lazowska 2010). While the skills situation is critical the *opportunities* for women (and others who are currently under represented) are tremendous. Thus, this is a message that requires increased attention, yet many parts of the western "developed" world struggle to attract and retain students with diverse backgrounds and perspectives. The situation could benefit women in particular, but just as

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importantly "it is in the interest of the computing world, rather than in the interest of any specific underrepresented group in this community, to enhance diversity in general, and gender diversity in particular" (Hazzan 2007). Clearly, it is in the interest of women, of the nation, and the field of computing to attract and train talent from a diverse pool of potential participants.

Our ongoing case studies at Carnegie Mellon University (CMU) provide evidence to show that a focus on *culture* offers great potential as an approach for investigating women's participation in CS. To date, our research demonstrates that women, alongside their male peers, can fit successfully into a CS environment and help shape that environment and computing culture, for the benefit of everyone, without accommodating presumed gender differences or any compromises to academic integrity. We call this a Women-CS fit, a phrase we have used in previous publications (starting with Frieze et al. 2006).

In this paper, we illustrate a cultural approach and show the significance of cultural factors by describing a new case study, 2009–2010, which examines the attitudes of CS majors at CMU. Specifically, this case study—the latest in a series of case studies from CMU—sets out to examine if the culture of computing in the CS department is still working for the benefit of all students, men and women. We look at a range of cultural factors including faculty approachability, environment, social fit, academic fit, and ingredients for success.

This article is structured as follows. First we summarize the current gender gap in CS by presenting national enrollment statistics of women studying CS at Ph.D. granting institutions. We then relate literature on cultural shaping to gender in CS research. In doing so, we highlight several longstanding essentialist beliefs about women and provide contradictory empirical evidence to this approach. This is followed by an overview of the studies to date on the Women-CS fit at CMU (Margolis and Fisher 2002; Blum and Frieze 2005a, b; Frieze et al. 2006). Next we present details and data from the most recent case study examining the attitudes of undergraduates in CS at CMU. The data from this examination comes from surveys conducted with 58 women and 201 men in the CS major during the fall of 2009. Finally, we discuss implications for interventions to increase the representation of women in CS educational programs.

Background

The Gender Gap in Computer Science

The Taulbee Survey is conducted annually by the Computing Research Association to document trends in student enrollment and degree production in technical degree programs in the United States. Data supplied by the 2010 Taulbee Report (reporting findings from 2008 to 2009) on participation in CS at the undergraduate level show that overall enrolment in CS majors dropped by half between 2000 and 2005. This dramatic decline was followed by 2 years of stability and then by small, but welcome, upturns from 2007 onwards. CS enrollments have not climbed back to the peak we saw in 2000, nor is it really plausible to think that would happen since conditions are so different. But the signs are generally encouraging. The 2011 Taulbee survey, providing data from 2009 to 2010, now reports that "(t)otal enrollment among majors and pre-majors in US CS departments increased 10%. This is the third straight year of increases in total enrollment, and indicates that the post dot-com decline in undergraduate computing program enrollments is over" (Zweben 2011, p. 4; see Fig. 1).

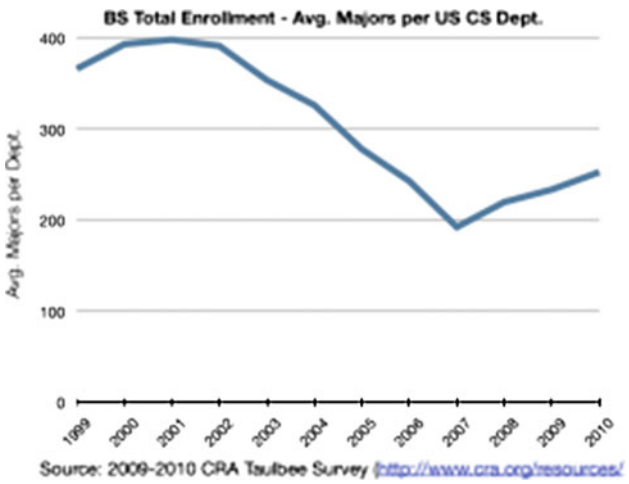

Fig. 1 Bachelor's degrees in computer science average enrollment (From Zweben 2011)

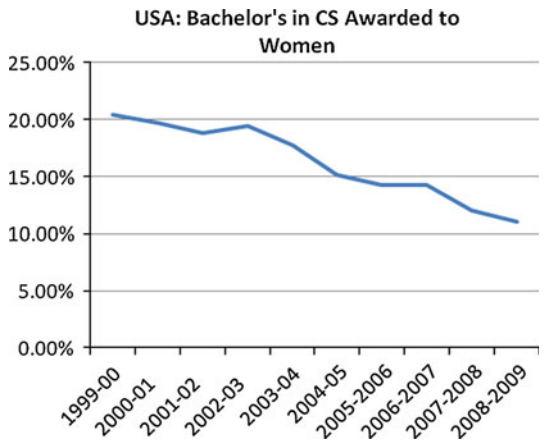

Fig. 2 Bachelor's degrees in computer science awarded to women in the USA (From Zweben 2010)

It is not clear at the moment if women are included in this welcome upturn in CS enrollments. A 2008 article in the New York Times notes that "(m)any computer science departments report that women now make up less than 10% of the newest undergraduates" (Stross 2008). What is clear is that from 2000 onwards, until very recently, data show year to year declines in the number of bachelor's in CS awarded to women in the USA (see Fig. 2). The 2011 Taulbee Report shows the share of bachelor's degrees in CS granted to females now stands at 13.8% in 2010 (Zweben 2011). This is a small but welcome increase but clearly, the participation of women in CS in the USA remains at a disappointing and unacceptable level.

CMU has not been immune to national trends. However, even in the face of a nationwide decline in the number of new CS majors, the School of Computer Science[1] (SCS) has sustained a critical mass of female students within the entire CS undergraduate student body. For the past few years, the percentage of women enrolling in the CS major at CMU has held steady or increased at well above national averages. Indeed since 2002, the percentage of bachelor's degrees granted to women in the CS major at CMU has exceeded and stayed well above the national average. We believe this success is due in large part to the school's commitment to the success of women in computing and to its ability to build and sustain a culture and environment which works for both men and women.

A Cultural Framework

What Is Culture?

It seems reasonable to assume that a multitude of factors are involved in women's participation in CS—biological, educational, psychological, cognitive, social, etc.—factors which this paper cannot hope to untangle. This concept was nicely illustrated by Barnett and Rivers (2004) when they explained, "We are all a product of many interacting forces, including our genes, our personalities, our environment, and chance." This paper promotes the view, and provides evidence to show, that factors relating to culture and environment which encompass so many of these "interacting forces," play critical roles in determining women's participation in CS.

So what do we mean by culture and what does it mean to take a cultural approach? First, we should explain that this paper is not theory-building driven and cultural theorists may find our definition somewhat naïve. However, our working definition of culture is derived from British cultural theorist and historian Raymond Williams who, by the mid 20th century, had brought a new way of thinking about culture. Williams proposed that culture belonged to everyone being part of our everyday experiences and being *"made and remade"* by us on both the personal and the societal levels (Williams 1958). This definition allows us to see culture as a *synergistic* process for change. We are shaped by the cultures we occupy while also being active contributors to those cultures. And while a dominant culture may embrace and influence a large community, counter or micro-cultures may also exist and exhibit unexpected features. We might argue that this is the case of CMU's School of Computer Science where women's participation in CS has not followed dominant national trends.

In brief, this paper uses the term culture as previously defined (Frieze et al. 2006) to refer to the complex and broad set of relationships, values, attitudes and behaviors that bind a specific community *consciously and unconsciously*. This community can be localized as in the micro-culture of a department or extensive as in the culture of a nation. In all cases this definition posits that culture is bound by context and history and that we are born into specific cultures with prevailing values and structures of opportunity.

A cultural perspective can both *broaden* and *focus* our thinking. It can broaden our thinking as we think outside of our own cultures and it can focus our thinking as we recognize specific factors affecting specific situations. Taking a cultural perspective on women's participation in CS is an approach which allows us to look at *factors outside of gender* as leading contributors to different levels of participation. As gender is often constructed differently in different cultures taking a cultural approach allows us to see quite clearly and *convincingly* that many characteristics ascribed as natural to men and to women are actually produced in specific cultures. Indeed, several researchers have brought this fact to our attention (Adams et al. 2003; Cheek and Agruso 1995; Galpin 2002; Eidelman and Hazzan 2005; Gharibyan and Gunsaulus 2006; Huyer 2006; Othman and Latih 2006).

Gender Differences and the Rhetoric of Essentialism

This paper promotes the importance of culture and in doing so hopes to raise awareness of what we believe is the return, or continuation, of essentialist thinking which has not served women well. Essentialism is the belief that people have properties that are essential to their composition. In this sense, all members of a particular demographic group (e.g., gender, race, sexual orientation) share common and finite characteristics. Wajcman (1991) argues that essentialism with regard to gender is based on the concept that fixed, unified and

[1] Carnegie Mellon's School of Computer Science is made up of seven departments: the Computer Science Department, the Robotics Institute, the Human Computer Interaction Institute, the Language Technologies Institute, the Institute for Software Research, the Machine Learning department and the Lane Center for Computational Biology.

opposed female and male natures are primary components in understanding human actions. Hence, at the core of essentialism is the belief that since men and women are inherently different in their physical bodies, they are also different in the ways in which they act, behave and think. Marini (1990) adds that this frequently leads to the assumption that biological features can be used to explain other observed differences between men and women. Thus, DeCecco and Elia (1993) explain that biological characteristics constitute the primary influencing factor influencing human behavior, thereby minimizing the effects of culture or social shaping.

Researchers argue that essentialism uses biological differences between the sexes to explain differences in male and female decisions to study CS (e.g., Ratliff 2005; Schiebinger 2000; Trauth 2006; Wajcman 2000). Consequently, essentialism studies generally conclude that men relate to technology in differing and opposing ways from those of women. For instance, Pinker (2002) suggests that the lack of women in technical careers could be due to biological differences in average temperaments and talents. Furthermore, Baron-Cohen (2003) argues that "the female brain is predominantly hard-wired for empathy. The male brain is predominantly hard-wired for understanding and building systems" (p. 1).

Essentialist rhetoric has become more noticeable in relation to CS and technology, and more broadly to some areas of science in general, as we have struggled to address the low participation of women. Signs of essentialist thinking are not only evidenced in the remarks of Larry Summers, when he was president of Harvard and should have known better, but also in the way we are constantly searching for ways to make science *appeal to girls and women*, as if tapping into something inherent in girls and women, or re-shaping science to suit women's interests, will provide the answers. For the past 15–20 years the search for gender differences has dominated research into women and CS. Indeed, the National Science Foundation[2] (NSF), perhaps the largest funding agency for gender and CS research, has required the search for gender differences as part of their criteria for awarding grants for gender and CS research programs (NSF 2011). Such approaches, though well intentioned, may ultimately play into essentialist thinking and serve to reinforce a gender divide. By identifying gender differences and *subsequently accommodating those differences* we can be our own worst enemies playing a harmful role in *perpetuating stereotypes and differences*. These differences, which are often only *perceived* differences that can change according to situation, can serve to *deny diversity* and the cross-gender spectrum of characteristics, interests and identities that can emerge. If our primary aim is for diversity in the field, we contend that a focus on gender is more likely to lead to a gender divide, setting up men and women as separate categories when research has shown that there are more differences within each gender than between them (e.g., Adya 2008; Hyde 2005; Kvasny et al. 2009; Trauth et al. 2008).

Without an awareness of cultural contexts gender difference approaches can serve (a) to reinforce the belief that men and women are two distinct and fundamentally different categories which in turn can support an essentialist position, and (b) to exclude significant cultural factors outside of gender that are impacting participation in CS.[3] Research recommendations without awareness of cultural contexts typically suggest that men and women should be treated differently with regard to the study of CS and employment in the workforce. Hence, at its extreme it could be concluded that there should to be two different CS workforces: a female CS workforce and a male CS workforce. We propose that taking a cultural approach can offer more prudent insights and open up new possibilities for thinking about participation in computing without contributing to a gender divide.

New Research and the Ingredients for Success

There is a growing body of research that challenges the historical notions of essentialism. Epstein (1990) argues that men and women are overwhelmingly similar and that any differences between them are socially constructed. For instance, Fine (2010) argues that sloppy science is frequently used to justify gender stereotypes—which she labels "neurosexism." She critiques the use of fMRIs and high-tech scanners to explain how sex hormones shape the brain, which then shapes behavior and intellectual ability, from mathematics to nurturance. It is not that she is opposed to neuroscience or brain imaging; quite the opposite, she strongly argues against making authoritative interpretations of ambiguous data. Supporting her argument is research emerging from the fields of psychology and neuroscience which suggests that men and women may not be so different after all. For example, Halpern (2000) recognizes that the female brain is slightly smaller than the male brain, but studies show this to have no significant effect on a woman's intellectual performance. Further, through empirical analysis, Barnett and Rivers (2004) show that the idea of a "math gene" or the hardwiring of a male or female brain is a fallacy.

[2] The synopsis of the NSF program, "EHR: Research on Gender in Science and Engineering" illustrates this point: "Typical projects will contribute to the knowledge base addressing gender-related differences in learning and in the educational experiences." The goals of the program include: "To discover and describe gender-based differences and preferences in learning science and mathematics" http://www.nsf.gov/pubs/2010/nsf10516/nsf10516.htm.

[3] Factors such as opportunities, experience, exposure to computing are outside of gender and not intrinsic to one gender or the other.

This work is not without its critics. Nevertheless, nowadays the very concept of what is "natural" is being challenged even further as an increasing number of studies emerging from psychology and neuroscience uncover the "plasticity" of the brain. Recently, Carnegie Mellon scientists have discovered evidence of brain rewiring among children (National Institute of Mental Health 2009). In their study of 72 children, they found that reading remediation improves children's reading skills and positively alters brain tissue.

Scientists are showing that more and more behaviors once thought to be hard wired can be seen to change when behavior is changed. Further, research shows that cultural shaping towards social norms affects and even changes the brain. For example, Eliot (2010) uses the notion of the brain's plasticity to explain how human brains are works in progress. She argues that brains change based on experience, especially in early childhood. Consequently, a child's environment can dramatically influence how he or she develops in terms of skills and interests. Eliot also argues that the brain-based differences that seem so immovable in childhood can lessen with age.

For our purposes we are reminded that at one time different math abilities in men and women, with women having poorer ability, were attributed to "different brains" (Benbow and Stanley 1980, 1983). Such "scientific" explanations have been used to explain women's weaker performance in math and to uphold and justify a culture entrenched in beliefs that men and women are fundamentally very different. By paying attention to girls and math, by increasing their levels of encouragement, of experience and practice, girls have caught up with their male peers and indeed women now earn the majority of bachelors in the field of mathematics.

We believe there are several important ingredients outside of gender which contribute to any student's participation and success in the STEM fields at all levels of academic and personal growth. Factors such as opportunities, experience, exposure to computing are outside of gender and not intrinsic to one gender or the other. Thus, we can be very pragmatic in recommending that we pay close attention to a small but effective set of best practices:

- Hands-on experience to gain important skills
- Inclusive learning environments
- Expectations that girls can do as well as their male peers in STEM fields
- Role models to inspire and allow students to see themselves as next generation scientists
- Set challenges and encourage students to take them on
- Make leadership and professional opportunities available
- Exposure to career advice and the breadth of opportunities in computer science

With access to these important ingredients girls and women are more likely to reach their full potential and more likely to enter and be successful in previously male dominated fields. Such opportunities should not be left to chance as is often the case for women: "(I)f no one suggested [CS] to me, I probably would have gone to law school or something else." (Female CMU graduate 2004). With regards to CS specifically we might add to this that having a program of CS studies on the US national K-12 curriculum could make a huge difference in ensuring that students do not miss out. Efforts to do this are currently being promoted by (among others) the Association for Computing Machinery (ACM), National Science Foundation (NSF), the College Board[4] and the CS Teachers Association (CSTA).

The CS Culture at Carnegie Mellon University

Background

For the past 10 years, we have been paying close attention to the culture of computing among undergraduates in the CS major at CMU. For the most part, prior to 1999 CMU maintained a very traditional male dominated CS culture, a culture which tended to support the personalities of stereotypical computer science students. From 1999 onwards, we began to observe what we believed to be the evolution of a new culture of computing. As the environment shifted from an *unbalanced* to a more *balanced environment* women began to participate, contribute, and be successful, in the CS major. By balance we refer to three specific areas –balanced in terms of gender, breadth of student personalities, and professional support for women (Frieze and Blum 2002). Our research findings show that interventions leading to balance in the environment have contributed to changes in the CS micro-culture and the development of a Women-CS fit. Most notably our findings also show that in this new culture of computing women and men relate to CS through a spectrum of attitudes, including many gender similarities, rather than a gender divide. It is also important to note that while the CS department at CMU clearly allows for diversity and a more balanced environment, the academic curriculum was not adapted to become "female-friendly", and in fact has continued to be an extremely rigorous and highly competitive program receiving, for example, over 3,000 applications in 2011 for the 140–150 places offered each year.

A full account of actions leading to change at CMU have been well documented (Blum 2004; Frieze and Blum 2002; Margolis and Fisher 2002). But evidence that prior programming experience did not affect graduation rates (one of the findings from the 1995 to 1999 Margolis/Fisher

[4] http://www.about.collegeboard.org/.

research) proved to be particularly significant. This finding, along with the (then) SCS Dean's proposal to develop admissions criteria that would select for future leaders, led to a fundamental change in admissions to the CS major.[5] By 1999 these changes would lead not only to a dramatic increase in the numbers of women but also to more men with wide ranging characteristics, selected and admitted for their "community" and leadership potential along with high SATs. By the time our research started in 2002 CMU had a more diverse student body and had gone from being among the universities[6] with the lowest percentage of undergraduate women in CS in the USA to being among the highest.

The school did not approach this situation with complacency; after all, the increased numbers of women and CS students with broader ranging personalities and interests were entering a very traditional CS culture dominated by (mostly male) students selected primarily for their high SATs and programming background. In 1999 Lenore Blum joined the CS faculty at Carnegie Mellon. As a long time advocate for women in science and technology, with much experience creating action-oriented programs, she decided to formalize a program which would help ensure that undergraduate women, now dramatically increased in numbers, could thrive. The organization took on the name, *Women@SCS*[7] and has since become catalytic in building an environment in which the new student body could flourish. The appointment of Blum, along with funding for a program of professional and social activities for *Women@SCS*, indicated the department's commitment to women's success in CS at Carnegie Mellon. We believe this level of commitment was crucial for changes to be successful.

Women@SCS has not evolved to provide "handholding" for women but rather as an action oriented organization ensuring that women do not miss out on the mentoring, socializing and professional opportunities that are more readily available for those in the majority. At the same time women students often take leadership roles which provide benefits for their male peers and/or for the entire SCS community.[8] Thus, the organization has not developed as a marginalized women's group, but rather as an integrated professional organization and as a valuable asset to the school. An indication of how the school has continued to value *Women@SCS* was shown in the SCS Milestones video shown at the inauguration of the new Gates-Hillman Centers (home of the Computer Science Department) where the initiation of *Women@SCS* was shown as a major milestone in the history of the school.

In sum, the mindset at CMU is that men and women have the same academic potential in CS and that women can do as well as their male peers if they receive similar levels of encouragement, experience and opportunities. Thus, there were no calls to make the academic curriculum "female friendly" and indeed the post-1999 changes to the CS curriculum were made for the benefit of *all* CS majors after the undergraduate student body had become more diverse in terms of gender, student personalities and backgrounds. But the need for an organization like *Women@SCS* was recognized and initiated to ensure that women would not miss out and could in fact contribute to the department.

Our research findings provide quantitative and qualitative evidence to show that CMU has built and sustained a CS culture in which both men and women can participate and be successful. Several students in our 2009–2010 cohort made specific comments relating to the significance of the school's culture and environment. They were attracted to CS at CMU not just for "academic excellence" and "national ranking" but also for its "diversified student body" and "the overall environment." Research has also pointed to the importance of motivation in selection of field of study (e.g., Koul et al. 2010). One student liked the "mix of great technical school with fine arts," while others noted that "culture" and "atmosphere matters." One female junior said "(I) felt like I fit from the start."

Culture and environment are not always easy to measure or define but we believe that pride in building an inclusive culture has become pervasive, integrated into CMU's school identity. This is indicated at the faculty and leadership levels where the Dean of SCS, and senior faculty, play a critical role in setting the tone and paying close attention to the demographics of the student body. The Dean of SCS is a truly active member of the CMU president's diversity committee and also the leader of the SCS Pacesetter team.[9] It is also indicated in the school's

[5] At CMU new students are admitted directly into the CS major.

[6] Here we refer to the Ph.D. granting schools with data collected and monitored by the CRA Taulbee Reports.

[7] *Women@SCS* is a professional organization of faculty and students in CMU's School of Computer Science working to promote diversity in the field both on-campus and through outreach programs. The organization contributes to building an environment that works for all. For a fuller picture of the activities and resources offered through *Women@SCS* please see the web site at: http://www.women.cs.cmu.edu.

[8] One example of this is the *Women@SCS* led "Pre-Registration Event" advertised as "No Faculty Allowed" and open to all undergraduates. Students share information and advice about classes and professors. In other words they formalize a common activity more readily available to those in the majority and make it available to all.

[9] Pacesetters, an offshoot of NCWIT (National Center for Women & Information Technology), is a group of schools around the nation who have shown themselves to be outstanding examples of good practices for diversity in CS and IT.

commitment to host various workshops[10] aimed at broadening understanding of, and participation in, CS. These are workshops in which SCS faculty and students participate above and beyond their academic obligations. Sustaining an inclusive culture is on the SCS radar.

Case Studies at Carnegie Mellon University

This paper aims to present the findings of our most recent investigation[11] of the localized culture of the CS department at Carnegie Mellon, 2009–2010. But first we present some brief background on earlier case studies.

1995–1999 Case Studies

The pre-1999 student body in the CS major was fairly homogenous, dominated by male students admitted largely for their strong programming proclivity, a situation which lent itself to the well documented "geek" culture of computing. Early studies 1995–1999, carried out at CMU by Jane Margolis and Alan Fisher in this environment, revealed a dismal picture of women's experiences in the CS major. This picture appeared to match the broad dismal picture of women and CS across the nation—a bleak picture of young women feeling excluded from computing, of women's declining interest and low participation in the field—a dismal picture which continues to this day. The early study set out to examine gender differences in how men and women relate to CS and concluded that men and women relate to CS in very different ways. Findings from the 1995 to 1999 study are described in *Unlocking the Clubhouse* (Margolis and Fisher 2002); the researchers concluded that women wanted to do useful things with computing while men liked to focus on programming and the machine itself, summarized as "computing with a purpose" and "dreaming in code," respectively. They also found that women's confidence was extremely low (even "extinguished") and many women were leaving the program (Blum 2004; Margolis and Fisher 2002).

One of the critical findings from the 1995 to 1999 early research was that prior programming experience did not affect graduation rates in CS. A valuable summer outreach program for high school CS teachers was also conducted during this time frame. The outreach ultimately gave the message that CMU was a place where they paid attention to both women and men in CS.

2002 and 2004 Case Studies[12]

Observations that change was in the air after the dramatic increase in the number of women entering the CS major provided the impetus for a preliminary research study starting in 2002. The study was based on intensive interviews with CS majors, men and women. Findings from this study proved to be very surprising and have been documented elsewhere (see Blum et al. 2007; Blum and Frieze 2005a, b; Frieze et al. 2006). While we found some similarities to the earlier Margolis/Fisher findings we identified several *significant changes*, changes which led us to question some of the accepted differences in how men and women relate to CS. Indeed the two social scientists, Larsen and Stubbs, who were hired to analyze the interview transcripts independently, soon observed that focusing on gender differences could not provide adequate conclusions for what they were finding (our italics):

> The original objective of this study was to locate and identify gender differences in the perceptions of these students. Our diligent attempts to meet this objective were consistently frustrated by *the clear existence of gender similarities* and evidence of other sources of diversity (Larsen and Stubbs, 2005).

Findings from this study showed that those women in the 2002 cohort seemed to be constructing a new identity that was both "geeky" and feminine. At the same time both men and women in the cohort were reevaluating and redefining what it meant to be a computer scientist. When we conducted further studies in 2004 we found this new identity had evolved yet further as students, men and women, broke with old stereotypes, claiming the "good" aspects of geekiness, respecting diversity, and ensuring they maintained broad and balanced lifestyles.

The findings from our 2004 case study and 2002 preliminary interviews indicated a marked change from the earlier studies at Carnegie Mellon. We found men and women showing a spectrum of attitudes and interests in computing, including many gender similarities and the Women-CS fit was clearly evident. Old stereotypes were giving way to new identities, rich in breadth and diversity. When they drew on aspects of traditional CS stereotypes

[10] One example is CS4HS (Computer Science for High School Teachers), now in its 6th year, which provides resources to help High School teachers bring a broad range of computer science principles into their classrooms. Another example is OurCS (Opportunities for Undergraduate Research in Computer Science), a 3 days research focused workshop in which undergraduate women from across the nation come to CMU to work in teams on research problems designed and led by CMU faculty.

[11] This research study was funded through the CRA-W undergraduate research program (CREU).

[12] The 2002 and 2004 interviews were carried out as part of a project funded by the Sloan Foundation. Surveys carried out 2004–2005 were funded by a grant from the CRA-W, CREU program.

these often became a source of common ground and humor for both men and women.

Perhaps the most significant change we found related to programming, a change which challenged the early gender divide which had defined women as "computing with a purpose" and men as "dreaming in code." Almost all students, men and women, reported programming as one part of their CS interests and the computer as a "tool" for their primary focus which often was applications. We also found that students understanding of CS had shifted and broadened—CS had come to mean a challenging and complex field. Students, men and women, stated that although their confidence increased overall, levels varied greatly over the years, depending on the classes they were taking. Most importantly we found that female students felt they fit into the department both socially and academically.

Our 2002 and 2004 studies provided evidence of important changes, changes which illustrate that in the post-1999 *more balanced environment*, gender similarities have emerged along with the Women-CS fit. We believe that factors relating to *balance* have been the crucial factors for cultural change. As mentioned earlier by this we refer to balance in three critical areas: (1) improved gender balance; (2) a broader range of student personalities; and (3) professional and social support for women through *Women@SCS*, to ensure that women do not miss out. These findings stand in sharp contrast to the gender divide noted in the pre-1999 findings, which looked at a different student body in a different environment, an environment *un*balanced in the areas noted above. In light of the new findings we suggest it is unwise and misleading to make generalized assumptions about how men and women relate to CS without reference to the specific culture and environment which students occupy.

The Women-CS fit at Carnegie Mellon was indicated in our 2002 case study and further endorsed in our 2004 case study having evolved alongside the culture of computing. As the student body has changed and the atmosphere has become more inclusive, the older culture has been displaced. CMU students in the CS major, who share a love of the field, are both shaped and shaping this new culture as they challenge old stereotypes and redefine what it means to be a computer scientist.

The Current Case Study: 2009–2010

The latest in our series of studies of the Women-CS fit at Carnegie Mellon was also part of a CRA-W Collaborative Research Experience for Undergraduates (CREU)[13] involving two CMU CS majors. The major goal of the new study was to continue examining how undergraduates were relating to CS. This time we extended our target participants from seniors only to include all undergraduate years, freshmen through seniors.

Data Collection

We developed a two-page survey to assess attitudes and perceptions towards CS among the CS undergraduates (men and women) at CMU. We limited the survey to two-pages knowing that undergraduates would be more likely to complete a short, primarily multiple-choice, questionnaire. The survey was comprised of five main sections. The first section of the survey focused on the background of the participants including questions about demographic characteristics (e.g., gender, year of study, etc.) and interests or previous experiences in computing (e.g., relatives in the CS field, academic competition experience, other academic interests). The second section of the survey inquired about high school experiences. The questions gathered information about the number and types of previous computing courses and if these courses had an impact on the participant's decision to major in CS. The third section of the survey inquired about general views of the CS field. In this section, participants were asked to define computer science, to compare stereotypes and the public perception of CS with their own perceptions of CS students at CMU, to list famous CS professionals (real and fictional), and to share any thoughts as to why there has been an enrollment decline in recent years. The fourth section of the survey inquired about participants' experiences at CMU. Questions were included that inquired about why the participants chose to study CS at CMU, experiences with CS required courses (e.g., difficulty level, amount of time required in courses, and experiences with the Freshmen Immigration course). Participants were also asked to share their plans for post-college life (graduate school or work interests). The final section of the survey included several multiple-choice questions on a variety of cultural experiences in the CMU CS department. The format of these questions asked students to rank their responses to various statements and also invited them to comment on their choices. The choices ranged from strongly agree, to agree, to unsure, to disagree and to strongly disagree. Additionally, since some questions were predicated on considerable experience at CMU (e.g., "Name one thing that you know about CS that you didn't know when you entered as a freshman?") a separate survey with similar design was created for freshman.

The survey was used to gather a breadth and depth of information about the experiences of CMU CS students. Ultimately we wanted to see if we were sustaining a CS culture in which students felt they fit. In this sense, the

[13] See the CREU website for more details: http://www.cra-w.org/creu.

questions were both open-ended/qualitative and quantitative in nature in order to elicit a rich set of responses from the participants. Over 35 questions were included on the survey and focused on a variety of constructs: experiences and reasons for selection of a CS degree of study (individual background and high school experiences), experiences in the cultural environment of the CMU CS department, views of the CS field and career plans. Hence, a variety of questions were used to gather information on each area of construct of focus. In this article, we investigate a subset of the data collected to focus specifically on cultural factors of faculty approachability, environment, social fit, academic fit, and ingredients for success in the CMU CS department.

Participant Demographics

The core classes in the CS curriculum were targeted in order to deliver the survey and collect as much data as possible. Only undergraduate students with CS listed as their primary major were allowed to take the survey. Given the distribution across years of study we decided to separate the data into three groups: all students in cohort, freshmen, and upperclassmen (i.e. sophomores through seniors). The CS freshmen were very easy to reach through the CS immigration course which they are all required to take. The upperclassmen, on the other hand, were more difficult to reach as they are spread out among classes. Nevertheless we were pleased with the response rate and managed to collect a considerable amount of data.

The survey was given to 110 out of 131 total CS freshman and 149 out of 456 total CS upperclassmen and we were able to collect 259 survey responses. Hard-copy surveys were distributed and collected. The surveys results were then manually translated into electronic form. The participants included represent both men and women from all years of study. The sample represents approximately 46% of undergraduate CS males and 52% of undergraduate CS women. The table below shows the total number and percentage of participants by year of study and gender (Table 1).

Findings 2009–2010 Case Study

We collected and analyzed a significant amount of data from the undergraduate surveys, most relating to the micro-culture of the CS department, some relating to pre-CMU experiences. We were delighted to find that most men and most women were feeling comfortable in the school, and felt they could be successful in the CS environment at CMU and that they fit in socially and academically. In brief, we did not see any evidence of a strong gender divide in student attitudes towards fitting in or feeling like they could be successful; indeed we found that the Women-CS fit was still going strong. The remainder of this section summarizes our results of the following components: social fit, academic fit, the CMU environment, factors relating to academic success, perceptions of performance, leadership, teamwork, and challenging the stereotypes.

Social Fit

The need for social belonging—or for seeing oneself as socially connected—is a basic human motivation (e.g., Baumeister and Leary 1995; Walton and Cohen 2007). Indeed, a sense of social connectedness can predict favorable outcomes such as intellectual achievement, feeling respected, and compliance with authority figures. Hence, in our previous studies (2002 and 2004) we asked students to comment on whether or not they felt they fit in socially. Continuing in this vein the new study asked students to respond to the statement: "Overall, I feel like I fit in socially" (See Fig. 3). We found that 30% of the women in our cohort and 23% of the men *strongly agreed* with the comment. Only one woman disagreed and no women strongly disagreed. Indeed, 86% of the women either strongly agreed or agreed with the statement while 75% of the men strongly agreed or agreed. Clearly, the women in our cohort felt like they had a good social fit. The positive comments from students on their social fit often related to having "lots of friends" and conversely the negative comments related to having "no friends." However, the most common responses were about finding "people like

Table 1 Participant demographics

Year	# of participants	% of participants	# of female participants	% of female participants	# of male participants	% of male participants
Freshman	110	42	31	53	79	39
Sophomore	48	19	7	12	41	20
Junior	60	23	11	19	49	24
Senior	41	16	9	16	32	16
Total	**259**	**100**	**58**	**100**	**201**	**100**

Total values are in bold for emphasis

me," people with "similar mindsets" and "similar interests." One woman commented that "we're all geeks" while another said "I used to not fit in until I came here."

When we looked at the freshmen and the upperclassmen separately we found positive indicators that as women moved through the program their sense of strong social fit increased dramatically, from 15 to 42%. The upperclasswomen also appeared to be less unsure and no women disagreed or strongly disagreed with the comment. For the male students, the responses were fairly consistent throughout (see Table 2).

Academic Fit

Researchers also explain that perceptions of academic fit are important considerations in students' decision to pursue or remain in a CS degree program. Further, a lack of perceived fit may lead to decreased performance, increased attrition rates and lack of identification with the field (e.g., Beyer et al. 2003; Cheryan et al. 2009; Steele 1997). Hence, in our previous studies we also asked students about their academic fit. This time we asked students to respond to the statement: "Overall I feel like I fit in academically" (See Fig. 4). Although fewer women than men agreed or strongly agreed with the statement we still found that most

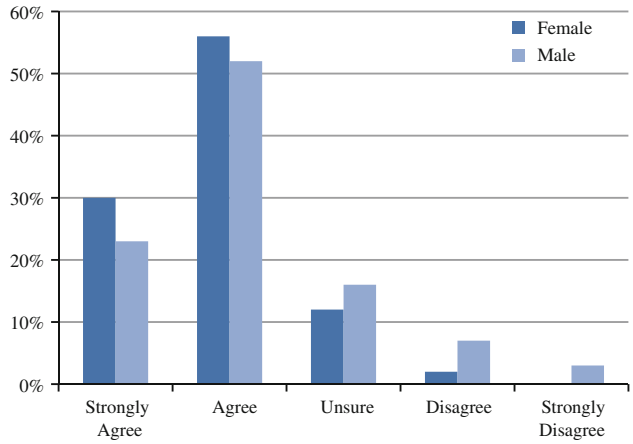

Fig. 3 Percentage response of all students in cohort by gender to multi-choice statement: "Overall, I Feel Like I Fit in Socially"

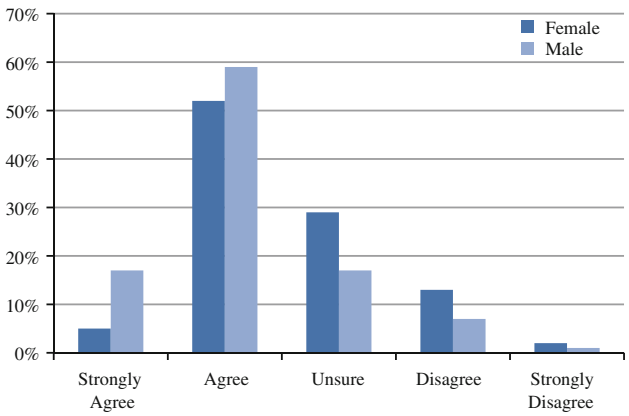

Fig. 4 Percentage response of all students in cohort by gender to multi-choice statement: "Overall I Feel Like I Fit in Academically"

Table 2 Responses by gender to multi-choice statement: "Overall, I Feel Like I Fit in Socially"

	% of females	% of female freshmen	% of female upperclassmen	% of males	% of male freshmen	% of male upperclassmen
Strongly agree	30	15	42	23	24	23
Agree	56	65	48	52	54	50
Unsure	12	15	10	16	16	16
Disagree	2	4	0	7	4	8
Strongly disagree	0	0	0	3	3	3

Table 3 Responses by gender to multi-choice statement: "Overall I Feel Like I Fit in Academically"

	% of females	% of female freshmen	% of female upperclassmen	% of males	% of male freshmen	% of male upperclassmen
Strongly agree	5	3	8	17	12	20
Agree	52	40	65	59	52	63
Unsure	29	40	15	17	26	12
Disagree	13	17	8	7	9	5
Strongly disagree	2	0	4	1	1	1

women, 57%, felt they had a good academic fit. The finding that fewer women than men felt sure about their academic fit may be related to the fact that far fewer women come into the CS major with any background in CS and for many entering the CS major it is a shot in the dark. Most students, men and women checked the "agreed" box, 59% men and 52% women, agreed with the statement. A number of students, 29% women and 17% men, were unsure about their sense of academic fit and expressed ambiguity in their responses. This woman commented: "Sometimes I feel too smart, sometimes too dumb," while another woman said: "I sometimes feel like I don't know as much as others, but then I find others." Such ambiguity also appeared in some of the men's comments: "(I'm) ahead in some things, behind in others," while another man said: "There is a set of people who are wildly better than me, but a much larger set of those I beat academically." Both men and women commented that the CS major is "hard, demanding." We found a strong gender similarity in such comments: one freshman female said "It's hard but mostly doable," while a male freshman said "It's hard but I can handle it."

When we looked at the freshmen and the upperclassmen separately one striking result was that in their freshmen year 40% of the women felt unsure about fitting in academically but in subsequent years this dropped to 15%. We also saw a

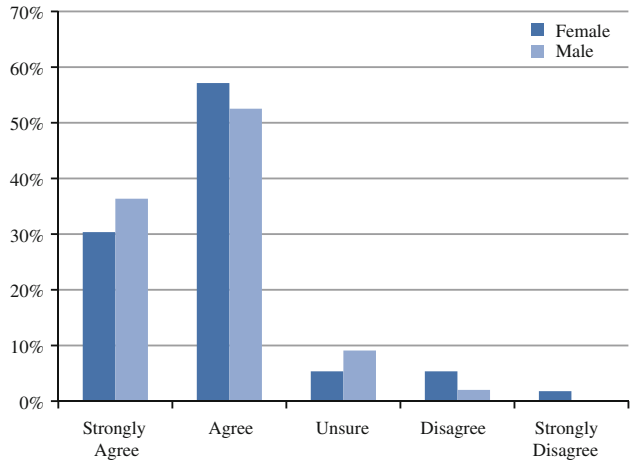

Fig. 5 Percentage response of all students in cohort by gender to multi-choice statement: "The Environment at CMU Provides Me with Everything I Need To Succeed"

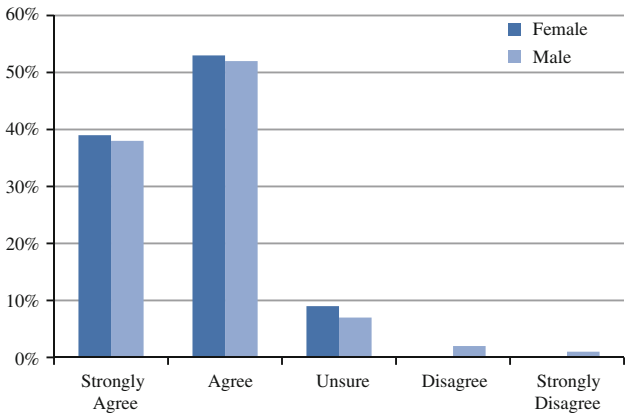

Fig. 6 Percentage response of all students in cohort by gender to multi-choice statement: "I Know People I Can Ask for Help if I'm Struggling with an Assignment"

Table 4 Responses by gender to multi-choice statement: "The Environment at CMU Provides Me with Everything I Need To Succeed"

	% of females	% of female freshmen	% of female upperclassmen	% of males	% of male freshmen	% of male upperclassmen
Strongly agree	30	33	27	36	42	33
Agree	57	60	54	53	47	56
Unsure	5	3	8	9	10	8
Disagree	5	3	8	2	1	2
Strongly disagree	2	0	4	0	0	0

Table 5 Responses by gender to multi-choice statement: "I Know People I Can Ask for Help if I'm Struggling with an Assignment"

	% of females	% of female freshmen	% of female upperclassmen	% of males	% of male freshmen	% of male upperclassmen
Strongly agree	39	42	35	38	40	36
Agree	53	52	54	52	51	53
Unsure	9	6	12	7	5	8
Disagree	0	0	0	2	4	1
Strongly disagree	0	0	0	1	0	2

drop in uncertainty on the part of the men even though it was not quite as dramatic from 26 to 12% (see Table 3).

The CMU Environment

Since we propose that factors relating to culture and environment play a major role in determining a Women-CS fit, we were particularly interested in the responses relating to specific questions about the environment at CMU. To gain insight into how students felt about the environment at CMU we asked them to respond to this comment: "The Environment at CMU provides me with everything I need to succeed" (See Fig. 5). We received very positive responses with 87% of the women and 89% of the men in our cohort either strongly agreeing or agreeing with the comment. These responses showed a very strong gender similarity among students in our cohort in how they felt about the CMU environment. The qualitative data also supported these findings. For example, one female shared that "I have different groups of friends in every class, and I never really feel alone." Another male student explained "I'm a nerd, but I'm social. There are several people here like that."

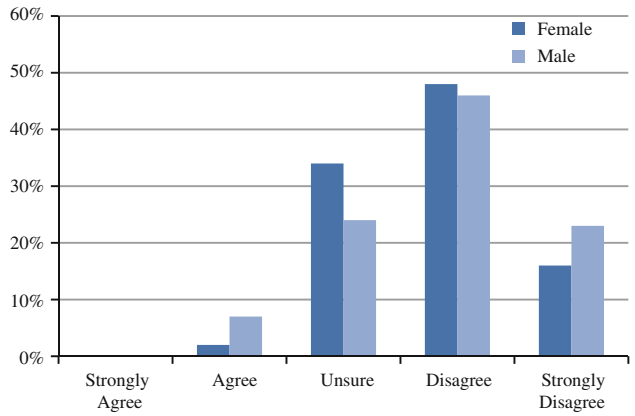

Fig. 7 Percentage response of all students in cohort by gender to multi-choice statement: "The Professors at CMU are not Approachable"

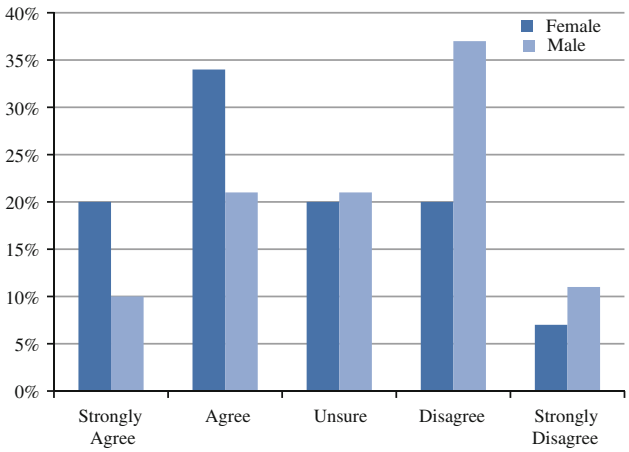

Fig. 8 Percentage response of all students in cohort by gender to multi-choice statement: "I Feel Like Everyone I Know Performs Better Than I Do"

Table 6 Responses by gender to multi-choice statement: "The Professors at CMU are not Approachable"

	% of females	% of female freshmen	% of female upperclassmen	% of males	% of male freshmen	% of male upperclassmen
Strongly agree	0	0	0	0	0	0
Agree	2	3	0	7	5	8
Unsure	34	47	19	24	25	24
Disagree	48	40	58	46	50	43
Strongly disagree	16	10	23	23	20	25

Table 7 Responses by gender to multi-choice statement: "I Feel Like Everyone I Know Performs Better Than I Do"

	% of females	% of female freshmen	% of female upperclassmen	% of males	% of male freshmen	% of male upperclassmen
Strongly agree	20	23	15	16	14	7
Agree	34	37	31	33	25	18
Unsure	20	17	23	33	21	21
Disagree	20	17	23	59	35	39
Strongly disagree	7	7	8	17	5	15

When we looked at the freshmen and the upperclassmen separately there were no dramatic differences between the two groups and overall the responses were very positive and similar between men and women (see Table 4).

Factors Relating to Academic Success

Prior research demonstrates that faculty attitudes and behaviors, and institutional context can have a substantial effect on whether women leave the undergraduate CS major at higher rates than men (e.g., Bettinger and Long 2005; Cohoon 2001; Kumar and Morris 2005; Strenta et al. 1994; Wood et al. 2011). Two other statements gave students the opportunities to respond to factors relating to academic success: "I know people I can ask for help if I'm struggling with an assignment" (See Fig. 6) and "The professors at CMU are not approachable" (See Fig. 7). In response to the statement "I know people I can ask for help if I'm struggling with an assignment" once again we received very positive responses with 91% women and 92% men agreeing or strongly agreeing that they had someone to turn to for help. When we looked at the freshmen and the upperclassmen separately we found there were little differences among the cohorts. For instance, no woman (freshman or upper classman) disagreed or strongly disagreed with the statement. Likewise, only 4% of the

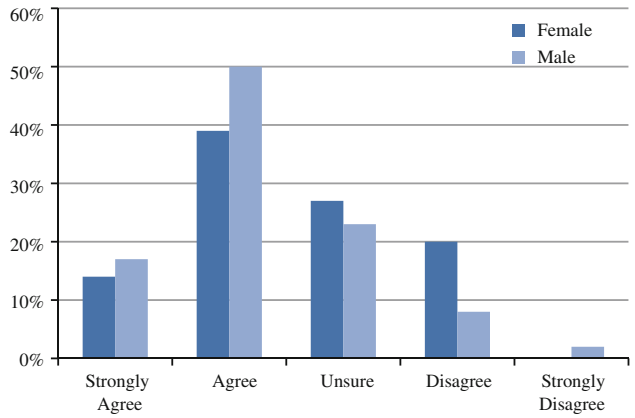

Fig. 9 Percentage response of all students in cohort by gender to multi-choice statement: "I Feel Comfortable Taking a Leadership Role"

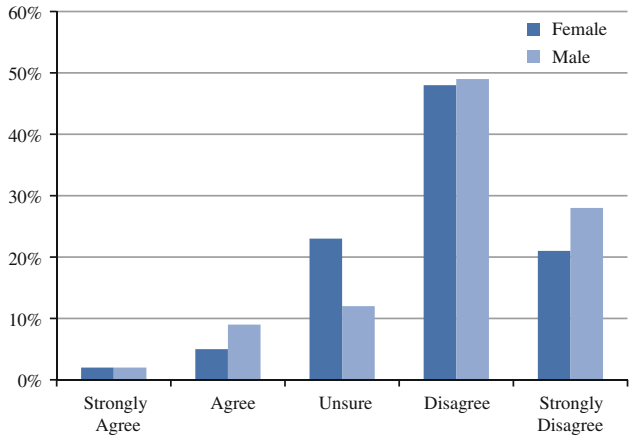

Fig. 10 Percentage response of all students in cohort by gender to multi-choice statement: "Teamwork Makes Me Nervous"

Table 8 Responses by gender to multi-choice statement: "I Feel Comfortable Taking a Leadership Role"

	% of females	% of female freshmen	% of female upperclassmen	% of males	% of male freshmen	% of male upperclassmen
Strongly agree	14	0	31	17	10	21
Agree	39	37	42	50	44	54
Unsure	27	43	8	23	27	21
Disagree	20	20	19	8	17	3
Strongly disagree	0	0	0	2	1	2

Table 9 Responses by gender to multi-choice statement: "Teamwork Makes Me Nervous"

	% of females	% of female freshmen	% of female upperclassmen	% of males	% of male freshmen	% of male upperclassmen
Strongly agree	2	0	4	2	1	3
Agree	5	3	8	9	10	8
Unsure	23	23	23	12	13	11
Disagree	48	53	42	49	52	48
Strongly disagree	21	20	23	28	23	31

male freshman and 3% of the male upper classman disagreed or strongly disagreed with the statement (see Table 5). The qualitative data also supported these findings. For example, one female shared that "I feel comfortable speaking up in class and asking questions." Another male student stated "I feel challenged without feeling overwhelmed."

Students, both men and women, clearly felt that professors were approachable, with 64% women and 69% men disagreeing or strongly disagreeing with the statement: "The professors at CMU are not approachable." Responses to both of these statements illustrated a very strong gender similarity among our cohort. When we looked at the freshmen and the upperclassmen separately we found that the female freshman were more unsure about faculty approachability than the male freshman, with 47% of the women compared to 25% of the men. For instance, one male participant felt "everyone is helpful and friendly." The figures for faculty approachability are more equal among upperclassmen with 19% of the upperclasswomen feeling unsure and 24% of the male upperclassmen feeling unsure. This may indicate that as women move through the program they gain more experience and confidence in approaching faculty (see Table 6).

Perceptions of Performance

Studies have found that students' confidence has direct effects on their likeliness to challenge themselves in courses, research, and graduate education (e.g., Barker and Garvin-Doxas 2004; Beyer et al. 2002; Irani 2004). Not all responses showed such a strong gender similarity, indeed responses to the statement "I feel like everyone I know performs better than I do" showed that men seemed much more confident about their performance and women were twice as likely as men to strongly agree with the statement. The percentage of men who agreed or strongly agreed with the statement was 31% while for women it was 54%. An almost equal number of men and women felt unsure: 20% women and 21% of the men (See Fig. 8). The qualitative data also supported these findings. For example, a female students stated "sometimes I feel too smart, and other times too dumb." Another female student shared that "[Carnegie Mellon University] is a very competitive school, sometimes it's hard to keep up." Whereas many of the male students shared experiences like "I can keep up with classes," "I do well enough" or "I seem to be keeping up."

When we looked at the freshmen and the upperclassmen separately we found similar improvements in their perceptions of performance. By the time students reached sophomore through senior levels 46% of the women strongly agreed or agreed with the statement compared to 60% of the female freshmen. For the men the responses were 25% for upperclassmen and 39% for freshmen (see Table 7).

In general the responses indicated a positive shift for the women as they gain in experience and receive more feedback about their own performance and the performance of their peers. But overall, as many other studies have shown, men were still far more likely to admit to higher confidence levels than the women. We also suggest that in the predominant culture of the USA it is less gender appropriate for women to express a sense of confidence than it is for men since the general cultural message they have been subjected to is that women's self-esteem and confidence are lower than men's.[14] Our students' attitudes, while shaped by the micro-culture of the department, are not isolated from broader, prevailing cultural messages.

Leadership

Opportunities to build leadership skills are an important area of skill building in computer science education. Likewise, an educational context where men and women feel comfortable holding leadership roles is an indicator of a positive climate. Beyer et al. (2004) explains that a lack of these opportunities may be a deterrent to pursuing a degree in CS. Another statement which we interpreted as relating to confidence levels was "I feel comfortable taking a leadership role" (See Fig. 9). The percent of "strongly agree" responses and the percent of "unsure" responses were similar from both men and women. However, when we added strongly agree and agree together to get an overall picture, men appeared to feel far more confident than women with 67% of the men to 53% of the women indicating they felt comfortable about leadership ability.

When we looked at the freshmen and the upperclassmen separately we found an increase in perceptions of leadership ability in both men and women as they moved through the program. However, the increase was particularly dramatic for women who jumped from 37% in their freshmen year to 73% in sophomore through senior years (strongly agree or agree; see Table 8).

Teamwork

As with leadership skills, opportunities to build teamwork skills are an important area of skill building in computers science education. Beyer et al. (2004) adds that a lack of these opportunities may also be a deterrent to pursuing a

[14] Two examples of this cultural message are Peggy Orenstein's *Schoolgirls: Young Women, Self Esteem, and the Confidence Gap,* Anchor, 1995 and the AAUW Report *Shortchanging Girls, Shortchanging America*, AAUW 1991.

degree in CS. Gender similarities were very strong in response to the statement "Teamwork makes me nervous" (see Fig. 10). Most students, men and women appear to feel comfortable with team work, with 48% of the women and 49% of the men *disagreeing* with the statement. The majority of female and male students did not feel nervous with regard to their teamwork abilities or responsibilities. For example, 69% of the female students and 77% of the male students *disagreed or strongly disagreed* with the statement "teamwork makes me nervous." The qualitative data also supported these findings. For example, one female student shared "people are friendly; it is an environment of teamwork rather than competition."

When we looked at the freshmen and the upperclassmen separately we found that the responses remained fairly consistent across cohorts. For example responses from female freshmen showed 73% *disagreed or strongly disagreed* 73% while 75% of the male freshmen 75% *disagreed or strongly disagreed* (see Table 9).

Challenging the Stereotypes

Many researchers have found stereotypes of CS (namely, that it is a boring subject, devoid of interesting applications and stimulating only to 'geeks') can have a dramatic impact on students' decisions to pursue or remain in the CS field (e.g., Frieze 2005; Graham and Latulipe 2003). We found that many undergraduates in the CS major at CMU continue to challenge CS stereotypes by showing they are very social and interested in activities beyond their CS studies. CS students at CMU agree that some geeky stereotypes do apply but generally they describe themselves as a "wide range of different people," "hard working, normal students," "nerdy," "diverse," "more well-rounded than average," "usually social," "some computer obsessed, some normal." One male suggested CS students are "awesome and strange," while one female student said "some are awesome, others are awkward." Overall they appear to admire and respect each other's characteristics, the "coolest group of people ever."

Conclusion

> In the classroom, studio, laboratory, office and dormitory, a multitude of experiences, perspectives and beliefs will enrich all that we do. – CMU President Jared L. Cohon's Statement on Diversity[15]

At Carnegie Mellon University we have the advantage of being able to examine the attitudes of undergraduates to CS both *pre and post 1999*, the year when some critical initiatives came into play. These initiatives led to changes in the CS department, gradually displacing the older homogenous culture and unbalanced environment. From 1999 onwards the department moved towards balance in three important domains—improved gender balance, a more broad ranging student body, and professional support for women—all of which contributed to the development of a more inclusive and diverse culture.

Our research studies set out to examine student attitudes in the context of this culture and more balanced environment and to compare them with findings from the pre-1999 studies.[16] Findings from our 2002 and 2004 studies revealed many gender similarities and a spectrum of attitudes towards CS rather than the gender divide found in *pre*-1999 studies. Our latest study, 2009–2010, set out to examine if the culture of computing in the CS department at CMU is still working for the benefit of all students, men and women. In this investigation we considered a range of cultural factors including faculty approachability, environment, social fit, academic fit, and ingredients for success. Our findings endorse the 2002 and 2004 findings showing that an inclusive culture still prevails and that the Women-CS fit has been sustained without accommodating presumed gender differences. One particularly significant finding is that the experiences of women become more and more positive as they progress through the program. We attribute this outcome not only to their academic ability and performance but also, in part, to their own contributions as they help shape the environment and computing culture, for the benefit of everyone.

Our findings lead us to argue that attitudes towards CS are not deep rooted, nor are they specific to one gender or another but rather are largely determined by factors within the culture and environment. We have been able to relate the post-1999 changes in student attitudes to factors outside of gender, including faculty approachability, environment, social fit, academic fit, and ingredients for success. These factors appear to be positively related to a Women-CS fit and to conditions that work well for diversity, for both men and women. *The implications of our findings are that to promote the participation of women in computing our attention should be focused on cultural change and conditions in the environment, not on gender and gender differences*.

The culture of a department is largely determined by its members and by the direction of its leadership. CMU is top-ranked in CS and has several thousand applications (over 3,000 in 2011) for the 150 places in the CS major. This situation, along with its broad admissions policy, helps

[15] See http://www.hr.web.cmu.edu/drg/overview/statement.html.

[16] We plan to continue our investigations over the next few years using surveys and in-depth interviews as data collection tools.

ensure that the CS major includes a critical mass of smart young women many of whom have strong leadership potential, and thus the potential to impact the culture of the department alongside their male peers. The school also has leadership committed to diversity and provides line-item resources to ensure that women do not miss out. We acknowledge that such conditions may not all be replicable elsewhere. At the same time, the culture of computing in many CS departments is changing as CS education has broadened to encompass the ever growing breadth of the field. This situation would appear to lend itself to addressing factors in departmental culture and environment.

If our aim is to increase diversity in CS we need to move beyond old models of research which continue to re-present men and women as two distinct categories with either a male or a female view on CS and no reference to the context or situation in which such views are formed. The idea that men are not interested in the broader applications of CS and that women do not like programming has become an outdated cliché. Men and women are multi-dimensional, capable of a cross-gender spectrum of perspectives as they discover and respond to the exciting field of CS studies and the environments in which they work and socialize.

It is clear that the gender difference model is intrinsically divisive and has not served the interests of women or the field itself. Indeed, we believe that focusing on gender alone without attention to cultural factors, and on gender differences in particular, can perpetuate stereotypes and further marginalize women. Gender difference approaches have not provided satisfactory explanations for the low participation of women in CS and beliefs in a gender divide may deter women from seeing themselves in male dominated fields. We strongly believe that without due caution the search for gender differences can work against diversity and inclusion efforts.

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