THE CRITICAL ROLE OF CULTURE AND ENVIRONMENT AS DETERMINANTS OF WOMEN'S PARTICIPATION IN COMPUTER SCIENCE

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This thesis is dedicated to my loving parents, Vera and Harry Gregory, and to my precious granddaughter, Maisie.

THESIS ABSTRACT

The Critical Role of Culture and Environment as Determinants of Women's Participation in Computer Science

This thesis proposes the need for, and illustrates, a new approach to how we think about, and act on, issues relating to women's participation, or lack of participation, in computer science (CS). This approach is based on a cultural perspective arguing that many of the reasons for women entering –or not entering– CS programs have little to do with gender and a lot to do with environment and culture. Evidence for this approach comes primarily from a qualitative, research study, which shows the effects of changes in the micro-culture on CS undergraduates at Carnegie Mellon, and from studies of other cultural contexts that illustrate a "Women-CS fit". We also discuss the interventions that have been crucial to the evolution of this specific micro-culture.

Our argument goes against the grain of many gender and CS studies which conclude that the reasons for women's low participation in CS are based in gender --and particularly in *gender differences* in how men and women relate to the field. Such studies tend to focus on gender differences and recommend accommodating (what are perceived to be) women's different ways of relating to CS. This is often interpreted as contextualizing the curriculum to make it "female-friendly".

The CS curriculum at Carnegie Mellon was not contextualized to be "female-friendly". Nevertheless, over the past few years, the school has attracted and graduated well above the US national average for women in undergraduate CS programs. We argue that this is due in large part to changes in the culture and environment of the department. As the environment has shifted from an *unbalanced* to a more *balanced environment* (balanced in terms of gender, breadth of student personalities, and professional support for women) the way has been opened for a range of students, including a significant number of women, to participate, and be successful, in the CS major. Our research shows that as men and women inhabit, and participate in, a more balanced environment, perceived gender differences start to dissolve and *we see men and women displaying many gender similarities in how they relate to CS.*

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CONTENTS

SOME IMPORTANT DEFINITIONS

In this thesis we use some concepts which are open to various interpretations as evidenced by the many dictionary definitions. Here we include brief explanations for a few terms in order to clarify the way in which we are using them.

Culture:

We are using the term *culture* to refer to the complex and broad set of relationships, values, attitudes and behaviors that bind a specific community together, consciously and/or unconsciously.

Our definition also posits that culture is bound by context and history and that we are born into specific cultures with prevailing values and structures of opportunity. Most importantly, our definition of culture emphasizes that culture *allows for change*. It is dynamic, *shaping and being shaped by those who occupy it*. We see culture as a synergistic diffusive process.

Micro-culture:

We use the term *micro-culture* to refer to a localized culture: a set of relationships, values, attitudes and behaviors specific to a particular group within a broad culture. While a broad, dominant culture may embrace and influence an entire community, micro-cultures may exhibit some features which are quite distinct from the broader culture.

When we use the term micro-culture we often are referring specifically to the localized culture that prevails within the Computer Science (CS) Department at Carnegie Mellon.

Gender:

We are using the term *gender* to refer, in addition to biology, to the roles, behaviors, attitudes, etc., attributed to men and women as they are born into specific cultures and moments in history. Thus, our working definition of gender *embraces the complex dynamics of both natural and cultural factors and influences*.

Environment:

We use the term *environment* to refer to physical surroundings, atmosphere and conditions. In the case of this thesis the environment most often referred to is that of the Computer Science Department at Carnegie Mellon. We see environments as appropriate sites for interventions and opportunities.

"Women-CS fit":

We first coined the expression Women-CS fit in a 2006 paper [Frieze et al, 2006] to refer to the situation in which women fit into the CS micro-culture, contribute to it and are successful in the field alongside their male peers and without compromises to academic integrity.

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PREFACE

The argument for this thesis has developed over several years but gained impetus in 2002 when, with a grant from the Sloan Foundation, we conducted an interview study with a group of Carnegie Mellon CS seniors just prior to their graduation. We were particularly interested in this group because they were a class in "transition"; this class and the classes ahead of them had very few women students, while the classes behind them had a very good gender balance. We had also been somewhat baffled by the disparity between the successful women students we were seeing in our department, women who appeared to have a very good CS fit, and the dismal picture of women's experiences as portrayed in previous studies carried out at Carnegie Mellon [ibid.]. The latter also seemed to match the broader representation of women in CS across the nation, i.e. women showing declining participation and feeling like they did not fit the computing culture. Evidently there had been some dramatic changes with regards to the Women-CS fit at Carnegie Mellon, changes which were contributing to a successful outcome for all students – women and men. Our findings from the 2002 interviews [Blum and Frieze, 2005b] were confirmed by external evaluators who set out initially in search of gender differences (the traditional approach of many social scientists) and instead found *a range of similarities and differences* in students' attitudes towards CS [Larsen and Stubbs, 2005]. Clearly the situation in 2002 called for further research, research that could well have crucial implications for women's participation in CS.

THESIS SUMMARY

THE CRITICAL ROLE OF CULTURE AND ENVIRONMENT AS DETERMINANTS OF WOMEN'S PARTICIPATION IN COMPUTER SCIENCE

This thesis proposes the need for, and illustrates, *a new approach to how we think about, and act on, issues relating to women's participation in CS*. This new approach is based on *a cultural perspective* arguing that many of the reasons for women entering and being successful in CS programs have little to do with gender and a lot to do with culture and environment. Research evidence for this approach comes primarily from a qualitative case study based on interviews with CS undergraduates in the class of 2004 at Carnegie Mellon. Further evidence for our argument is drawn from studies of other cultural contexts that illustrate a Women-CS fit, as well as from gender similarities research, and from studies of gender myths and stereotypes.

Specifically, findings from our 2004 case study at Carnegie Mellon will illustrate that under certain conditions women can fit into CS and relate to CS in ways that are very similar to their male peers. We will show that *a balanced environment allows for changes in the micro-culture* (i.e. culture at the localized departmental level) *such that perceived gender differences in how students relate to CS start to dissolve*. We will discuss the interventions and changes that have allowed for gender similarities to emerge and for a Women-CS fit. By the latter we mean a situation in which women participate, contribute, and are successful, in the CS major alongside their male peers without any compromise to academic integrity.

The concept of a *more balanced environment* is critical to our argument. From 1999 onwards the CS environment became more balanced in three major domains: in terms of students with breadth of personalities and interests, in terms of gender, and in terms of professional support for women to reflect implicit professional support for the majority.

With regards to *balance in terms of student personalities and interests:* in 1999 Carnegie Mellon adopted *a broadened admissions policy* for the CS major, emphasizing leadership potential and diverse interests along with high achievement in mathematics and science while de-emphasizing prior programming. The new admissions criteria not only opened the doors to more women but also to many men who did not fit the programming-focused personality that had been dominant in previous years. From 1999 onwards the CS department started to see more men and women with breadth of interests and personalities. Thus, the students we interviewed for our case study, from the class of 2004, had experienced their school years among a more diverse student body.

With regards to *gender balance*: the students in our 2004 case study enrolled in 2000 in a class with 39.5% women and continued throughout their CS studies with at least one third women in the undergraduate student body as a whole. Prior to 1999 the women in the student body comprised well below 20%, indeed most of the time below 15%. In contrast, the students we interviewed from the class of 2004 had experienced a much improved gender balanced environment.

With regards to *balance in relation to professional support for women:* the organization *Women@SCS* was established in 1999 to ensure that the increased numbers of women entering the CS major could thrive and have the professional and social opportunities (e.g. peer advice, mentoring and networking), often taken for granted by those in the majority.

Thus, during their school years, the students in our case study, the class of 2004, experienced a more balanced environment overall than students in CS at Carnegie Mellon prior to 1999. This is significant because research findings from our case study will show that when men and women are exposed to a more balanced environment, many of the perceived gender differences noted in early 1995-1999 research studies at Carnegie Mellon [Margolis and Fisher, 2002] are not in evidence and instead *we see men and women displaying many gender similarities in how they relate to CS*.

The argument we present goes against the grain in terms of many gender and CS studies (including the one done at Carnegie Mellon 1995-1999), which conclude that the reasons for women's low participation in CS are based in gender --and particularly in *gender differences* in how men and women relate to the field. Such studies tend to focus on finding gender differences and on strategies to accommodate (what are perceived to be) women's different ways of relating to CS. One example is the recommendation to contextualize the curriculum to make it "female-friendly" to increase women's participation in the field.

However, the curriculum at Carnegie Mellon was not contextualized on behalf of women. The CS program continues to rank among the top undergraduate programs in CS in the USA and over the past few years has attracted and graduated well above the US national average of women in undergraduate CS programs. We argue that this success is due in large part to the school's commitment to pay attention to the micro-culture and environment of the department, and to ensure that structures of opportunity are *available to all*. Indeed, over the past few years, we have witnessed the evolution of a new culture of computing at Carnegie Mellon.

This thesis provides unique and compelling evidence to support the argument that culture and environment, not gender differences, are primary determinants of women's participation in CS. Findings from our case study, and our argument for new research paradigms, will be of interest to a broad audience and will have important implications for the future of the field –and particularly for broadening participation in CS education.

THE CRITICAL ROLE OF CULTURE AND ENVIRONMENT AS DETERMINANTS OF WOMEN'S PARTICIPATION IN COMPUTER SCIENCE

CHAPTER ONE: INTRODUCTION, RESEARCH ISSUES, & METHODOLOGY

Chapter Overview: In **Section 1** of this chapter we introduce our thesis argument proposing that *women's participation in computer science (CS) is determined largely by culture and environment* and not by gender characteristics. We present an overview of the issues relating to women and CS, including why these issues have broad implications for the field. We suggest that traditional approaches addressing women's declining participation in CS have limitations and may have become part of the problem itself. Thus, we propose *an alternative research paradigm* which places gender under the umbrella of culture and shows that by taking a cultural perspective we can open the way for a Women-CS fit. To support our position we refer briefly to our primary research findings from a 2004 case study based on interviews with CS undergraduates at Carnegie Mellon. We also refer to a range of other cultural evidence. This evidence and our research findings will be revealed in later chapters. In **Section 2** we present the methodology for our research: an ethnographic, qualitative case study which included a total of 55 interviews with CS seniors at Carnegie Mellon. We discuss the methods used for participant sampling, for data collection and analyses, and for verifying our findings. The research aimed at furthering our understanding of how a cohort of seniors from the class of 2004 perceived their relationship to CS. Most importantly, we wanted to examine the effects of some post-1999 interventions. Had they, as we believed, allowed for changes in the culture of computing, changes which improved women's participation in CS at Carnegie Mellon?

Section 1: Introduction and Research Issues

> "When men and women are in similar situations, operating under similar expectations, they tend to behave in similar ways".
>
> [Rosabeth Moss Kanter, 1977]

> "Boys and girls have similar psychological traits and cognitive abilities; thus, a focus on factors other than gender is needed to help girls persist in mathematical and scientific career tracks".
>
> [Janet Shibley Hyde and Marcia C. Linn, 2006]

In the past few years we have been observing what we believe to be the evolution of a new culture of computing at Carnegie Mellon, Pittsburgh. This thesis uses a cultural perspective to show that as the environment has shifted from an *unbalanced* to a more *balanced environment* the way has been opened for women to participate, contribute, and be successful, in the CS major. Our research findings show that interventions 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.

1.1. A New Perspective on Women's Participation in CS. This thesis, while acknowledging prior efforts and shared concerns, proposes the need for, and illustrates, *a new approach to how we think about, and act on, issues relating to women's participation in CS and computing related fields*[1]. The approach we propose is based on a cultural perspective arguing that many of the reasons for women entering and being successful in the field of computer science *have little to do with gender and a lot to do with environment and culture.* Evidence for this approach comes primarily from a case study at Carnegie Mellon, grounded in qualitative research, and based on interviews with CS undergraduates in the class of 2004.

Our focus on the critical role of culture and environment provides an alternative viewpoint to those arguments that suggest women need academic handholding, such as a "female friendly" curriculum, in order for them to participate and be successful in CS and related fields. This is also an alternative viewpoint to those arguments that suggest we need to change the field to suit women or help women adjust to the field. The argument of this thesis shows none of these may be necessary. We believe that findings from this thesis will be of interest to a broad audience and will have implications for the future of the field.

[1] The case study presented in this thesis would mostly be considered within the realm of *traditional* or *core* computer science, although such definitions are still under debate. We are using the term "computing related fields" to refer to such areas as e.g. Information Sciences, Information Networking, which may be outside of core computer science, but have some relevance to this argument.

1.2. Women's Low Participation in CS: A National Issue. The failure to attract and retain women in CS in the USA, and in other "developed nations", has grown over the past few years into an issue of national concern. The issue has stimulated widespread attention from government agencies, from industry, and from academia, all calling for answers to such fundamental questions as why does this situation exist and what can be done about it? Yet in spite of a general agreement that the nation needs more women in the field, and numerous studies and ensuing recommendations to address these issues, *the problem persists and is getting worse:* "Computer science has the dubious distinction of being the only science field to see a fall in the share of its bachelor's degrees granted to women between 1983 and 2002" [CRA Bulletin May 4, 2006]. The 2004-2005 Taulbee survey shows that the percentage of CS bachelors' awarded to women has dropped "from 17.0% in 2003-04 to 14.7% in 2004-05" [Taulbee Survey, 2004-2005].

> "Unlike most other fields, which have seen women's representation increase over time, the portion of CS degrees granted to women fell in the late 1980s and has yet to return above 30 percent. With a fall in degree production looming, it is difficult to see how CS can match expected future demand for IT workers without raising women's participation at the undergraduate level" [Vegso, 2005].

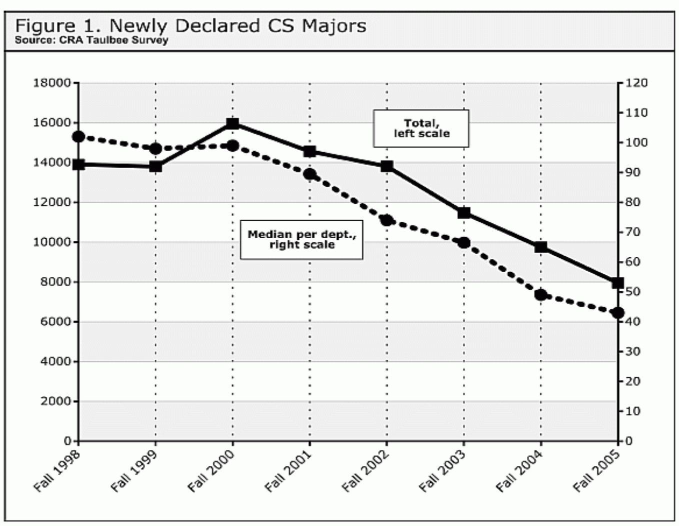
1.3. The Value of Diversity. Increasing the participation of women in CS in the USA has been recognized as critical on several levels, ranging from moral arguments for fairness to acknowledging a national economic need. Women make up more than half of the population of the country, and are now graduating with more bachelor's degrees than men. Clearly, the potential is there, and yet women are missing out on job opportunities in what is probably the fastest growing field in the nation.[2] While girls and women in the USA have caught up with boys and men as *users of technology*, they lag behind their male counterparts as the more lucrative *producers of technology* [Huyer, 2006]. The large technology industries are now making great efforts to recruit women and minorities to

[2] See Vesgo 2005. Also contrary to popular myths that technology jobs are being outsourced the Bureau of Labor Statistics "estimates that the number of new IT jobs will increase at more than twice the rate of total new jobs between 2004 and 2014 (30.5 percent versus 13 percent), accounting for 1 in 19 new openings and adding a million new workers" [2006 CRA Bulletin http://www.cra.org/wp/index.php?cat=14].

bring more diverse perspectives on board, in part to design products that appeal to multiple buyers, but also because diverse teams may have the potential for increased efficiency and profits [WiST, 2006, CIPD, 2006]. In the computing fields of academia women are missing out on the intellectual challenges that the field has to offer, while the field is missing out on the intellectual input that women could contribute. Thus, it is generally agreed that the low participation of women in computer science needs to be turned around for the benefit of women, for the benefit of the field, and, with fears of the USA falling behind its competitors, for the benefit of the nation as a whole.

1.4. Implications for the Field. Evidence for our argument is now emerging from within the USA (and other developed nations), as we see a dramatic decline in the overall numbers of *both men and women* making the choice to enroll as CS majors. In Jay Vesgo's article in CRA News (Figure 1.), he reports that "(a)fter five years of declines, the number of new CS majors in fall 2005 was half of what it was in fall 2000 (15,958 vs. 7,952)" [Vesgo, 2006].

Figure 1. Newly Declared CS/CE Undergraduate Majors [Vesgo, 2006]



Clearly, the enrollment crisis in CS is not a "women's issue", although we may well find that many of the factors that have been deterring women from entering the field, may also be deterring many men too. At the same time we have found that the conditions that work well for women tend to work well for *all* in that they are more inclusive of a broader spectrum of characteristics and personalities. Currently however, in the USA we are somehow failing to attract, educate and encourage the next generations of computer scientists – *men and women*.

This situation has triggered debates and discussions within CS communities across the nation. In “The Incredibly Shrinking Pipeline Is Not Just for Women Anymore”, CS professors James Morris and Peter Lee suggest that declining numbers “are merely symptoms of deeper problems in how we educate our students. In a nutshell, our current approaches to CS education fail to teach the science of computing. As a result, they fail to inspire the very best and brightest young minds to enter the field” [Morris and Lee, 2004]. Arguably, concern for women’s enrollment preempted what is now an overall concern for the field, or as Professor Lenore Blum says “Women are the canaries in the coal mine” [Dean in New York Times, 2007]

1.5. Stereotypes and Images. These concerns, and what is now being called a “crisis” in CS, are pointing to factors outside of gender as determinants of student choices to enter the field --or not. Factors such as cultural images and in particular stereotyped images, may have particular significance. We suggest, for example, that the images of computing culture are usually confined to images *of hacking or geek culture* leading to generalizations and a limited view of the field and those who work in it. We may actually be discouraging educators and parents from seeing CS as a viable and attractive option of study for the girls and young women they influence. While unattractive stereotypes persist in our culture they shape the public view of CS. Girls and young women (and boys and young men) may not feel easily drawn to a field seemingly populated by geeky guys doing little more than coding. This is especially true if coding is perceived as an anti-social, monotonous task, rather than something that students, men and women, can actually enjoy and find challenging. In our section on stereotypes we will address this issue more fully and propose some possibilities for changing perceptions of CS, *but clearly, the image of CS as a broad and exciting field with the potential for diverse participants is missing from the big picture.*

1.6. Changes in the Micro-culture at Carnegie Mellon. The primary contribution of this thesis to gender and CS research is to offer a new direction based on a cultural perspective supported by research findings from a case study of CS undergraduates at Carnegie Mellon. This research provides unique and compelling evidence to support the argument that culture and environment, not gender differences, are primary determinants of women's contribution to CS. Our 2004 case study illustrates the evolvement of a computing culture as the environment shifted from an *unbalanced* to a more *balanced environment*. Prior to 1999, the undergraduate CS environment at Carnegie Mellon was *unbalanced* in terms of gender, the range of student personalities, and professional resources and opportunities for women. Our findings, with data collected from student interviews, show that in a more balanced environment, resulting from certain cultural and environmental conditions, men and women reveal *many gender similarities and a spectrum of attitudes in how they relate to CS rather than a gender divide.* This more balanced environment is the product of an array of factors, admissions changes, increased gender balance, students with broader interests and backgrounds, enhanced opportunities for women (in this case through the student/faculty organization *Women@SCS*), that interact in the complex processes of an evolving micro-culture.

Examining the perspectives of CS undergraduates at Carnegie Mellon allows us an exceptional opportunity to assess *change,* as we can compare findings from our 2004 case study to those of an earlier 1995-1999 Carnegie Mellon study carried out by Jane Margolis and Allan Fisher [Margolis and Fisher, 2002]. While their study found a strong gender divide in the way men and women were relating to CS, by 2004 a very different picture was emerging. This suggests that the perceived gender divide they found was a product of examining a particular kind of student body and the culture that prevailed at the time. This thesis will provide and describe evidence of change and how we can account for these changes.

Our findings show that under certain cultural and environmental conditions women can be seen to fit very well into computing fields, just as they can, and do, fit many other academic areas they may choose to study. Thus, we argue that the *different and/or similar* ways in which men and women relate to computing, are the product of a specific culture and environment, and are not produced by any deep-rooted distinctions between men and women. We argue that what has been perceived, and treated, as a gender issue, is primarily a cultural issue: an issue that concerns us all.

1.7. The Significance of Numbers and Gender Balance. The context of our case study is quite unique. In 2004, at the time of this Ph.D. research, Carnegie Mellon had attained a much improved gender balanced environment, with women students comprising around one third of the undergraduate CS student body, compared to around 18-20% across the nation in comparable schools. Since that time, in spite of the national downward trends in women's and men's applications to the CS major, the school has succeeded in maintaining a critical mass of women with numbers well above the national average. *By default,* the majority of studies addressing women's low participation in CS and *almost everything we've come to believe about women and computing (and men and computing) are the product of examining situations where there are either relatively few women participants or single sex situations.* This standpoint limits our understanding. Carnegie Mellon with its more balanced environment offers the opportunity for new insight. This is significant because while a gender divide may be observed elsewhere in schools across the USA, and is thus perceived as generalizable, we can show that this is not a universal situation.

1.8. Enhanced Opportunities for Women in CS. One of the major interventions contributing to cultural change in the CS department at Carnegie Mellon involved the setting up, and development, of the faculty/student organization, *Women@SCS*. This thesis will illustrate some of the activities of the organization, which works to promote the breadth of the field and its diverse community. The *Women@SCS* advisory council designs and implements a program of events and activities to provide academic, social and professional opportunities. Many of these opportunities are not available naturally to those in a minority situation (as is the case for many women and minorities in CS) while they may be taken for granted by those in a majority situation. In this way, valuable professional support is afforded all students, men and women, as part of the balanced environment at Carnegie Mellon.

1.9. Limitations of Traditional Research Approaches to Gender and CS. This thesis proposes that the *prevailing approaches* to address the low participation of women in the field *may be part of the problem itself*. Discussions, studies and recommendations coming out of the USA to address these issues, have, for the most part, taken place within the framework of theories of gender differences. Indeed, the National Science Foundation[3] (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. It has been argued that men and women are different[4] and relate to computer science in different ways[5]. Therefore if the field is failing to attract and retain women, we need to re-shape the field to suit them and/or better equip women to adjust to the field.

Such conclusions have led to strategies and recommendations to contextualize CS coursework to fit what is thought to be women's approach to CS. We offer a different perspective and a word of caution. Curricular changes, for example, based on presumed gender differences can be misguided, particularly if they do not provide the skills and depth needed to succeed and lead in the field. Such changes will only serve to reinforce, even perpetuate, stereotypes and promote further marginalization of women.

Indeed the Carnegie Mellon CS undergraduate academic curriculum *was not adapted to suit women* and in fact has continued to be one of the most rigorous CS programs in the US. Yet most women, and men, thrive and are successful in this environment. The implications of our thesis are that we do not need to change the field to suit women in

[3] 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". In 2005 we raised this issue in our presentation at the "Crossing Cultures, Changing Lives" conference in Oxford, England, and the NSF representative acknowledged, even seemed supportive, of our call for change.

[4] This is argued from both a natural-biological perspective and from a socialization perspective. Publications from the Gurian Institute (see http://www.gurianinstitute.com/) are good examples of books on nature-based theory. However, among academics especially, theories of gender socialization as the source of gender differences are far more prevalent. Indeed, the term *gender* is a concept that allows us to talk about non- biological factors that determine what it means to experience being male or female. *Athena Unbound: The Advancement of Women in Science and Technology* [Etzkowitz et al, 2000], provides many examples of the array of socialization factors that contribute to gender differences and how gender-appropriateness is acquired.

[5] A primary example is *Unlocking the Clubhouse: Women in Computing* [Margolis and Fisher, 2002].

order for them to enter and be successful in CS. Rather, we suggest paying close attention to the micro-culture and environment, fostering the conditions that allow for diversity, and enhancing the opportunities available to both women and men.

We also suggest that future generations, and gender equity in CS and elsewhere, will not be well served by any theories of gender differences which serve to endorse differences in intellectual ability. Women have shown by example that they are capable of succeeding in many fields once considered appropriate only for men. We have witnessed examples (e.g. law, mathematics, medicine) where women's equal and/or increasing participation serve to challenge any theories that attribute different intellectual characteristics to men and to women. Cynthia Fuchs Epstein made a similar observation in 1990 (our italics):

> "Over the past two decades, women have clearly demonstrated competence in spheres in which it was once believed they had no interest and no qualifications. This success demonstrates how opening *the opportunity structure* has developed their interest and ambition" [Epstein, 1988, p.164].

Yet difference theories persist and are often unwittingly used to justify and reinforce the different and unequal roles men and women occupy. This cycle of reinforcement in our thinking and action may, in part, be responsible for the slow progress we have made in addressing the low participation of women in CS. What is in reality a complex issue, involving a multitude of factors (cultural, social, biological, cognitive, and psychological, etc) that are difficult, if not impossible, to untangle, are often reduced to an oppositional gender issue with the onus usually placed on women themselves. This also serves to remind us that focusing on the gender divide, often assumes that all women and all men fall into two separate homogeneous categories, which mask differences of race, class, and socio-economic differences which exist among, and between, women and men.

However, we do *not* suggest that the difference debates have had no general value. We argue that they are products of their time, raising public awareness to important issues.

For example, during the 1970's, second wave feminism and the women's movement brought much needed visibility and attention to women's lives, their work and experiences, and most important of all, inequalities between men and women were fore-grounded in a way that had never been seen before. But for the past 20 years or so, as men and women have struggled to understand and account for the *lived* gender differences that clearly exist, those who pointed to *substantial gender differences as sources of inequity* appear to have carried most weight. We believe it is time for alternative perspectives and other research paradigms.

1.10 Against the Grain: For the most part our argument to focus on culture and environment goes against the grain of many gender and CS studies. But we have some allies outside of the CS community who have challenged the validity and significance of gender differences. In contrast to difference thinking, other theories, such as those articulated in the work of Rosabeth Kanter and Cynthia Fuchs Epstein, have pointed to *prevailing structures of power and opportunity*, as the primary factors contributing to gender inequities. There is substantial data coming out of cognitive and psychological theory to show that men and women, girls and boys, show many gender similarities; indeed they also show that differences and similarities cut across gender in a spectrum which shows men and women are far more similar than generally presumed. This thesis will show how such theories tie in with findings from our case study of undergraduates in CS at Carnegie Mellon and with other studies.

1.11. Thinking Culturally. We suggest that "thinking culturally" opens new possibilities for examining the complexities and the dynamics of gender issues in computing. A cultural perspective offers an alternative to difference thinking which frequently serves to justify, accommodate and maintain inequities. A cultural perspective can also open our eyes to the contradictions inherent in a culture of individualism, a primary characteristic of western thinking (particularly in the USA). A culture of individualism places the perceived onus of responsibility for beliefs and actions on individuals. The fallacy of such thinking is that while we believe we have "individual freedom", our choices are, for the most part, culturally inscribed. With regards to gender this usually means adopting gender-appropriate roles and codes of behavior, areas of study and occupations, even when such cultural positioning does not work in our best interest. We suggest that "thinking culturally" can raise awareness of such cultural contradictions, and allow us to examine the complex relationships between women, computer science and perceived "choice".

A cultural perspective can both *broaden* and *focus* our thinking. It can broaden our thinking as we think outside of our own cultures and learn from different cultures, and it can focus our thinking as we recognize specific factors affecting specific situations. If, for example, we look outside of the USA to some of the *developing nations*, we find evidence that the low participation of women in CS is not universal, and other countries and cultures reveal more positive stories of women's interest and contribution. Some studies reveal that in some parts of the world women are not being turned away from computing fields, indeed in some environments women are showing themselves to be capable and active participants. If women are seen to be contributing to the field in other nations it seems reasonable to assume that culture is playing an important role, and what we have been attributing to gender differences may actually be the result of differences in culture and environment. In this thesis we will reference, and explore, a range of case studies and research findings which support the cultural perspective we propose.

1.12. In Sum. Our research findings, grounded in a cultural perspective, lead us to conclude that where environmental and cultural conditions *allow for* diversity, a spectrum of perspectives can emerge, and in terms of our 2004 case study of undergraduates at Carnegie Mellon, men and women are found to be more alike than different in how they relate to CS. This also means that certain conditions allow the Women-CS fit to be revealed and expressed, without resorting to handholding or adapting the curriculum to be "female-friendly", a recommendation which some women find somewhat condescending to women's intellectual integrity. In this way, we show that changes at the micro-cultural level, rather than strategies to accommodate a gender divide, may have significant effects on the participation of women in CS. Thus, these findings can have implications well beyond Carnegie Mellon. Changing culture, especially the dominant culture of a nation, can be a very complex process, but culture, for better or worse, does change. We will show that positive changes at the local level of a micro-culture are feasible. We will conclude with concrete recommendations for actions, interventions and strategies, as we believe this thesis has valuable implications for change.

Section 2: Research Methodology

The research methodology for this thesis was based on an ethnographic, qualitative approach which is commonly used to further the understanding of how members of communities respond to specific phenomena [Maxwell, Trochim, Babbie]. In this case I was attempting to understand how a cohort of CS seniors from the class of 2004 at Carnegie Mellon perceived their relationship to CS. I used traditional qualitative processes for the analyses and evaluation of the data i.e. listening, reading, categorizing, interpreting, and describing (along with quantitative data analyses where appropriate). In this thesis the data collection tools have included interviews, discussions and observations, with interviews providing the primary data.

Ethnographic approaches have been used in several major studies of gender and CS issues. In *Unlocking the Clubhouse*, Margolis and Fisher used this approach "to understand the different ways men and women approach and experience computing in college and beforehand" [Margolis and Fisher, 2002, p.3]. In *Talking About Leaving: Why Undergraduates Leave the Sciences*, Seymour and Hewitt conducted ethnographic research for a major study based on "students' reflections on their undergraduate experiences". In such studies undergraduates themselves are regarded as the "expert informants who are well-placed to describe the strengths and limitations of their educational experiences" [Seymour and Hewitt, 1997, p.13-14]. Seymour and Hewitt note the value of the kind of qualitative data accumulated from interview studies: "Accounts which are gathered and analyzed in a systematic manner allow the investigator to discover things that cannot easily be discovered by any other means. In complex human affairs, noticing the patterns in the independent accounts of expert witnesses plays the same role as laboratory observations in the formation of hypotheses". Qualitative research also informs many of the chapters in *Women and Information Technology*, the authors explain "Qualitative research seeks deep understanding of an issue through comprehensive data that describes the richness of social life and emphasize the importance of context. These data are often collected through field research involving direct observation or interviews" [McGraph Cohoon and Asprey, 2006, p.x1].

2.1. Research Framework. Joseph A. Maxwell's work on qualitative research, *Qualitative Research Design: An Interactive Approach* [1996], provided a framework for this research. Maxwell suggests four main steps for structuring a qualitative study:

2.3. Establishing a Research Relationship with Participants

2.4. Determining the Research Setting and Method for Participant Sampling

2.5. Determining Data Collection Methods

2.6. Data Analysis Strategies and Techniques

I use this four step framework below to illustrate the organization of my research.

2.2. Establishing a Research Relationship with Participants. I have worked in the School of Computer Science since 2000 when I was hired as Associate Director of *Women@SCS* and subsequently became Director of *Women@SCS*. In this role I have worked closely with graduate and undergraduate students (mostly, but not all, women), and with women faculty in SCS. My role has been to oversee, help create and implement the program of activities and events organized by *Women@SCS*, including coordinating outreach activities and managing the organization's web site along with a team of *Women@SCS* students. I have always had an open door policy and have become something of a "sounding board" for *Women@SCS* students, indeed I have formed lasting relationships which means many Alumnae stay in touch with me and visit when they can.

By 2002 the faculty advisor to *Women@SCS*, Dr. Lenore Blum, and I had observed that, contrary to early studies at Carnegie Mellon, our women students appeared to be not only thriving, but making a positive impact on the culture of the department. We also observed that these action oriented women fit very well into the field. In 2002 we decided to investigate further and applied for funding to conduct a small study based on interviewing the seniors who were about to graduate. We were particularly interested in this group because they were a class in "transition"— this class and the classes ahead of them had very few women students, while the classes behind them had a very good gender balance. We realized that the improved gender balance at Carnegie Mellon did not seem to be happening elsewhere so we were looking at quite a unique situation. Findings from this study led us to hypothesize that the culture and environment within the CS department had changed and these changes had allowed for a Women-CS fit [Blum and Frieze, 2005(b), Larsen and Stubbs, 2005]. One striking finding was that the gender divide perceived in the early studies of 1995-1999 appeared to be disappearing and gender similarities were emerging. It was clear that a further study was called for and this seemed like a perfect fit for my thesis topic.

By 2002 I was hired also to manage the websites of the School of Computer Science (SCS)[6] and the Computer Science Department (CSD)[7] web sites along with a web designer. My roles with *Women@SCS* and the SCS and the CSD web sites have afforded me many opportunities, and the *advantages of being an insider*, in the SCS community. I have been able to discuss any questions I have had about the CS program with faculty and administrators. Faculty have given me approval to sit in and observe their courses. As a special faculty member I have been able to work with faculty and administrators to gain statistics and data on the trends in CS at Carnegie Mellon. All in all I have been able to work with, and be involved with, many faculty, staff and students in the School of Computer Science, and beyond to members of the Carnegie Mellon campus community. Thus, I have been able to establish credibility with faculty, staff and students within the School of Computer Science and I have been in an ideal situation to observe and interact with students on a day-to-day basis.

2.3. Determining the Research Setting and the Method for Participant Sampling.

The primary subjects for my study came from the class of 2004 at Carnegie Mellon. The decision to do this study of seniors was to provide a follow up to the 2002 interviews enabling me to investigate the effects of the post-1999 interventions further. The results provide a series of findings on how students were relating to CS at Carnegie Mellon as

[6] http://www.cs.cmu.edu/
[7] http://www.csd.cs.cmu.edu/

the environment and culture was changing: i.e. the findings from the early study (1995-1999), the brief, but striking, findings from the 2002 interviews, and the 2004 interviews conducted within the framework of my Ph.D. research.

The research setting was the CS Department at Carnegie Mellon, Pittsburgh. The location for the interviews was an office in Wean Hall, home of the CS Department.

- **Sampling for Interviews**

The technique used for sampling is described by Maxwell as "purposeful sampling" [Maxwell, 1996, p.88] i.e. sampling aimed at gaining information from specific groups that could not be gained by other means. Trochim and Babbie call this kind of sampling "purposive" sampling [Trochim, p.41, Babbie, p.183]. "A type of non-probability sampling in which you select the units to be observed on the basis of your own judgment about which ones will be the most useful or representative" [Babbie, p.183]. The research aimed to further our understanding of how seniors from the class of 2004 were relating to CS, thus it was important to collect a variety of perspectives and as much of a representative group as was possible. Just as the 2002 interviews purposely targeted a class in "transition", in 2004 I was particularly keen to ensure that the 12 *Women@SCS* active council members were included as they represented a very interesting community, comprising roughly one quarter of the total women in the class of 2004. In this class the 12 *Women@SCS* active group members were all women, although men have been quite active in the organization.[8]

The 12 *Women@SCS* active council members (referred to unless otherwise stated as *Women@SCS* active members) were invited to interview and they all accepted. I also learned that some students from the class of 2004 would be graduating early, i.e. prior to spring semester 2004, so I invited them to interview and several accepted. Several other students stopped me in the corridor, or came to my office, and asked if they could take part, some were encouraged by friends. By this point I had 9 students, plus the 12

[8] The class of 2006, for example, had two men who had been actively involved since their freshmen year, one of whom became an excellent web team leader. In 2007, we have one man (a freshman) actively involved in the organization, and one male sophomore who contributes whenever he has time.

Women@SCS members, lined up for interviews with very little encouragement on my part, but clearly I needed to reach out to other students in the class of 2004.

To gather more perspectives and more data a computer program for randomizing student identifiers was generated to select other potential interviewees, men and women, from the total 2004 seniors' list. Using the program generated list, the first 25 male students and the first 25 women students on the list were invited by email, and/or phone, to participate in the seniors' interviews as part of this Ph.D. research. If a student did not respond (after at least two invitations) the next student from the list was invited. This process continued over several weeks until another 34 students (18 women and 16 men) agreed to meet and be interviewed. All of the interviews were tape recorded and eventually transcribed. I conducted 55 interviews in total. In small qualitative research studies like this one, 55 interviews comprise a reasonable and representative sample[9] as they drew from various sub-groups and comprised over one third of the class of 2004. At the time of the interviews, the total number of students in the class of 2004 was 156[10] with a gender breakdown of 52 women and 104 men. Figure 2. below illustrates the breakdown of the 3 sub-groups that made up the total sample.

Figure 2. Total Students Interviewed: Class of 2004

	***Women@SCS* Active Members**	**Other Women**	**Total Women**	**Total Men**	**Total Students**
Senior CS Majors	**12 (out of 12)**	**20 (out of 40)**	**32 (out of 52)**	**23 (out of 104)**	**55 (out of 156)**

All 55 interview transcripts were read and analyzed. The three subgroups, *Women@SCS* active members, other women, and men, were compared and the findings were charted by percentages. Several charts, illustrating the findings for all 55 interview transcripts, appear in the appendix.

[9] Abbbe Herzig suggests that in practice "it is almost impossible to generate a truly representative sample of most populations of interest". Her advice to researchers and readers is to pay close attention to the specific context of the research and the population being observed [Herzig, 2007].

[10] Some students do double majors and graduate in schools other than SCS.

- **The Representative Cohort: 20 Men and 20 Women**

In order to focus more closely on the perspectives of these students I decided to examine the data through 2 sets of interview transcripts from women and men. A reasonable sized cohort for such comparisons seemed to be a group of transcripts from 20 men and 20 women from the initial data sample of 55 interview transcripts. I refer to this 20/20 cohort as the representative cohort.

To arrive at the representative cohort from the total students interviewed, I took the first 20 transcriptions from the interviews with men (out of the 23 total) and the first 15 transcriptions from interviews with women (out of the total from 20 other women) to arrive from the transcriptionists. This meant that the early interviews (that included the early graduating seniors) were likely inclusions in the 40 transcripts. Indeed 2 men and 2 women who graduated early were included. I then added 5 interview transcripts from the *Women@SCS* active members group. These 5 were selected "randomly" from the transcripts of the 12 *Women@SCS* active members. This number provided a good representation of *Women@SCS* active members without too much of a bias. In this way I ended up with a representative cohort of 20 men and 20 women. (See Figure 3 below for breakdown.)

Figure 3. The Representative Cohort of 20 Men and 20 Women

	***Women@SCS* Active Members**	**Other Women**	**Total Women**	**Total Men**	**Total Students**
Senior CS Majors	**5**	**15**	**20**	**20**	**40**

2.4. <u>Data Collection Methods</u>. The core of the data for this thesis came from the in-depth interviews with senior students from the class of 2004. Data also came from observations and documentation of group meetings, discussions with faculty, classroom and workshop observations, and documentation of the *Women@SCS* program of events and activities.

- **In-depth Interviews**

The interviews with senior students were aimed at capturing the thoughts, recollections, and attitudes of the CS undergraduate students from the 2004 graduating class. The interview questions (sample provided in appendix) were modeled on questions used in the 1990's study whenever possible, with some additional questions to include attitudes towards, and participation in, *Women@SCS* and the program of events. The interviews were very open ended and meant to solicit perceptions and comments rather than direct quantifiable information. While the interview questionnaire was based on the questions used in the 1990's interviews, *in no way was this research meant to replicate the earlier longitudinal study*.

Each consenting student subject took part in a one-on-one private interview. The interviews lasted approximately one hour, sometimes up to one and a half hours. Each student subject signed consent forms and read guidelines to conform to the university's Human Subjects policy and protocol. Anonymity of student participants has been maintained.

- **Group Meetings: Documentation and Observations**

Although I did not set up any *focus groups* as such, I have been meeting with students in ongoing weekly meetings of the *Women@SCS* Advisory Council. At these meetings students plan the program of events and activities. They also discuss whatever is on their minds at the time. These meetings provided me with tremendous insight into students' interests and attitudes. My observations at these meetings have guided my understanding of what it means for some women to be a woman in CS at Carnegie Mellon. Many of the observations gleaned from these ongoing meetings have helped shape this thesis. For example, listening closely to women students led me to question the implications of "female friendly" strategies; watching students working hard to plan and implement a program of activities and opportunities led me to recognize the importance of the *image* of the group and its mission. Several of the graduate students who had been involved with *Women@SCS* from its beginnings had already been dealing with the problem of being labeled a "support group" –these students saw this as a misrepresentation suggesting they needed *help* when in fact they aimed to provide opportunities for professional and social interaction. They soon recognized the importance of defining themselves, their goals and their image as a professional organization.

- **Discussions with Faculty and Administrators**

Informal discussions with faculty throughout my years in the School of Computer Science corroborated my sense that changes in the student body and changes in the culture were indeed occurring at Carnegie Mellon. Early discussions with my advisor, Dr. Blum (and faculty advisor for *Women@SCS*), confirmed my sense that the attitudes and perspectives of the women students I was working with did not ring true with findings from the 1995-1999 research. At the same time I was receiving email requests for information, and questions at conferences, from faculty and administrators at other universities who were interested to hear what was happening at Carnegie Mellon since the numbers of women had increased. These questions were often framed by asking how the curriculum had been changed, or contextualized, to attract more women into the program. This raised some alarm among those of us who felt strategies for broadening participation in CS at Carnegie Mellon had been *misinterpreted* by outsiders. I raised this issue in discussions with faculty to further my understanding of the CS curriculum, especially regarding what had been changed and what had not been changed. Faculty confirmed that changes in the CS curriculum were made for the benefit of the student body as a whole and *not changed on behalf of women.*

As I proceeded with my thesis, I met informally with several faculty and administrators from the School of Computer Science to hear their thoughts on culture and gender in the department and to gather further information. Several faculty members had been in the department prior to, and during, the 1990's study, and two women faculty members had been Ph.D. students in the School of Computer Science. I also met with Carnegie Mellon's Director of Admissions to clarify my understanding of how students are admitted into the CS major. These informal discussions were used to broaden my understanding. The perspectives of faculty and administrators have been integrated into this thesis.

- **Classroom and Workshop Observations**

I sat in on the Freshman Immigration Course during the fall of 2004 and 2005 to get a sense of how new students are introduced to the department, the CS program, and the School of Computer Science. The Freshman Immigration Course (inspired by the Immigration Course for graduate students), is a weekly meet-up for the entire freshman class, run by the freshman advisor throughout the fall semester, and is held in the large CS auditorium. The students get to hear from senior faculty (including the Dean of the School of Computer Science and the head of the CS department), and administrators from both CS and Carnegie Mellon generally (e.g. speakers from university housing, university libraries, etc.). New students also meet faculty from a variety of areas in SCS and hear about courses and research areas. Student organizations are given opportunities to address the freshman class, indeed the groups I work with, *Women@SCS*, the Undergraduate Web team, and SCS-Day[11] organizers, have all taken advantage of this opportunity to recruit and inform. The atmosphere of the Freshman Immigration Course appears to be fairly relaxed and interactive, with many students asking questions. It moves along at a lively pace to accommodate a great many speakers. The freshmen students get to hear very early on that CS is a broad area and far removed from the programming classes they may have taken in high school. By 2005 the gender balance was reduced somewhat from its 2004 level but in this particular course when all students are present, there is still a critical mass of women.

In spring 2006 I attended a course (introduced fall 2005), Principles of Computation, and sat in throughout the classes to learn more about the underpinnings of CS as conceptualized by our faculty. The course, which satisfies the computing requirement for many majors, is aimed at non-CS majors and offers a model for introducing computation to students with little or no background in the area. The diversity of the (20 or so) students taking this course was striking, with a good gender balance and a mix of races represented. Throughout the classes students, women and men, appeared to be very comfortable asking, and responding to, questions.

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[11] SCS-Day is a day of workshops and activities culminating in an evening talent show, all celebrating diversity in the School of Computer Science.

I also attended some classes, but not the entire course, in the fall section of the course 15-251 Great Theoretical Ideas in Computer Science, again to further my own understanding of the field and to get a sense of the ideas our students are exposed to. In this theory course, which is a required course for all CS majors, lectures include the history and philosophy of computation, formal proofs, number theory, and problem solving methods, among other abstract mathematical models.

My involvement with K-12 teachers, through the *Women@SCS* Outreach Roadshows and various workshops, has given me good insight into the current issues facing middle and high school CS teachers. CS teaching certification, recruiting students to their classes (girls and boys), and being confined to teaching CS as defined by the AP CS curriculum, are just some of the issues they struggle with. I have worked with K-12 teachers during the annual Java workshops[12] and in particular I helped organize and implement a new 2006 workshop, CS4HS[13] aimed at reaching out to high school teachers to provide practical resources and ideas for teaching CS principles (as well as programming) to their students. As I illustrate later, my research findings suggest that students are excited to have their eyes opened to the breadth and creativity of CS, and that before coming to Carnegie Mellon the majority in our cohort had, not surprisingly, equated CS with programming. It may, therefore, be reasonable to propose that if the breadth, challenges and creativity of CS could be taught in K-12 schools more students–girls and boys, men and women—could be engaged in the field at an early age.

- **Documentation of the *Women@SCS* Program of Events and Activities**

Throughout the years I have documented the program of events and activities offered by *Women@SCS*. Most of this is written up in a paper co-authored with Lenore Blum and revisited (and extended) here in Chapter 4, Section 1, in a section on "Building an

[12] Mark Stehlik, Teaching Professor and Assistant Dean for Undergraduate Education has been teaching these workshops for over 20 years bringing HS teachers on campus: http://www.intro.cs.cmu.edu/ap/
[13] CS4HS is a Summer Workshop for high school teachers run by Tom Cortina, lecturer in CSD. The workshops are now being held at several other schools under the umbrella name of CS4ALL. For details of the CS4HS workshop see: http://www.cs.cmu.edu/cs4hs/summer/index.html

Effective Computer Science Student Organization: The Carnegie Mellon *Women@SCS* Action Plan".

2.5. Data Analysis Strategies and Techniques

- **Transcription and Analysis of Interview Data**

The interviews were transcribed verbatim by paid assistants into word documents. This was done as whole interview transcripts and then as sets of responses to specific questions. The majority of data from the interviews was qualitative data and as such was read for themes, prominent words, and repeated phrases. I read entire transcripts to get a sense of each whole person, and I read entire sets of responses to individual questions. The latter was particularly helpful for finding prominent themes, common issues, and patterns of repeated perspectives.

The transcripts were read many times and responses were compared. For some questions, especially the ones which had revealed signs of change in 2002 (i.e. attitudes to programming and applications, women fitting in, etc.) the responses were also read by volunteers from inside and outside of the CS department and grouped into categories relating to specific responses to specific questions. In these cases only after the initial categorization process was the data charted according to the gender. As well as comparing the responses of men to women I also compared some of the responses of members of *Women@SCS* to women who have not been actively involved in the organization. This allowed me to investigate if, and how, being an active member of *Women@SCS* impacted women's attitudes.

- **Validity**

I use the concept of "validity" as Maxwell describes it: "I use validity in a fairly straightforward, commonsense way to refer to the correctness or credibility of a description, conclusion, explanation, interpretation, or other sort of account". In this sense I do not imply that I am searching for "objective truth", nor do I feel this is essential, but rather I want to show credibility such that my findings are "useful and believable" [ibid. p.106].

Maxwell suggests that there are two major sources of "validity threats" which could lead to invalid conclusions. These are **reactivity** which is the effect of the researcher on the subjects, and **researcher bias** which I discuss at some length after explaining how I dealt with reactivity.

- **Reactivity.** Maxwell's notion of reactivity concerns the effect of the researcher on the subjects. As Director of *Women@SCS*, I was concerned that students being interviewed would feel uncomfortable in some sections of the interviews especially those dealing with gender issues. I tried to minimize this validity threat by opening the interviews with two comments. I informed the students that I was collecting *their perspectives*, not mine, and they should feel free to express their views –indeed, I explained that without their freely given perspectives the data would not be helpful. I also told the students that I would not be responding to their comments, again because it was *their perspectives* I was interested in. I tried not to prompt student answers and only occasionally did I have to clarify the questions when students asked. For the most part students appeared to be very comfortable expressing their ideas and many spoke at length, interviews often running well over the allotted one hour time slot. Indeed, many students, men and women, said they had enjoyed doing the interviews and were happy to have had the opportunity to take part in the research. They were actually quite appreciative that the department was interested in their perspectives and opinions.
- **Researcher Bias.** Maxwell suggests that researcher bias is not in itself a threat to credibility because we all have our biases; rather the threat lies in not reflecting on the bias and acting to minimize it as much as possible. With this in mind I was very aware that in my attempts to challenge the traditional methodology that focuses on gender differences, I was deliberately searching for gender similarities. To minimize this tendency I made an effort to be open to a spectrum of responses rather than targeting similarities or differences. I believe this allowed for greater validity in my conclusions.

I was particularly concerned about ensuring validity of the data relating to the key questions that had revealed important signs of post-1999 change. One of the methods for doing this is described and illustrated below in *Data Verification.* I also involved external readers to give input into categorizing student responses; these readers were given free range on how they categorized the responses.

I was looking for a method of categorizing other than by gender, in order to avoid starting from a gender dichotomy bias, the bias that I have critiqued in the thesis. An interesting method was suggested by my colleague and external advisor, Dr. Orit Hazzan. The strategy for doing this was to separate the responses to specific questions to produce a set of totally anonymous answers; all identifiers such as men or women, numbering, etc. were removed. Different volunteers were then called upon to categorize the responses as they thought appropriate. Only after this categorization process was carried out did I match gender to the responses in the categories to assess gender similarities, gender differences, and/or a spectrum of responses.

Example of Data Verification: **Figure 4. Categorizing Students' Perceptions of the Atmosphere in the CS Department**

Category 1. Atmosphere as cooperative/friendly/helpful • **M. 10** • **W. 11**
Category 2. Sense of "community" atmosphere being reduced since first year • **M. 3** • **W. 1**
Category 3. Did not notice anything in particular about the atmosphere • **M. 1** • **W. 1**
Category 4. Atmosphere as competitive/stressful • **M. 2** • **W. 2**
Category 5. Feeling increased comfort level in department with time • **M. 1** • **W. 2**
Category 6. Atmosphere as diverse (people and interests) • **M. 3** • **W. 3**

Figure 4 above illustrates an example of this method of data verification in which students' perceptions were categorized. A volunteer received a collection of individual answers from the representative cohort to Question 9: "How would you describe the atmosphere in the CS Department now? And has it changed?" The volunteer was asked to categorize the answers in any way they liked. In this example the volunteer saw 6 categories, 1 through 6. After the responses were categorized, I took the 6 categories and responses in each one and looked at the gender breakdown. Figure 4 illustrates the results with "M" referring to men who responded, and "W" referring to women who responded in this category. Again I emphasize that in this case and several others, the gender labeling was not done until *after* the initial categorization. I believe this strategy allowed me to be more open to a spectrum of attitudes and perspectives.

This categorization method of data verification was then compared with my own findings to arrive at what I thought was a reliable understanding of the gender distribution. Categorizing the responses in this way revealed a spectrum of attitudes. The findings from the example below are described fully in Chapter 3, Section 4 (4.7.). The particular technique of categorizing the data *prior* to gender matching, used in some key questions, helped me avoid the bias that Barrie Thorne suggested is common practice in gender research, practice which serves first to create a gender divide and then find evidence for it [Thorne, 1993].

2.6. In sum. I believe this research methodology, modeled on Maxwell's four steps for framing qualitative research, served to provide a reliable and reasonable set of data and strategies for examining the ways in which a representative sample of seniors from the class of 2004 were relating to CS. The findings of this research were compared to the findings of the 2002 research and the early research (1995-1999). Some of the data was expertly verified by Dr Hazzan. My thorough and repeated reading of the transcripts, along with additional reading and categorizing by volunteers helped provide validity of the data and the analyses. I also presented my research at several conferences and workshops to get external feedback that helped clarify and strengthen my work.

Throughout the interview processes and analyses described above I was able to reflect on the numerous meetings and discussions that I have had with students, faculty and staff, over the time I have worked in the CS department. All of these components came together and contributed to a better understanding of how our students perceived the micro-culture they inhabited. The findings from this 2004 qualitative research appear in Chapter Three.

CHAPTER TWO[14]: A CULTURAL PERSPECTIVE

Chapter Overview: In **Section 1** of this chapter we expand on our proposal to shift the discussion from gender to culture, and answer an obvious but interesting point: *Isn't gender a cultural issue?* In this section we try to explain the distinction and why our suggestion to focus on culture may be a more pragmatic and positive move to arrive at recommendations and strategies for change. We present a comprehensive background on the dynamics of culture and gender along with evidence from a variety of sources (e.g. from research on gender similarities, gender myths, and numbers) to support our argument. We then, most importantly, assign **Section 2** to show *how this evidence and our argument relate to CS and women's participation in the field*. We discuss the impact of gender difference theories and of the early Carnegie Mellon research (1995-1999). We refer to our own research findings, the 2004 Carnegie Mellon case study, which will be presented in chapter three. We point out some of the important changes we found in relation to the micro-culture and the emergence of a good Women-CS fit. In **Section 3** we draw on single case studies from several countries, cultures and micro-cultures, along with meta-analyses, to show that women's participation in CS is culturally diversified. By taking a global view we can point to specific factors in culture and environment that contribute to the different levels of women's participation in CS. Finally in **Section 4** we focus on stereotypes because we believe that cultural images and representations surrounding women and CS play an important role in determining women's participation in the field.

Section 1: The Dynamics and Distinctions of Culture and Gender

This thesis explores *cultural factors,* acknowledging that *culture* is a very complex concept and the term is open to various interpretations. Here we are using the term *culture* to refer to the complex and broad set of relationships, values, attitudes and behaviors (along with the micro-cultures and counter-cultures that also may exist) that bind a specific community consciously and unconsciously. Our 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.

But culture, like history, *allows for change.* Culture is dynamic, *shaping and being shaped by those who occupy it*, in a synergistic diffusive process. Indeed, while a dominant culture may embrace and influence a community, counter or micro-cultures

[14] This chapter is based in part on a paper accepted for publication 2007. See A Cultural Perspective on Gender Diversity in Computing [Blum, Frieze, Hazzan, and Dias, 2006] http://www.cs.cmu.edu/~lblum/PAPERS/CrossingCultures.pdf

may exhibit unexpected features. As individuals, and/or as groups, we contribute to culture(s) in different ways to different degrees, and are impacted by culture(s) in different ways to different degrees. In this sense we view culture, and cultural occupants, as agents of change. Environments (surroundings, atmospheres and conditions) are appropriate sites for interventions and opportunities.

1.1. Culture and Gender. In this thesis, we propose a new approach for examining the determinants of women's participation, or lack of participation, in CS. This approach, grounded in a cultural perspective, assumes that many factors (cultural, social, biological, cognitive, and psychological, etc) are at work in determining women's participation, and that this multitude of factors is difficult, if not impossible, to untangle. However, we suggest and show that culture and environment are significant factors in this process. The cultural perspective we propose also offers an alternative paradigm to gender based thinking, and gender difference thinking in particular.

1.2. The Construct of Gender and its Limitations. First we should explain that we are using the term *gender* to refer, in addition to biology, to the roles, behaviors, attitudes, etc., attributed to men and women as they are born into specific cultures and moments in history. Thus, our working definition of gender *embraces the complex dynamics of both natural and cultural factors and influences*.

Historically, there have been (at least) two seemingly divergent academic viewpoints of how we distinguish women and men. These are commonly referred to as the nature/nurture debates. One concept, *essentialism*, focuses on biology or sex, and claims that men and women are by nature biologically different, and naturally suited to different roles and tasks. Building on from biological differences of the body, the essentialist claim is that men and women also have different attitudes and different psychological and intellectual interests and abilities. The second concept uses the construct of *gender*, to help distinguish socialization factors from the born characteristics of men and women. This viewpoint contends that most of the differences noted by essentialists are actually the result of *socialization processes* resulting in different male/female gender roles that we adopt early in life and continue according to social expectations. The latter concept is currently the most favored as it accounts for, and allows for, *changes in time and behaviors*. Many, if not most, studies of how girls and women (and boys and men) relate to computing, begin with an understanding of gender as a social construct.

However, in some cases, essentialist and socialization theories, while appearing to start from different positions, are ultimately *collapsed* into a similar way of thinking[15]. This tends to occur when both the essentialist and socialization theories, share a focus on *gender differences* and on *accommodating those differences*. In this situation, socialization theory ultimately works to sustain, rather than counter, the essentialist viewpoint. Gender is a useful construct, and thinking about gender and socialization processes has great value over the essentialist viewpoint (indeed this thesis refers to these concepts throughout), but the concept of gender has significant limitations *as a research paradigm*, especially when it is construed as a source of gender differences.

Thus, we argue that the differences debates, however they are grounded, can serve to perpetuate a model of oppositional thinking, a model which begins and ends with dividing men and women, rather than looking at the culture in which the complex dynamics of diversity and areas of common ground are situated. “It’s not nature versus nurture” claim Barnett and Rivers, whose work closely aligns with our own, “We are all a product of many interacting forces, including our genes, our personalities, our environment, and chance” [Barnett and Rivers, 2004].

Another of our concerns about focusing on gender, instead of culture, is that gender issues tend to be equated with women’s issues and though not intentional they become categorized, even marginalized, as such. Women have become the primary contributors to research on gender issues, and what should be an area of common ground (in that findings and recommendations affect both men and women) becomes, for the most part, a segregated area of study. In the process of turning gender issues into women’s issues we also lose many women who do not want to be attached to women’s issues, choosing not

[15] We suggest that in the public consciousness both theories reveal themselves in simple oppositional thinking: “men are like this” and “women are like that”.

to be marginalized further, or, as Rosabeth Kanter points out preferring not to be attached to those perceived as being less powerful[16] [Kanter, 1977].

1.3. Limitations of the Traditional Research Approach to Gender Issues. A particularly significant, and potentially damaging, way in which gender issues have become self-limiting lies in the popularity of traditional theories of gender differences which are used indiscriminately to account for our behaviors and attitudes. We have observed that research on gender and CS tends to be driven by the search for gender *differences*. Indeed, as noted earlier, a crucial component of NSF funding criteria for CS and gender studies has been to find such differences. Paradoxically, to find no differences is to have no findings.

> "Social science research is based on a search for differences. Since we don't look for similarities, we don't find them and thus perpetuate an overemphasis on the differences between girls and boys. …..The concept of "statistically significant differences" is widely accepted and used – there is no general concept of statistically significant similarities. Thus in a research study, if you find differences, you have something. Your research is more likely to be seen as meaningful, and it is more likely to be published than it would be if you didn't find differences. Finding similarities isn't currently an option, regardless of what your data say.
>
> When research focuses on differences and when differences are all that is reported, difference-based stereotypes are reinforced and continued" [Campbell and Storo, 1994].

The possibility exists that most gender research has been invested in validating what is already believed to be true, i.e. that substantial differences exist between men and women.

[16] In her classic examination of *Men and Women of the Corporation* Kanter returns again and again to structures of power and powerlessness as significant determinants of attitudes and behaviors. One example being that when men and women claim to prefer a male boss/leader it is indicating that "a preference for men is a preference for power" not for a specific gender. (Kanter, 1977, p.199)

The British psychologist, Peter Cathcart Wason, showed that people have a tendency to look for confirmation of their beliefs while ignoring or downplaying things that invalidate them (the famous Wason test was designed to demonstrate this phenomenon[17]). Certainly, the above observations from Campbell and Storo, would suggest this practice exists in some areas of social science research. Barrie Thorne long ago pointed out the potential for flawed findings inherent in the difference model of enquiry when "the strategy of contrast is often built into the research". She explains how many studies begin by separating boys and girls into single sex groups and proceed by working with each group separately to find differences, differences which are then attributed to gender [Thorne, 1993].

At the academic level the endless search for differences serves to perpetuate the high "investment in gender differentiation" [Epstein 1988, p.240] that Cynthia Fuchs Epstein noted in the late 1980's, an investment not only in resources but in attitudes and behaviors, an investment that pays off by becoming self-sustaining and self-fulfilling. Scientists (our italics) "have tended to find support and justification for gender distinctions and inequality rather than locate *the sources of these distinctions* and understand the dynamics" [ibid. p.4]. In sum, the bias in focusing on, and subsequently finding, gender differences (consciously and unconsciously), appears to be standard practice in this research paradigm. Clearly, we need to re-think this approach.

We do not, of course, suggest that there are no differences between men and women, indeed the *lived experiences* of men and women are often quite different, and our biological and socially determined differences do account for some of these lived gender differences. Nor do we deny that studying gender differences appeals to us in many ways. Such studies *appear to* help us account for inequities, while findings form the basis of many strategies that *appear* to redress them. To most of us this sounds perfectly reasonable. But what sounds reasonable may just be the conventional way of thinking about these issues. Epstein suggests that "it is easier to propose dichotomy than to explicate the complexities that make them invalid" [ibid. p.15]. Indeed, we need to pay

[17] For examples of the Wasson card problem see: http://skepdic.com/refuge/ctlessons/lesson3.html

close attention and be wary of attributing differences to gender when they are the outcome of cultural and environmental factors.

1.4. Gender Myths. A related concern for keeping culture in the foreground of our discussions—and our thinking--is to raise awareness of how easily we buy into *myths* about gender differences. In the book, *Same Difference: How Gender Myths Are Hurting Our Relationships, Our Children, and Our Jobs* [Barnett and Rivers, 2004], the title of the first chapter, "The Seduction of Difference", caught our attention. Gender differences are indeed seductive in that they form so much of the exciting, fun and attractive dynamics of relationships, as well as fueling our fires as we argue for fairness and against inequity. We have only to examine characteristics of our national humor to see the extent to which gender differences are entrenched in the comic discourse. The now famous self-help best-seller, *Men are from Mars, Women are from Venus,* published in 1993, exemplifies the "irresistible" combination of humor and gender differences, although not all reviews of the book are favorable:

> "Psychotherapist Gray (What You Feel You Can Heal) adds to the growing number of self-help books that assess marital and relationship problems in terms of distinct and pervasive gender differences. Unfortunately, his overuse of gimmicky, often silly analogies and metaphors makes his otherwise down-to-earth guide hard to take seriously. Here Martians (men) play Mr. Fix-It while Venusians (women) run the Home-Improvement Committee; when upset, Martians "go to their caves" (to sort things out alone) while Venusians "go to the well" (for emotional cleansing). While graphically illustrative, the hyperbolic, overextended comparisons, particularly in the chapters that refer to men as rubber bands and women as waves, significantly detract from Gray's realistic insights" [Publishers Weekly, 2002[18]].

[18] See Publishers Weekly Review, 1992
http://reviews.publishersweekly.com/bd.aspx?isbn=006016848X&pub=pw

Barnett and Rivers point out that this book, among others, served to revive theories of *innate* gender differences, and could be seen as the beginning of backlash to women's progress. Such theories seem to have been prevalent during the early 1990s, and some feminist writers, eager to prove women were different to, and possibly better than, men were no exception. 1991 saw the arrival of Deborah Tannen's *You Just Don't Understand* which argued that men and women have different ways of communicating. 1993 saw the publication of Carol Gilligan's *In a Different Voice* which assigned deep rooted differences to men's and women's moral senses, with women having superior morality. The works of Gray, Tannen and Gilligan, among others, were to have a long lasting influence on how men and women are perceived in both academic and mainstream thinking.

This is evidenced in a 2006 issue of The Chronicle of Higher Education[19] which devotes an article to the question of attracting and retaining women in CS. The article begins "Are computer programmers from Mars? Is CS a guy thing? Some experts are wondering just that --- at least, as it is taught now" [Chronicle of Higher Education, 2006]. The journalist may not have intended to bias his readers but the "difference" idea is clearly upfront in the allusion to Grey's book and how the article proceeds: "Could it be that men are more attracted to the nuts and bolts of computers, while women are more interested in the social and cultural applications of the devices". We will have more to say about these assumptions later. For the moment we refer to the article as an illustration of how books like Gray's and difference thinking are still pervasive even in highly respected publications.

Yet, as authors Barnett and Rivers point out *so many of these "differences" turn out to be myths.* One of the major myths they debunk relates to girls and mathematics. "Male superiority in math-related subjects is often taken as fact in conversations between parents, teachers, counselors, and others" [Barnett and Rivers, 2004], and herein lies the potential for damage from cultural messages that children may receive. The math myth,

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[19] According to Harvard Law School, The Chronicle of Higher Education "is a highly respected source of news and information from the world of academia".
http://www.law.harvard.edu/library/services/research/guides/eresources/chronicle_higher_education.php

has prevailed in the public consciousness for many years, and is based in large part on misleading data gathered from tests which never tell the whole picture. Psychology professor, Diane Halpern says that overall “while boys score higher on tests of mathematics, girls achieve higher grades in math classes” [Halpern, 2000, in Barnett and Rivers, 2004]. Also, when girls (and boys) get coaching on test taking their scores improve [Halpern, 2000].

Other researchers have noted the importance of experience and practice in relation to math test scores, and early studies often did not take experience into account when concluding that men were better than women at mathematics [Lang, 2002, Clarke & Teague, 1994]. Currently, according to a 2006 Stanford report, women gain around 46% of bachelors degrees in mathematics.[20] Clearly, any messages which suggest girls and women are not intellectually capable in the field of mathematics are seriously misinformed.

Boys and girls (and men and women) may well act differently because of the *cultural messages* they have received and taken on board, and because of the different levels of exposure and opportunities they receive. Gender myths based on differences are also easy to buy into because they seem to ring true, but like stereotypes they tend to focus on, and disproportionately expand, partial and superficial facts. The danger of the seduction of difference lies in closing our eyes to the bigger and more complex picture which often reveals gender similarities, cross-gender dynamics, and recognizing “that people’s behavior today is determined more by situation than by gender” [Barnett and Rivers, 2004]. Changing cultural messages may sound quite daunting but academics can, and should, be part of changing the broad conversation: “Rather than focusing on gender differences, mathematics and science educators and researchers could more profitably examine ways to increase awareness of the similarities in performance and in ability to succeed” [Hyde and Linn, 2006].

[20] See Stanford report http://news-service.stanford.edu/news/2006/february15/mathem-021506.html

Over the past few years we have seen the emergence of the myth of the "boy crisis".[21] A 2006 report, "The Truth About Boys and Girls"[22], from Education Sector, a non-profit education think tank, discusses how girls' increased educational achievement has been played out by the media as a *crisis for boys,* when in fact the "real story is not bad news about boys doing worse; it's good news about girls doing better". While there are clearly some boys who are disadvantaged and need help, "boys' overall educational achievement and attainment are not in decline—in fact, they have never been better" [Education Sector, 2006]. The report suggests that such mis-conceptions can thrive in the current culture because it "touches on Americans' deepest insecurities, ambivalences, and fears about changing gender roles" [ibid.].

An area closely related to myths is stereotypes, which help keep myths alive in the public consciousness. Margaret Matlin provides a very interesting account of how stereotypes are used in the media which, she claims, continually falls back on stereotypes to create, and reinforce, a gender divide, which obscures our thinking but has no basis in the "real" world: "In real life, the characteristics of women and men tend to overlap. Unfortunately, however, gender polarization often creates an artificial gap between women and men" [Matlin, 1999]. We will discuss Matlin's account more thoroughly in Stereotypes, Section 4 of this chapter.

Also, we would add, one of the dangers of stereotypes is that they work synergistically with, and fit very well into, essentialist and "difference thinking". A culture dominated by beliefs in deep rooted differences between races and between genders can be further reinforced by stereotypes to produce what many of us see as "reality". Culturally produced gender myths and stereotypes can have significant impact on student performance, public attitudes, and the choices we make, while also perpetuating a gender divide. The good news is that stereotypes, like essentialist and "difference thinking", are

[21] We suggest such myths are encouraged by authors who specialize in gender differences. Michael Gurian and Kathy Stevens, for example, provide educational guides for teachers and parents based on essentialist beliefs that boys and girls learn differently. The Gurian Institute is "a training organization focused on providing schools, homes, workplaces, and community agencies with crucial understanding of how boys and girls learn differently and women and men work and lead differently". http://www.gurianinstitute.com/
[22] See: http://www.educationsector.org/usr_doc/ESO_BoysAndGirls.pdf

cultural products that can be challenged and changed. This is evidenced in our section on CS stereotypes in chapter 4 where we present the findings from our 2004 Ph.D. research at Carnegie Mellon.

1.5. Similarities Data. A 2006 National Academies study examined the hiring and promotion processes in science and technology fields in universities in the USA, and concluded that: "Studies have not found any significant biological differences between men and women in performing science and mathematics that can account for the lower representation of women in academic faculty and leadership positions in S&T fields" [National Academies Press Release, 2006]. Indeed, many early researchers have questioned the dominance of theories of gender differences by "*going back to the data*". They note that much of it is misinterpreted, amplifying differences and ignoring gender similarities. Several researchers, outside of the gender and CS community, have adopted a perspective close to our own, a perspective in which they question the conclusions drawn from the traditional research paradigm. Diane Halpern's review of math and cognitive tests led her to suggest that any differences in boys' and girls' cognitive skills are so small as to be insignificant [Halpern, 2000]. Janet Shibley Hyde's extensive meta-analysis of psychological gender differences led her to write "The Gender Similarities Hypothesis" in which she affirms "men and women, as well as boys and girls, are more alike than they are different" [Hyde, 2005, p.581]. Hyde concluded that "30% of the effect sizes are in the close-to-zero range, and an additional 48% are in the small range. That is, 78% of gender differences are small or close to zero". [ibid. p.586] What is particularly interesting about Hyde's study is that she looked at those areas and authors that have been heralded as the foundation works of gender differences.

> "The small magnitude of these effects is even more striking given that most of the meta-analyses addressed the classic gender differences questions—that is, areas in which gender differences were reputed to be reliable, such as mathematics performance, verbal ability, and aggressive behavior. For example, despite Tannen's (1991) assertions, gender differences in most aspects of communication are small. Gilligan (1982)

> has argued that males and females speak in a different moral "voice," yet meta-analyses show that gender differences in moral reasoning and moral orientation are small" [Hyde, 2005].

Hyde also reminds us of the important effects of timing and context when attempting to measure gender differences. Test results can "fluctuate with age" and vary "creating or erasing gender differences in math performance" when test takers have preconceived views on the outcome of their performance [ibid. p.588-9].

A much earlier work, 1989, by Marcia C. Linn and Janet S. Hyde, "Gender, Mathematics, and Science", made at least two conclusions drawn from their analyses of "difference data" that support our argument: "gender differences are not general but specific to cultural and situational contexts," and "gender differences in cognitive processes often reflect gender differences in course enrollment and training".

Yet there seems to be a national investment in keeping gender differences alive. We believe this is further enabled by a focus on finding differences and the entrenched use of statistical significance tests which ignore the extent of gender similarities. Hyde and Linn illustrate this phenomenon by looking closely at results from the 2005 National Assessment of Educational Progress, which tests the achievement in math and science of thousands of students. Its 2005 conclusions are that males outperform females at all grades tested in science. However, Hyde and Linn suggest that differences are overly emphasized by the large sample size which detects increasingly small differences, differences which are very small to begin with. "The NAEP data provide better evidence for gender similarities in science achievement than they do for gender differences" [Hyde and Linn, 2006]. The lack of public awareness of gender similarities has implications for parental attitudes and educational practices and recommendations, be it the call for single sex schooling or a general acceptance and assumptions that girls are simply lacking in math and science ability. "A cultural overemphasis on gender differences may mask critical predictive variables and lead to decision making that is empirically unsupported" [ibid.].

Further evidence from the field of psychology shows the effects of cultural stereotypes and environment on test-takers. Psychologist Claude Steele questions the accuracy of standardized tests set up to measure intellectual merit on the grounds that prevailing racial and gender stereotypes have already shaped the thinking of those taking the tests, such that girls and women and/or African Americans who have been stereotyped as less able in specific academic domains will perform accordingly. Another example, from Michael Inzlicht and Talia Ben-Zeev, found that "college women perform markedly better on math tests when their fellow test-takers are all female than when they are all male--even when they believe their test scores will be kept private from classmates" [quoted from M. Dittman in APA online[23]]. This finding supports the concept of threatening intellectual environments and shows how far reaching the effects of stereotypes can be. In the section on Stereotypes we look more closely at possibilities for reducing stereotype threat by changes in the culture and environment.

1.6. Other Theories on Social Dynamics and Differences. In her classic 1970's work examining the attitudes and behaviors of men and women in a large corporation (the Industrial Supply Corporation or Indsco)[24], Rosabeth Kanter argues that "(w)hen men and women are in similar situations, operating under similar expectations, they tend to behave in similar ways" [Kanter 1977, p.312]. She concludes that the systems in place which determine social dynamics and differences, *are opportunity and power related*, not gender based. Kanter argues that three primary variables -- power, opportunities, and numbers -- determine social dynamics, not gender. Her theories have relevance to many other situations, and offer a wonderful array of evidence to support the argument that the origins of attitudes and behaviors often lie in culture and environment, and, consequently, have the potential for change.

Kanter examines the systems at work in this large corporation in order to locate the *sources* of gender differences: "This is a *system* rather than an individual construct—

[23] See APA online reference to Inzlicht, Michael; Ben-Zeev, Talia. Do High-Achieving Female Students Underperform in Private? The Implications of Threatening Environments on Intellectual Processing, Journal of Educational Psychology, 2004. http://www.apa.org/monitor/jan04/college.html
[24] Indsco is a pseudonym for a real large corporation that was the site of Kanter's huge study in the 1970's.

located not in characteristics of the person but in how many people, like that person in significant ways, are also present" [ibid. p. 241]. Thus, Kanter concludes that "(s)*ystem phenomena* require *system-level intervention* to make change" and "number balancing" is "a worthwhile goal in itself, because, inside the organization, relative numbers can play a large part in further outcomes—from work effectiveness and promotion prospects to psychic distress" [ibid. p.242]. In a later section we will examine the roles played by numbers and "system-level intervention" in changing the culture of computing at Carnegie Mellon.

Echoing Kanter's perspective, Cynthia Fuchs Epstein advocates the "structural approach [which] looks at the ways in which factors external to the individual explain even those attributes ordinarily regarded as wholly internal, such as motivation and aspiration" [Epstein, 1990, p.100]. Epstein is particularly critical of the branch of scientists who perpetuate theories of gender differences. She points out, the structural approach is crucial to counter a trend in research "to find support and justification for gender distinctions and inequality rather than locate the sources of these distinctions and understand the dynamics. In this sense, scientists have also been active agents in perpetuating distinctions based on mainstream viewpoints" [ibid. p.4]. Indeed, we believe that the situation calls for a significant change in the way we *think about* these issues.

How we approach women's contribution–or lack of contribution—to any field in the USA, can benefit from ongoing debates that have gathered momentum in the postmodern world. Dramatic changes in the way we think about the world around us (what "reality" and "scientific truth" means, changing notions of subject and "self", taking a global rather than an insular perspective), have been a source of academic discussion for many years. In Thomas Kuhn's famous work of the 1970's, *The Structure of Scientific Revolutions*, he describes how throughout history science research was subject to major shifts in thinking which he called *paradigm* shifts.[25] Kuhn argues that paradigms cannot

[25] "As Kuhn defined it (1970), a "paradigm" is a "constellation" of values, beliefs, and methodological assumptions, whether tacit or explicit, inscribed in a larger worldview. Kuhn observed that throughout the history of science there were *paradigm shifts*, conceptual revolutions that threw the dominant approach into crisis, and eventually dissolution, a discontinuous change provoked by altogether new assumptions,

build on old ways of thinking, nor is knowledge accumulative, but rather a shift emerges when old ways of thinking about problems fail to resolve the contradictions within some scientific theories. While Khun was referring to scientific research, Michel Foucault argued that similar dramatic upheavals in thinking, which he called “epistemes”, changed not only scientific thinking but thinking in all disciplines, such that a new view of the world emerged.[26] It may well be that as we become more aware of gender similarities and of women’s increasing potential, and as we adjust to thinking globally, a significant shift towards “thinking culturally” about gender issues will become part of a larger reassessment of the way we think about the world around us.

1.7. The Significance of Numbers and Gender Balance. For Rosabeth Kanter, the ratio of men to women in a given situation takes on particular significance, and ties in closely with our own findings which we discuss later. She found that numbers affected almost all aspects of life in the corporation, e.g. how one experiences work, how one is perceived, access to training and insider information, and social life: “(a)s proportions begin to shift, so do social experiences” [Kanter, 1977, p.207].

Kanter regretted the inability to test the “balanced” part of her numbers theory, abbreviated below, because there was no gender balanced situation she could call on within the company. She did find extensive evidence for the other groups.

- **Uniform**: are all one kind of person.
- **Skewed:** mainly one kind of person, perhaps a ratio of 85:15. The few in this group are **Tokens,** but not enough tokens form alliances **(**tokens are individuals viewed as representing their group i.e. all women, all blacks). Tokens are visible and easily stereotyped, and they arouse

theories, and research programs.” Quoted from Steve Best and Douglas Kellner: The Postmodern Turn: Paradigm Shifts in Theory, Culture, and Science *http://www.uta.edu/huma/illuminations/best8.htm*

[26] “Foucault attempted to identify for different stages in the development of modern culture through his concept of *episteme* (1972). As we conceptualize it, the "postmodern paradigm" signifies *both* specific shifts within virtually every contemporary theoretical discipline and artistic field, as well as the *coalescing* of these changes into a larger worldview that influences culture and society in general as well as the values and practices of everyday life.” Quoted from Steve Best and Douglas Kellner: “The Postmodern Turn: Paradigm Shifts in Theory, Culture, and Science” http://www.uta.edu/huma/illuminations/best8.htm

self-consciousness in non-tokens. However, self–awareness in the majority group can show some the potential for an alternative culture.

- **Tilted groups**: the group is now leaning towards balance, perhaps 65:35, and now the majority and minority groups have the potential to form alliances and change the culture.
- **Balanced groups**: in equally mixed male-female groups of 60:40 or 50:50, culture can change and conversational themes can turn to shared concerns.

Although Kanter could not test the latter balanced group, she noted that laboratory experiments had shown that numbers made a difference. For example "the same person may be perceived differently depending on whether he or she is a token in a skewed group or one of many in a balanced group" [ibid. p. 211].

Other researchers have added further evidence to support Kanter's findings and point to *numbers* as an important factor affecting women's and men's experiences of, and performance in, any given situation. Eskovitz *et al*, in reference to graduates in CS, noted that "(e)ven though men and women are in the same graduate programs their experience can be strikingly different. Most men quickly become included in the informal life while women are often left out" [Eskovitz, 2000, p.101]. Other researchers have noted both the importance of critical mass and how attitudes can change according to the proportion of *"people like me"* [Ramsey and McCorduck, 2005]. Put simply, they argue that being in a minority situation is a different experience to being in a gender balanced situation. For the most part, being in the minority situation means missing out on valuable resources and opportunities often available naturally to those in the majority situation.

The evidence pointing to the importance of numbers, also provides evidence that context and environment play important roles in shaping the experiences, contributions and attitudes of men and women. We should, therefore, be cautious about generalizing from the attitudes of women in a minority situation, to women in general.

1.8. A Cultural Perspective on Gender Issues.

> "The culture sets broad guidelines for what men and women ought to do. These help shape individuals' behavior, the ways in which they educate their children, and the ways they interact with kin, friends, and coworkers in the course of daily life. Culture sets the stage, and when individuals act according to its norms, their behavior becomes part of a pattern. Because the pattern is widespread it seems normal and natural and therefore reinforces the values underlying it" [Epstein, 1988, p.153].

In terms of gender issues, "thinking culturally" means thinking that examines factors at work within broader cultures, other countries, and more localized micro-cultures. Hyde and Linn, for example, looked first at data from the USA and then how their findings compared to cross-national data from Taiwan and Japan. By taking a cultural perspective they were able to look at factors outside of gender to assess sources of gender similarities and differences. In this case they found that differences in fifth-graders' performance on mathematical word problems *were greater between countries* than between genders [Hyde and Linn, 2006]. In Section 3, Other Cultures, we will examine such cross-cultural evidence further in particular relation to CS.

"Thinking culturally" means thinking that embraces *gender similarities and intra-gender differences,* thus paying attention to similarities and differences *among* women and *among* men rather than focusing on a simplistic gender divide which tends to place all women (and all men) in one category. "Thinking culturally" opens the door for exploring the variables among women's experiences, attitudes and expectations, and allows us to view the more realistic and complex *spectrum* of gender similarities and differences that exist among, and between, men and women.

We also believe that the discourse of culture is more inclusive, not only for examining gender issues but also issues of race and class, and as the 2006 Education Sector report reminds us the "gaps between students of different races and classes are much larger than those for students of different genders" [Education Sector, 2006].

While "thinking culturally" *broadens* the scope for examining other models of possibilities, other countries, other cultures and micro-cultures, it also serves to *focus* our attention on the factors at work in specific environments. In this way, gender issues are not reduced to a simplistic oppositional model which pits men against women and vice versa. Examining gender within the larger, or even localized, parameters of culture can help re-invigorate our research as we learn from other cultures, and share approaches and models of effective practices.

As noted in our introduction culture as an agent of change presents an alternative model to individualism, a dominant characteristic of western thinking (particularly in the USA), which places the perceived onus of responsibility for beliefs and actions on individuals. The fallacy of such thinking is that while we believe we have "individual freedom", our choices are, for the most part, culturally inscribed. This is illustrated in the way that men and women adopt gender-appropriate codes of behavior and appearance, even when such "codes" do not work in their best interest. Such thinking serves to limit power and masks the differences and inequities of the cultures we inhabit. If, as we propose, culture allows for change and is constantly shaping and being shaped by those who occupy it, then it is at the level of culture that the most effective changes can occur.

1.9. A Cultural Perspective on the Workplace. In their book *Occupational Ghettos: The Worldwide Segregation of Women and Men,* Maria Charles and David Grusky use a cultural perspective to explore the potential harm of gender difference beliefs to women in the workplace. They argue that *essentialism* is still entrenched in the dominant culture, and even if we no longer believe that men are *better* than women, we still subscribe to a belief that men and women are *very different*, "and this continuing belief in difference allows employers to assign men and women to different jobs and induces workers to come to want those different jobs".[27] Charles and Grusky suggest this is most prevalent in advanced industrial countries where a deep seated belief in gender differences is maintained and supported by a belief in individual preferences.

[27] Quoted in Womensmedia.com: http://www.womensmedia.com/new/Occupational-Ghettos.shtml

The argument these researchers present shows support for the way culture shapes our consciousness. For example, women have entered the workforce in huge numbers over the past 20 years or so, and have proved themselves to be capable in many areas, thus we believe we see a shift towards gender equity. But if we look closely we see that men and women are "freely choosing" to enter occupations that sit well with cultural definitions of what is appropriate work for men and for women, a situation that often does not work well for many women. Theories of gender difference do little to explain the inherent contradictions in this situation, or to contribute to real change. We suggest that only at the level of culture can we interrupt this cycle, because it at the level of culture that gender appropriateness is constructed.

1.10. Common Ground for Women and Men. We mentioned earlier that a cultural perspective allows us to see the common ground between men and women, as both men and women contribute to, and are affected by, changes in culture. Researchers looking into gender and science in academia, have noticed that "generational change" is contributing to the beginnings of "a cultural movement". They suggest that "a younger generation of male scientists, facing some of the same family pressures as women, will help reform the academic structure in ways that benefit both women and men" [Etzkowitz et al, 2000, p.233]. In this situation *both men and women* are up against old models in which the power to bring about institutional change lies in the hands of an older generation of men, and "an older generation of resilient women who stress a highly competitive, individualistic style that mirrors the traditional male stereotype" [ibid. p.147].

Ramsey and McCorduck also show support for generational theory and point to common concerns of men and women: "sensitivity to work-life balance is increasingly important to both men and women, and has become a generational rather than a gender issue". Such observations concur with theories that attribute the different attitudes of men and women to historically prevailing social structures, and to structures of power that exist within institutions [Kanter, 1977, Epstein, 1998] –not to deep-rooted gender differences. Such thinking opens the doors to new strategies for change in which we look at micro-cultures within institutions as the sites of interventions.

1.11. In sum. Thus, we argue that *yes – gender is a cultural issue* – but gender should be approached through culture. The arguments we make cannot be contained within the confines of "gender" or the framework of gender differences, and it is all too easy to equate and confuse our *born characteristics* with those we acquire as we grow up in specific social and cultural environments. Gender difference theories, for example, have never been able to account for the inherent contradiction and tensions of trying to reconcile *difference* and *equity*.[28] Barrie Thorne points out the need "to develop concepts that will help us grasp the diversity, overlap, contradictions, and ambiguities in the larger cultural fields in which gender relations, and the dynamics of power, are constructed" [Thorne, 1993, p.108].

We believe that a cultural perspective allows for the development of such concepts. Clearly thinking about gender issues through theories of gender difference have not answered the critical questions relating to women and CS. Thus, we need to look beyond gender to account for differences in the experiences and perspectives of men and women. "It is time to consider the costs of over-inflated claims of gender differences. Arguably, they cause harm in numerous realms, including women's opportunities in the workplace,... Most important, these claims are not consistent with the scientific data" [Hyde, 2005 p. 590]. For the most part such thinking also has us going round in circles, contributes very little change, and indeed may be perpetuating the very problems it set out to address. It may be as Thomas Kuhn points out "frameworks must be lived with and explored before they can be broken"[29]. But, we suggest, now is the time to look at other ways of addressing these issues. From our perspective "thinking culturally" provides one such approach. Using a cultural approach in our research at Carnegie Mellon revealed some major findings which we describe in Chapter 3. Put simply we found that a

[28] Mainstream Marxist theory, for example, has refused to deal with gender differences for this very reason, claiming gender issues construed within the difference framework divert attention from differences that really matter, in this case the sources and implementation of class structures and power relations.
[29] Quoted from http://www.des.emory.edu/mfp/Kuhnsnap.html

balanced environment[30] allowed for changes in the culture of computing such that perceived gender differences in how students relate to CS started to dissolve. In this situation we saw a Women-CS fit –a situation in which women fit into the CS micro-culture, contribute to it and are successful in the field.

Section 2: The Dynamics of Culture and Gender in Relation to Computer Science.

In this section we argue the need for a cultural perspective on CS. In Section 1 of this chapter we hope to have shown that the focus on gender differences, and the methodology for finding those differences, is a limited approach and one under debate. A cultural perspective allows us to open our eyes to the bigger picture which may include gender similarities and a spectrum of attitudes. Most importantly, a cultural perspective opens the way for us to look outside of gender for *sources* of gender differences. If some of the sources of gender differences can be shown to reside not in gender, but in the culture and environment, then strategies for change should take this into account in order to be effective.

A cultural perspective can help us account for change in a way that focusing on gender differences alone cannot. For example, the 1990's studies looking for gender differences among CS undergraduates at Carnegie Mellon, concluded that men and women relate to CS in significantly different ways. If these gender differences have any real foundation, we would expect them to show up again at a later stage. If these gender differences do not show up, and instead changes are observed, then we might argue that factors outside of gender are at work to account for some of these changes. We believe the latter is indeed true, and in Chapter 3 we describe changes in the culture and environment that we believe have contributed to the dissolving of the CS gender divide at Carnegie Mellon. We will provide findings from our 2004 case study to show evidence of gender similarities and a

[30] Balance in terms of gender, students with a breadth of personalities/interests, and professional support for women (to reflect implicit professional support for majority).

spectrum of attitudes that cut across gender. In sum we will show how a micro-culture can change to allow for the Women-CS fit.

For some time now several researchers have been noting the influence of culture on women's (and men's) participation and opportunities in computing fields. In Section 3, we will present case studies from around the world in which we will show that "gender distribution (in CS) is culturally diversified" [Schinzel, 2002]. Section 3 will also include an array of explanations and theories that attempt to account for broader cultural differences. There seems to be no single theory that covers all cases, nor should we expect to find one when the variables are so numerous, but what these studies reveal is a multitude of complex cultural factors—some specific and some more general—playing a significant role in women's choices. The point we want to make is twofold: first, if women are seen to be contributing in different ways in different cultures, then it seems reasonable to assume that culture is playing a significant role in their choices; secondly, "(w)hile the problem is wide-spread, the under-representation of women in CS is not a universal problem. It is a problem confined to specific countries and cultures" [Adams et. al., 2003, p.59].

A cultural perspective allows us to look at *the variables among women's experiences.* Within the US, the report written for the NCWIT[31], by Nancy Ramsey and Pamela McCorduck, suggests not lumping everything together as "dismal" but looking at specific successful micro-climates. They refer specifically to IBM's micro-culture, a "corporate culture" that encourages women, and Carnegie Mellon's academic environment which "has become a model of how to do it right. With no compromise to academic integrity, faculty and administration have made a conscious decision to change the culture" [Ramsey and McCorduck, 2005, p.17]. Such comments are of particular relevance to this thesis which claims that culture (and/or micro-cultures) and environment play a critical role in determining women's participation in CS.

[31] NCWIT is short for the National Center for Women and Information Technology: http://www.ncwit.org.ABI_Report.pdf

2.1. The Crisis in the Field of Computer Science. Examining gender through a cultural perspective may help to convey the message that *gender issues are really cultural issues that concern us all.* Ironically, evidence and support for this argument is now emerging from within the USA and other "developed nations", as we see a dramatic decline in the overall numbers of students, *men and women*, making the decision to enter the CS major. Arguably, concern for women's low enrollment preempted what is now an overall concern for the field. With continuing dismay, we have nevertheless become somewhat accustomed to seeing the ongoing decline in women's enrollment in CS over the past few years. This decline which shows that women's enrollment in the CS major has never returned to its national peak of around 37% in the mid-1980s. The 2004-2005 Taulbee survey notes "a decreasing proportion of female Bachelor's degrees, from 17.0% in 2003-04 to 14.7% in 2004-05" (see Figure 5.).

Figure 5. From 2004-2005 Taulbee Survey: Bachelor's Recipients in CS and CE (computer engineering) by Gender[32]

	CS	CE	CS & CE
Male	12,277 84.9%	2,548 87.6%	14,825 85.3%
Female	2,186 15.1%	360 12.4%	2,546 14.7%

The same survey shows that *the overall problem for all students* is not improving. Indeed, the Taulbee report declares "(W)e effectively have seen a halving of the number of new majors entering our programs over a three-year period. Total enrollment in Bachelor's programs is down nearly 14% from last year and 30% compared to three years ago".

Clearly, the US enrollment crisis in CS *is not a "women's issue"*, although we may well find that many of the factors that have been deterring women from entering the field, may also be deterring many men too. We need also to keep in mind that the declining enrollment of women in the US has been seriously low for some time, and is further exacerbated by overall trends. Women's participation in CS is truly fragile.

[32] Figure 9, chapter three, shows the specific results for Carnegie Mellon.

The "crisis" situation has triggered debates and discussions within CS communities across the nation as we saw in Morris and Lee's "The Incredibly Shrinking Pipeline Is Not Just for Women Anymore" [Morris and Lee, 2004]. Indeed, we are somehow failing to attract, educate and encourage the next generations of computer scientists, men and women, particularly at a time when computing technology is becoming even more integral to our scientific, economic and social infrastructure. Increased attention to declining numbers has brought a much needed re-examination of these fields and how they are perceived in the public consciousness. At the same time it has highlighted common grounds of concern.

One of the cultural issues to come to light in this re-examination is the public mis-perception of CS as conveyed through the current educational system. One (among several) of the fundamental misconceptions is that CS equals programming and/or computer applications. One of the biggest offenders here is the College Board's advanced placement (AP) tests in CS. Unlike AP tests in other fields—for example in biology, physics, and economics, where the tests (and the high school AP courses preparing for them) cover deep and even cutting-edge topics in the field—the AP CS test is almost devoid of deep intellectual content. Indeed, a perusal of sample tests provided by the College Board[33] shows that, for the most part, the tests focus on the idiosyncrasies of the programming language du jour. A student observing the content of the most advanced CS course in high school could hardly be blamed for thinking CS is programming. At the same time with the dot-com bust, many bright high school students may not be so excited by a future in programming. One suggestion is to replace the AP CS[34] with a course that includes programming but most importantly also exposes students to the breadth and depth of CS, perhaps along the lines of Andrew's Leap,[35] a summer program for high school students. Such a course could expand students' views of potential CS careers and

[33] See http://apcentral.collegeboard.com/
[34] At a minimum, the current AP test (and AP course) should be re-named "AP Programming."
[35] Andrew's Leap was created at Carnegie Mellon by Merrick Furst and developed by Steven Rudich to interest bright high school students in computer science. The Roboleap component is run by Matt Mason. Through special classes and independent projects, students are exposed to the frontiers of computer science. See: http://www.cs.cmu.edu/~leap/

attract many of the high school students taking advanced mathematics, half of whom today are female [Blum and Frieze, 2005].

Very few of the pioneers and current professors of CS were "hackers." Many were motivated by their interest in logic and in understanding intelligence and problem-solving. Today, in the twenty-first century, with the increasing ubiquity of computing, women and men with a broader and diverse vision and a deeper perspective are critical for the field and will drive its future. Our educational programs would do well to reflect that. In line with this philosophy, and practice, the criteria for admissions into the CS major at Carnegie Mellon was broadened in 1999[36] to allow for a more diverse student body, more diverse in terms of their own interests and more diverse in terms of gender [ibid. 2005].

The crisis in CS presents an ideal opportunity for broadening the scope of how we define, or re-define, the field, and how it is construed in the public consciousness. But, whether it is defined for example by its scientific aspects or by its engineering aspects, in order for real change to occur we need to recognize that these are cultural issues that concern us all.

2.2. Computer Science and Limitations of the Prevailing Research Approach. In her 1997 article "The Incredible Shrinking Pipeline" Tracy Camp brought gender and CS statistics to the foreground by documenting the widening gap between the numbers of girls and boys, and men and women, going into CS and beyond. The difference in numbers may have confirmed the assumption that if the numbers were dividing along gender lines then the sources must lie buried in, and among, the differences between men and women, and, in particular, the differences in how men and women relate to CS.

The gender and CS literature, that adopted this assumption, found a compatible niche in feminist gender literature that was already focusing on gender differences in the 1990's, as evidenced in the work of Sandra Harding, Sherry Turkle, Deborah Tannen, and Carol Gilligan. But perhaps the most influential literature came from Sue Rosser with her best

[36] This action was based in part on findings from the Margolis/Fisher research which concluded that prior programming experience was not a pre-requisite for success in the CS major.

seller "Female Friendly Science: Applying Women's Studies Methods and Theories to Attract Students", because it looked at women and science especially. The book draws on "women's ways of knowing" and inserts feminist scholarship and teaching into "masculinized" science [Rosser 1990]. In her 1995 book, "Teaching the Majority: Breaking the Gender Barrier in Science, Mathematics and Engineering", Rosser set out to pull together a "growing body of research" that proposed changing the way science was taught to include approaches that suited women [Rosser, 1995]. We suggest it is important to see the "gender difference" literature in the context of its time, a time when such thinking was popular in the broad culture and considered by some to be an important strategy for increasing the participation of women in science.[37]

However some of this literature appears to have inherent contradictions as well as a tendency to group all women into one category. For example, researchers often note how strategies that work well for women can work for the benefit of a broad base of students, and for encouraging diversity in general[38] [Eastman, McCullough, in Rosser 1995]. Such observations are very important. But the literature goes on to insist that some strategies *appeal to women specifically*: "(n)umerous studies have documented the attraction of science for females when they can perceive its social usefulness for human beings" [Rosser 2005]. In this way social responsibility is taken out of the broad cultural sphere that we all inhabit and categorized as "female" and labeled as women's work. This framework of thinking is extended to CS by ensuing investigations that adopt a gender difference belief and declare with certainty that "(m)ales and females differ in their use of computers and their approaches" [Eastman, in Rosser 1995].

To illustrate one way in which the "gender difference" literature has co-opted CS issues, we use a 1999 paper by Danielle R. Bernstein, "Java, Women and the Culture of Computing" (our italics):

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[37] Indeed on a panel at the 2006 Grace Hopper conference when the audience made it clear that the term "female-friendly science" may no longer be welcomed by many women, Rosser herself suggested that we may be entering a "transition" phase.

[38] For example: teachers are encouraged to use large type to make reading homework easier, teachers are encouraged to provide group projects, teachers are encouraged to include a range of successful role models of different races and genders, etc..

> “Every field has a culture, a language, buzzwords and expectations. But the importance of culture takes on more prominence in computing because so much of the subject is learned outside the formal classroom setting. *In particular, women and men have differing expectations and relationship towards computing. Women use computers as tools; they are interested in working with computers purposefully. Men look at computers as toys*. This paper will discuss the culture and language of computing and the disparate impact of the culture on female and male students” [Bernstein, 1999].

First, the paper proposes to discuss the culture of computing. However, it focuses on a specific kind of computing culture, and limits itself to *the study of hacking or geek culture* in which, for the most part, computing is equated with programming. Bernstein’s paper is not about CS (nor does she claim it to be) but the distinctions between computing, CS, and programming are not always made clear. This specific kind of *hacking or geek computing culture* appears to support a specific type of (male) student who exhibits great programming proclivity. It is within this culture that the perceived gender divide most often emerges. Subsequently, the divide is attributed to gender differences and the different ways in which men and women relate to computing.

We suggest, and have evidence to show, that when we examine a different kind of computing culture, one in which balance predominates, balance in terms of gender, in terms of opportunities afforded all students, and inclusive of a wider range of students (men and women), gender differences can be seen to dissolve and gender similarities and a spectrum of attitudes towards computing can emerge. We will illustrate this with our research findings in Chapter 3.

Bernstein re-presents an image of the culture of computing, in which CS is equated with programming, and programming is the domain of a specific group of men who set the language and the terms of engagement with, or detachment from, the field. This sounds very much like the stereotypical mis-representation of the field that is widely circulated in popular culture, and which, for the most part (particularly in the US), is largely due to how CS (or what is perceived as CS) is often taught in K-12 education. As mentioned earlier this results in the perpetuation of a limited view of the field and those who work in it and does not appear to offer a broadly viable and attractive option of study.

Bernstein does suggest that the culture of computing can be changed. She sees a potential for change in changing the language of computing: “Language is the mediator of human values and expectations. Language transmits cultural values and its metaphors shape a field. The language of computing, the words used to describe the processes and systems, has been violent from the beginning of the field. Much has been taken from military analogies and language where the computing culture originates. These military analogies persist and are carried on by young men …” This certainly rings true and we agree with Bernstein’s notion that language is a powerful mediator of cultural values.

However, Bernstein’s recommendation for changing the culture is to change the language to accommodate (perceived) gender differences, in particular to introduce, or replace, what is perceived as men’s language and interests with what is perceived as women’s language and interests. She suggests using sewing, quilting or knitting terminology pointing out that in “the early 1980s, there was a serious attempt to change the analogies to female imagery and skills, such as knitting and sewing (Boden, 1987). The language of knitting was used as an example of a procedural programming language” [ibid. 1999]. This strategy may or may not work, but it would certainly lend itself to perpetuating a gender divide. Bernstein herself points out that when she asked her students for terms to describe programming they came up with the following: “Needs patience, Frustrating, Logical, Abstract, Delicate, Language from another planet, Stressful, Tedious, and Time consuming”. Bernstein points out that these phrases “do not describe traditional male activities” yet surprisingly she goes on to dismiss this input and asks “why code warriors, why not code quilters?” [ibid. 1999].

Bernstein’s paper may be somewhat extreme in its gender dichotomous recommendations but it also represents a viewpoint which is common among the gender and CS community. She is not alone in believing that “it is well recognized that women and men are attracted to computing for different reasons. Women are concerned about the context in which the software will be used. They want their work to have a purpose beyond the specific program they need to write" [ibid. 1999]. There are several problems with this contention: 1. it is based on the stereotypical hacking culture, 2. it re-presents a narrow view of the field, 3. it collapses all men into the type of (male) mentioned earlier who fit this kind of culture, 4. it collapses all women into the type of women who don't fit this culture. This viewpoint may serve to reinforce and perpetuate differences and certainly does very little towards understanding the complex factors involved.

The 1995-1999 research at Carnegie Mellon, funded by NSF, also adopted a gender difference approach. The researchers "set out to understand the different ways men and women approach and experience computing in college and beforehand" [Margolis and Fisher, 2002, p.3]. The study came up with some transformational recommendations which contributed to the increased numbers of women in CS at Carnegie Mellon. Specifically they found that students did not need a background in programming in order to be successful in the field. This meant that admissions could be opened up to a broader group of prospective students. Without doubt this was a ground breaking finding.

The study also arrived at some conclusions which have caught the attention of the CS and gender community, and have come to epitomize the different ways in which men and women relate to CS. "Students motivation to study computer science varies by gender. For most women students, the technical aspects of computing are interesting, but the study of computer science is made meaningful by its connections to other fields. Men are more likely to view their decision to study computer science as a no-brainer, an extension of their hobby and lifelong passion for computing" [ibid. p. 49]. This finding was summarized as a gender divide: "computing with a purpose" (women) and "dreaming in code" (men), and has been circulated widely as such. This finding has subsequently been interpreted, *whether intentional or not*, as a recommendation to contextualize the curriculum to accommodate the perceived needs of women in order to attract more women into the field.[39]

[39] The 2006 Microsoft Research report, "The Future of Information Technology", illustrates an example of how *Unlocking the Clubhouse* has been mis-interpreted in relation to what has been done at Carnegie Mellon. In a section on "Encouraging Practices that Encourage Women", the report lists "Six Things that Made a Difference at CMU" including "Contextualizing Computer Science with Curriculum placing

> “The perspective that computer science can make itself stronger by incorporating the values typical of women in the field changes the question from ‘How can women change to fit into computer science?’ to ‘how can computer science change to attract more women?’” [Margolis and Fisher, 2002].

Findings from our 2004 case study at Carnegie Mellon lead us to question such a recommendation. Whether or not it is a good idea to incorporate applications into a particular course should depend on whether it makes sense for the subject matter, for the intellectual and technical skills to be developed, and/or for pedagogical purposes, not as a presumed means to promote gender equity [Blum and Frieze, 2005].

The recommendations arising out of the 1990’s study (or how the work has been interpreted) may well ring true to others in CS departments across the nation for several reasons: by default there may be few women in the department (and numbers do make a difference in shaping attitudes as we have argued earlier), CS may be being narrowly defined with an emphasis on programming, and/or the women may not have a sense of themselves as fitting into the academic and social environment, or a sense of having value and ability within the department.

The early pre-1999 studies of undergraduates at Carnegie Mellon suggested that being focused on coding and the machine itself was a male characteristic. In contrast, as we will illustrate in Chapter 3, in the class of 2004 representative cohort, comprised of men and women with broad interests, we did not see this at all. Thus, it seems unwise to generalize from the attitudes of the pre-1999 students[40], especially as they had been admitted for their programming expertise. Such admissions criteria would tend to both favor “geek”[41]

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technology in the context of its real-world uses and impact, increased relevance and need” p.18. Conversations with senior faculty at Carnegie Mellon deny that such strategies were ever adopted for women but rather if any “real-world” applications were included they were included as good overall teaching practices, not for women.

[40] The authors claim “While Carnegie Mellon is particularly competitive and selective, we believe our findings to be transferable to other settings” [Margolis and Fisher, 2002, p.9].

[41] The word “geek” seems to have entered the vernacular in the 1990s as a label for computer obsessed individuals. Although, the word is often used disparagingly, the moniker is also worn with pride within the computing culture. For an interesting definition of “geek” see http://dictionary.reference.com/search?q=geek

personality types and support the well documented “geek” culture of computing that had been so prevalent here in years past [Sproull, Kiesler and Zubrow 2002, Margolis and Fisher 2002]. This pre-1999 group was not only a very specific group of students, but also included a very specific group of men.

Evidence to show that the findings from the 1990’s study are still having impact can be seen in many places. In a paper from SIGCSE[42] 2005 “Climbing on the Shoulders of Giants”, which describes a substantial NSF funded study of “gender-based differences”, [Lopez *et al*, 2005], the authors are particularly interested in exploring the finding that women want “computing with a purpose”. These authors are not alone in perpetuating this notion.[43]

A 2004 paper describes a CS course, “A CS1 Course Designed to address Interests of Women”, that Georgia Tech researchers developed for non-CS majors [Rich et al, 2004]. The course was designed specifically to address the (perceived) interests of women – “creativity”, “relevance”, and “collaboration”. The course designers were adopting recommendations derived from gender and CS studies, and in particular those studies which recommend contextualizing the curriculum for women.[44] They found that “Of the 121 students who took the course (2/3 female), only three students dropped (all male)”, which supposedly gives credence to the perceived need to contextualize the course for women.

In contrast, in our 2004 case study at Carnegie Mellon, we found that most students in our representative cohort, *men and women*, were interested in the applications of CS, and indeed we suggest that the factors of interest addressed on behalf of women, “creativity”,

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[42] SIGCSE is the ACM annual conference for the Special Interest Group for Computer Science Education.
[43] The “Fall” noted in the paper “The Rise and Fall: Women and Computer Science” is attributed to gender differences as set out in *Unlocking the Clubhouse: Women in Computing* [Matsui and Chilana, 2004]. A 2006 Grace Hopper Celebration of Women in Computing panel session: “Riding the Technology Wave: Computer Scientists Building a Better Tomorrow” aligns “socially responsible” computing with women based on the findings of the 1990’s Carnegie Mellon study.
[44] Two studies are referred to: the Carnegie Mellon studies 1995-1999 culminated in the book *Unlocking the Clubhouse*, MIT Press, 2002, and AAUW. *Tech-Savvy: Educating Girls in the New Computer Age*, American Association of University Women Education Foundation, New York, 2000

“relevance”, and “collaboration” would be of interest to many men too. We have found no evidence to suggest that such factors relate to women’s characteristics nor have we found a need to contextualize the curriculum for gender fairness. Hazzan and Dubinsky’s case study of the software engineering industry corroborates our view (see 2.4.), showing that it is a myth to view “collaboration” as a characteristic of women.

One of the reasons stated for designing the Georgia Tech course was that the original course for non-CS majors had the reputation of being “extremely difficult” and “time consuming”. If the new course was designed specifically for women, it suggests that women do not have the ability to cope with “difficult” work and the time challenges involved. In contrast our research findings show that while women (and men) may complain about difficult and time consuming workloads these factors do not deter them from the field, and indeed such challenges become a source of pride and success.

In a 2006 intensive national study examining the retention rates of undergraduate women in computing, J. McGraph Cohoon, reported findings similar to our own, that contradicted past hypotheses:

> “Based on reports of students leaving STEM[45] majors because they required too much work or too narrow a focus (Seymour and Hewitt 1997), we had expected women to be disadvantaged in departments where faculty both expected many hours of homework per week and believed that student success required limiting extracurricular activities. Neither of these expectations were met; instead, women were retained at relatively higher rates in these departments” [McGraph Cohoon, 2006, p.225].

The course[46] described by the Georgia Tech researchers may well attract a significant number of women and turn out to be a very interesting class. However, we suggest it is based on questionable recommendations that accommodate perceived gender differences,

[45] STEM refers to Science, Technology, Engineering and Math.
[46] We do not see any evidence that Georgia Tech is now offering this course in the way it was described i.e. to address the interests of women.

and serves to perpetuate cultural mis-representations of women's intellectual ability and attitudes.

Thus, what is in reality a complex cultural issue is reduced to an issue of gender differences, and *in this case* resulting in what might be seen as a "dumbing-down" of the curriculum to suit women. This is an example of how the popularity of theories of gender differences applies to CS and how the tendency to accommodate perceived gender differences, *may actually serve to reinforce traditional assumptions about girls' and women's abilities and interests with regards to CS.*

2.3. Computer Science and Gender Myths. After exploring some of the limitations of gender difference research and how it applies to CS we now turn our attention to CS and gender myths. In their report written for the National Center for Women in Information Technology (NCWIT), Nancy Ramsey and Pamela McCorduck point to several myths they uncovered. From interviews with women who are, or have been, in computing-related fields they learn that women's love of, and positive attachment to, the field was never in question. These researchers suggest that women's low participation is due to "circumstances (that) are almost entirely cultural" and have "nearly nothing to do with the appeal, challenge, and excitement of the work itself" [Ramsey and McCorduck, 2005].

Some of the myths they revealed relate to perceived views that women are deterred by long hours, elements of risk, and competition. "Several of them cited the competition and the long hours to finish a project as a marvelous stimulant, a valued part of their professional lives. We want to make this explicit because the ideas that women don't like or can't thrive under competition, or prefer to avoid risk, or find long hours difficult, are simply more stereotypes" [ibid. p.14]. Making these points "explicit" is particularly important. It is all too often argued that women who are successful in fields where they are underrepresented, are simply anomalies, or "exceptions" to the rule, which is another way of feeding into the gender differences track, suggesting women do not, or should not, normally fit into the field.

Another interesting illustration of myths that have evolved around the perceived "characteristics of women" is presented by Hazzan and Dubinsky. Their case study comes from a micro-culture within the software engineering industry. It has been suggested that *collaboration* fits "women's style" because women are more communicative. However, the agile approach for software engineering, which promotes communication and gives rise to collaboration, was designed to improve software development in general, not to suit "women's style". Hazzan and Dubinsky found that men and women were equally communicative, and equally collaborative, when using the agile approach to software development projects. Thus, we see how the agile approach towards software development, *formulated to address problems in the software industry* and *not in order to meet women's needs,* creates an environment in which women and men behave similarly to the benefit of all. The example also serves to show that the "style" attributed to women is actually a style developed within the micro-culture of the software development industry which, not surprisingly, is currently male dominated. This example not only reveals a myth, but also shows how paying attention to culture and environment can reveal the unexpected; specifically we become aware of gender similarities and the common work practices built into a micro-culture that allows for diversity and the Women-CS fit [Hazzan and Dubinsky, 2006].

The TechBridgeWorld[47] program at Carnegie Mellon embodies a major challenge to gender difference myths and to gender-CS myths in particular. The program "innovates and implements technology solutions to meet sustainable development needs around the world". A glimpse at the courses on offer, from "Technology Consulting in the Community" to the new V-Unit, which enables "students and faculty 'to grow a Vision' of what computer science and technology can concretely do for society" indicates the strong social responsibility component integrated into the program. It has long been thought that women are more attracted to socially relevant coursework than men, a myth which perpetuates a gender divide and serves to situate social responsibility as women's work. The TechBridgeWorld program, and especially its V-Unit courses, has both men and women participating in roughly equal numbers. This shows that in a computing culture that allows for such participation and provides these opportunities men and

[47] For more on TechBridgeWorld visit the web site: http://www.techbridgeworld.org/courses/index.html

women share common ground, not gender differences, in applying computing technologies in socially responsible ways.

2.4. Computer Science and Gender Balance. We saw earlier in this chapter, sections 1.6 and 1.7, that the ratio of men to women in any given situation can impact how we experience the world around us and how others perceive us. We now look at numbers in relation to CS specifically. Some studies point to *isolation* as a primary factor negatively impacting the experience and performance of women and minorities in computing [Eskovitz, 2000, Taylor, 2002]. A 2006 nationwide study of undergraduate departments by Joanne McGraph Cohoon, provided concrete data to show that "environmental conditions in computer science programs are related to the balance of men and women enrolled" [McGraph Cohoon, 2006, p.206]. McGraph Cohoon concluded that "Of all the factors we considered, available same-sex peer support, measured as the female portion of enrollment, had the strongest relationship with gendered attrition rates" [ibid. p.216].

The findings of these researchers add further evidence for caution *against generalizing* from the attitudes of *women in a minority situation*, to *women in general*. We know there are few women in CS thus, *by default*, as mentioned earlier the majority of studies addressing this issue, including the early 1995-1999 study at Carnegie Mellon, have been conducted in *situations where there are either relatively few women participants or single sex situations.* This standpoint limits our understanding and can be misleading in the recommendations that ensue.

Section 3: Countries and Computing Cultures

This thesis argues, and provides evidence to show, that where cultural conditions *allow for* diversity, and where women are perceived, and perceive themselves, as capable of doing CS (or any science), the Women-CS fit is visible and active. By looking at different cultures around the world, and subcultures within the USA, we can see some positive pictures of women participating in CS and computing fields. That said, this is not the major trend. Nevertheless, the fact that women's participation does vary across cultures and countries, provides evidence to illustrate culture and environment as determinants of girls' and women's choices and participation in CS. In this section we offer an overview of the findings of several "cultural" researchers as further evidence.

However, as we examine studies from around the world, and even closer to home, it soon becomes clear that definitions of CS vary. In discussions about participation in computing related fields, there is often ambiguity about what fields we are actually talking about. This is not surprising, because of the newness and interdisciplinary nature of the fields and the changing and expanding boundaries.[48] But it can lead to confusion, particularly when data and findings about (and programs to increase) participation in "computer science" are sometimes used interchangeably with like data about "information technology" (IT). While many of the issues are similar, not all are, and the fields they refer to are not the same. The National Center for Women and IT (NCWIT) defines[49] IT broadly as: "1) all forms of technology used to create, store, exchange and use information in its various forms; and 2) the design and use of computers and communications to improve the way we live, learn, work and play". Computer scientists might or might not agree that this includes CS.[50] For example, computer scientists who work in the more theoretical and foundational aspects of CS, such as complexity theory or the theory of computation, might not. Other computer scientists might think that areas often considered IT, such as managing information in large corporations, are far removed from core CS [Blum et al, 2006].

In this chapter the closest comparisons to our 2004 case study of *traditional* CS presented later (undergraduates at Carnegie Mellon, Pittsburgh) are the case studies from Qatar and

[48] For example, the Carnegie Mellon School of Computer Science (SCS) is comprised of seven interrelated departments. In addition to "core" CS, these departments include robotics, software engineering, human computer interaction, language technologies, machine learning and entertainment technology.

[49] See: http://www.ncwit.org/Prospectus.pdf

[50] Herbert Simon defined computer science as "the theory and design of computers, as well as the phenomena arising from them." The Wikipedia is a source of various views of the fields (http://en.wikipedia.org/wiki/Computer_science): Computer science rarely refers to the study of computers themselves. The renowned computer scientist Edsger Dijkstra is often quoted as saying, "Computer science is no more about computers than astronomy is about telescopes." The study of computer hardware is usually called computer engineering, and the study of commercial computer systems and their deployment is often called information technology or information systems.

from Israel. Nevertheless, we believe that other studies of cultures and computing do have relevance to our argument. They offer valuable evidence to show the impact of culture and environment, they offer compelling challenges to any essentialist arguments, and they offer an alternative perspective to “gender difference thinking”.

On the global scale, most women, indeed most men too, do not have access to CS education and/or the broader information and communications technologies. From this standpoint our studies of cultures and computing around the world are limited. Our research is also bounded by “a paucity of internationally comparable data” [Charles and Bradley, 2006 p.186]. At the same time, “available evidence indicates that when women do have access to ICTs (Information and Communication Technologies), they can substantially improve their lives and increase their income” [Huyer, 2005]. Thus, our perspective can point to implications beyond academic investigations of cultural comparisons. Our review of women’s participation, and the multitude of variables involved, is by necessity shaped by the paucity of available data, and the inability to compare like with like. Nevertheless we feel this information has value as evidence for a multiplicity of cultural factors outside of gender that affect women’s participation in computing-related disciplines. We also believe this review of cross-cultural research initiates an important direction towards a cultural perspective. We are particularly interested to find that among the studies we have been able to gather, the stories are often quite surprising and certainly unexpected in light of the declining participation of women in the US and many parts of the western developed world.

3.1. A Global Perspective. Vashti Galpin describes the participation of women in undergraduate computing in more than 30 countries. She found that generally, participation is low and most countries fall in the 10%-40% range with a few below 10% and a few above 40% [Galpin, 2002]. But Galpin agrees with the premise of our thesis that cultural factors are significant: “The reasons that women choose to study computing will vary from culture to culture, and from country to country” [ibid]. She also reminds us that when we are “seeking solutions for women’s low participation in computing, it is important to consider all cultural and societal factors that may affect this participation”. Her 2002 findings offer no single consistent theory for the low, or higher, representation of women, nor should we expect one as there are so many variables to consider. Nor should we assume that what works in one country, or cultural environment, will work in another.

Galpin found the highest participation of women in computing related programs of study was in Thailand (55%), Guyana (54.5%), Malaysia (51.4%), Singapore (50%), Iran (41%), Zimbabwe (40.7%), and Mexico (39.2%). She found the lowest participation in Denmark (6%), Netherlands (6.6%), Slovenia (6.7%), and Tanzania (3%). We see no definite patterns emerging from her tables of data, except to note that among the South American countries with data, the percentages were all above 30% and the western industrialized nations below that. To put this in perspective, the latest figures from the NSF survey for the USA show that women's share of CS bachelor's degrees was at 27 % for 2002, and at 18% for PhD granting universities.[51] The 2004-2005 Taulbee survey of PhD granting universities shows that the percentage of CS bachelors' awarded to women was 14.7% in 2004-2005.[52]

Galpin gathers together a wide array of seemingly incongruous factors and comparisons among and between many countries. For example, in Thailand, Italy, and Kenya, *women are found to be less anxious* about computers than their male peers. The reverse is true for Israel and Hungary. There were significantly *fewer female technophobes* in Kenya, while the reverse is true for the USA, Hungary and Australia. In Indonesia *women had more experience with computing* than their male peers. She also mentions that in terms of attitudes to computers there were *fewer gender-based differences* between Chinese students than between Canadian students [ibid.].

Another "meta-analysis" comes from Britta Schinzel who looks at female enrollment in CS around the world and again notes a multiplicity of reasons that account for higher and lower rates of female participation. Schinzel agrees with our argument that participation in CS is "culturally diversified", and not the result of deep rooted gender characteristics,

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[51] See CRN report, http://www.cra.org/CRN/articles/may05/vegso
[52] 2004-05 Taulbee Survey: http://www.cra.org/CRN/articles/may06/figures.html

"there is no evidence for natural explanations of competence and interest in computing, as well as in mathematical and technical subjects" [Schinzel, 2002].

Schinzel notes single-sex education as a factor in the North African and Arabic countries where there is an "extremely high participation of women in CS". She highlights the fact that there is "no coeducation at any level of education in these countries" [ibid.]. She also describes how in countries with good gender distribution in computing like India, Brazil, and Argentina, "there seems to be no conviction like in the Northwest, stereotyping women as less capable of pursuing education in science and technology". Indeed this is something we hear frequently in discussions with international graduate students who are surprised to find few women in computing fields in the USA.[53] Although many "developing" countries would not be held up as models of gender equity, it does seem that when women and girls are fortunate enough to be educated they are not assumed to "think differently" to their male peers about math and science, nor are they perceived as less suited intellectually to CS.

Schinzel notes rising interest in India, China, the Latin countries, South Korea, Taiwan, Singapore and Hong Kong, and declining interest in the USA, the UK, Israel, Scandanavia, Germany. She points to a general declining interest in Europe except for Italy, Portugal, and Spain, so that even within Europe the situation differs according to the culture of the region. Like Galpin, Schinzel points out the marked low participation in the developed world. "It is interesting to note that many of the so called industrially developed countries are comparatively underdeveloped as far as the inclusion of women into these subjects is concerned" [ibid.]. Later, when we look at the contribution of researchers Charles and Bradley, we include one of their explanations for this situation.

Schinzel points to three interesting sets of factors based in culture and environment that she believes are important to observe: the *economic/political system, religion and gender roles,* and *dressing/describing the field.* Below we summarize these three sets of factors.

[53] Here we refer to informal discussions that take place during regular *Women@SCS* graduate meetings.

- *Economic/political system.* Schinzel notes that socialist countries had at one time equal numbers of men and women in computing education and careers. This was a result of communist policies which insisted on gender equality; women and men were trained equally for the job market (98% of women were in the workforce), whole day kindergartens were provided, and students were trained for the work market, with emphasis on science and engineering. This changed after the fall of socialism. Schinzel illustrates this by referring to what happened in Germany. During the 1980s and 1990s there was a marked decline in the numbers of women going into computing fields in Germany, while participation was equally distributed in the former GDR (German Democratic Republic or East Germany). With the fall of the Berlin wall and the reunion of Germany, what was GDR soon followed the West German model. There was, says, Schinzel, an "explicit policy to draw women from the job market". Kindergartens were closed, and "politicians declared that female work had to reduce to normal", which meant reducing the female workforce to the size of West Germany. Subsequently the participation of women in computing fields fell to well below 20% [ibid].

- *Religion and Gender Roles*. Schinzel has something very interesting to say about the part played by religion and gender roles in relation to CS. Women participate in computing in Italy and the Catholic countries of South America, at a much higher rate than in the USA, UK, Germany, and the protestant countries. She suggests that one explanation for this may be that in the Catholic countries men and women are confident in their gender roles. They have a strong sense of their different gender roles which are played out quite publicly, e.g. in behaviors and dress. Because of this they have no need to construct gendered educational and intellectual characteristics. In the US and other western countries, where we have *perceived freedom from such gender dichotomy*, we develop less confidence in our gender identification, a situation which opens the doors for the construction of gendered values in education and careers. This may be why computing, and high paying, valuable jobs, become associated with the "masculine" and girls and women become easily discouraged from entering these fields [ibid.].

- *Dressing/describing the Field*. Schinzel illustrates this finding by reference to a case study in a German province. When computing is perceived as social/interdisciplinary and labeled or described as such (e.g. in the course title), women are more likely to enter the field. When jobs are labeled too narrowly (e.g. "engineering"), the social/interdisciplinary nature is hidden from view, even though the subject requires knowledge of, and application to, other fields. Women are turned off by this labeling or "dressing" as Schinzel calls it. "The more emphasis in "dressing" and description is put on technology and engineering, the less women are interested, the more the subject is considered as interdisciplinary, the more it is put into social context, the more women are participating, even if the subject is mostly technical" [ibid].

We also argue that the image of the field (or "dressing" as Schinzel calls it) is an important factor in attracting or deterring some girls (and boys) and some women (and men) from considering computing fields. We suggest a need to diversify the images of CS[54]; by showing the breadth of the field and the potential for diverse participants. While some might argue that "dressing" simply *accommodates difference,* we suggest that it may actually give a *more realistic picture of the field,* since the popular representation of CS is so reductive and misleading. We suggest that re-presenting or "dressing" the field to show its breadth, possibilities, and potential for diverse participants, may not only help attract more women, but also a broader spectrum of men. Our preferred use of "dressing" would not accommodate any deep rooted belief in gender differences, nor would it suggest changing the field to suit women, rather it would take advantage of a culture in which images have tremendous impact for shaping the public understanding of what CS really means.

3.2. Some Industrialized Nations. A study by Maria Charles and Karen Bradley, which fits closely with our definition of culture, examines gender ratios in CS in 21 *industrialized nations*. They found more men gain degrees in CS overall, however, there were significant differences in the gender gap in different counties to provide evidence to

[54] See Chapter 4, Section 2, for examples of our Outreach programs to diversify the images of Computer Science.

“support an emphasis on cultural processes” [Charles and Bradley, 2006, p.193]. Charles and Bradley base their analysis on neoinstitutional theory “which emphasizes the importance of cultural ideas and belief systems in motivating the development of specific organizational forms as well as shaping people’s interests, aptitudes, and behaviors” [ibid. p.183]. The researchers point in particular to the 20th century rise of a “liberal-egalitarian” belief system, which predominates in western cultures, and which allows two apparently contradictory viewpoints to co-exist. On one hand is the idea that women and men have equal rights and value, a product of what the researchers refer to as progressive egalitarian views. On the other hand we see the persistence of “gender essentialism”, the idea that men and women are fundamentally different and therefore suited to different tasks. If we look closely the former viewpoint allows for the latter essentialist views to persist, especially as they are now placed in the context of equality, and thus perceived as “natural”. This means they become more difficult to challenge because anything perceived as “natural” easily becomes entrenched in our thinking.

Charles and Grusky suggest that this kind of thinking explains how “liberal-egalitarian” policies have resulted in more “opportunities” for women. In reality what has emerged are more women in the low-end, low paid workforce, and “female-friendly” education, specifically designed to accommodate what are thought to be women’s work choices and women’s attitudes. In terms of careers, we have seen the growth of access to training for female-gendered jobs/careers (service industries and childcare are good examples) but which are in reality the creation of “occupational ghettos” [Charles and Grusky, 2004]. The “liberal-egalitarian” policies, and a belief in separate but equal, that Charles and Bradley make visible help to perpetuate the “difference thinking” that we mentioned earlier. In this context a belief in gender differences thrives to the disadvantage of most women, and, ultimately, to society as a whole.

Charles and Bradley found that women were underrepresented in computing fields in all of the 21 industrialized countries they examined.[55] The degree of male overrepresentation

[55] The 21 industrialized countries include mostly affluent western countries but “differ in their levels of economic, social histories, and cultural traditions” [Charles and Bradley, 2006 p.187].

ranged from 1.79 in Turkey (the lowest) to 6.42 in the Czech Republic (the highest representation in computing fields). The researchers had expected to find less gender segregation in CS than in engineering which had a long established history of gender imbalance. They theorized that a new area of study like CS, built within the more modern context of increased gender equity, would reflect a more modern viewpoint in the industrialized nations. However it seems that CS succumbed quickly to stereotypical gender labeling in which its association with logic, machines, and mathematical reasoning, are defined as masculine.

Turkey, Ireland and Korea, had the best female representation in the countries that Charles and Bradley studied. These researchers see gender-appropriateness as a driving force in many industrialized nations: "modern economies support gender-specific career aspirations, and the realization of those aspirations. The consolidation of female niches within the academy and the economy reinforces cultural stereotypes" [Charles and Bradley, 2006, p.195]. Not surprisingly such insights face resistance from a western viewpoint that sees women participating in many areas in increased numbers and with greater influence and thus associates modern western economies with progress on gender equity.

> "To understand women's extreme underrepresentation in computer science and other technical fields today we must avoid equating the rise of liberal egalitarianism with the erosion of gender essentialism" [Charles and Bradley, 2006, p.196].

Another aspect of "liberal-egalitarian" principles which appears to perpetuate the cycle of gender-specific careers and aspirations, is freedom of choice. "The proliferation of choices in modern educational systems in turn provides more options for accommodating gender-specific preferences" [ibid. p.195]. Thus, progress towards egalitarianism allows for greater freedom of choice, but within a gender appropriate framework. The highest levels of women's participation in CS are found in those countries in which the national government exerts control over the curriculum, where, for example, boys and girls *are required to study math and science through high school.*

Ultimately Charles and Bradley believe, as we do, that gender essentialist cultural values, persisting in what we have called difference thinking, are deterring women's entry into CS programs [ibid. p.193]. This calls for institutional change.

3.3. The Case of Mauritius. In a single country case study Joel C. Adams, Vimala Bauer, and Shakuntala Baichoo showed that on the tiny island of Mauritius, women were entering and graduating in computing related fields at rates comparable to their proportion in the general population. In Mauritius students are matched to programs on the basis of ability and interest with no efforts to attract women in particular. The study found that contrary to other studies role models at the university were *not* significant, but in line with other studies single-sex education in high school may have played a part. The researchers concluded that "while the problem is wide-spread, the under-representation of women in CS is not a universal problem. It is a problem confined to specific countries and cultures" [Adams, et al., 2003, p.59].

3.4. The Case of Malaysia. Similarly, Mazliza Othman and Rodziah Latih studied a single population, this time the population of Malaysia, where they found that women are participating in equal numbers to men in undergraduate degrees and choosing to work in CS/IT fields. They theorize that the high representation of women has a lot to do with the field not being seen as a masculine field. "Young females in many parts of the world perceive CS as a masculine field—a perception we contend is not shared by their Malaysian counterparts" [Othman and Latih, 2006, p.111]. Unlike the Mauritius case study these researchers found no shortage of faculty role models. What was most pronounced was the students' attitudes that "pursuing a career in CS/IT is a normal, indeed, unremarkable option" [ibid. p.114].

3.5. An Australian Case. When Clarke and Teague examined women's participation in CS in Deakin University, Australia, they found a much higher proportion of women from overseas (Singapore, Hong Kong, Malaysia) than from Australia itself. The overall ratios of men to women in CS in Australia seem very similar to the ratios in the USA. At Deakin University, Clarke and Teague noted that overseas students "do not see computing as a male occupation and that they receive direct encouragement from their families to pursue post-secondary studies in computer science" [Clarke and Teague, 1994]. When Margolis and Fisher studied undergraduates in CS at Carnegie Mellon University, they found some similar cultural factors specific to the international students they interviewed. These students were more likely to have economic motivations, rather than "free choice" or personal satisfaction, to study CS and get good jobs; they had a belief in hard work, effort, and persistence as the route to success rather than innate ability, and they had usually been on a "non-gendered" math/science track back home which they felt prepared them well for CS studies. The women from the USA on the other hand were more likely to have *chosen* CS and have a belief in innate ability over effort, and more likely to opt out when they felt their innate ability did not match their male peers [Margolis and Fisher, 1999]. Their findings, like those of Clarke and Teague, clearly illustrate that cultural factors are playing a role in women's participation, or non-participation, in computing fields.

3.6. Two Case Studies from Eastern Cultures. In this section we consider two cases which illustrate the Women-CS fit within Eastern cultures. These case studies share a similar definition of CS to the one in our 2004 case study of undergraduates at Carnegie Mellon University, Pittsburgh, USA.

- **The Case of Jewish and Arab Israeli High Schools.** This case study, from within an Eastern culture, focuses on Jewish and Arab *Israeli high school CS classes*, and is based on the work of Eidelman and Hazzan [Eidelman and Hazzan, 2005] and included in our joint paper [Blum et al, 2006]. Most Jewish and Arab students in Israel attend separate educational systems with similar curricula in most subjects. Specifically, the high-level[56] CS classes are all coed, the syllabus is identical in both systems and the only differences are in the teaching language and the language of the matriculation exam.

Eidelman and Hazzan studied a population of 146 12th grade high-level CS students from 9 typical high schools from both sectors (5 schools from the Jewish sector, 4 schools from Arab sector). In the Jewish sector 28% of the students were female, in the Arab sector 61% were; that is, while female high school students in the Jewish sector are under represented in higher level CS classes, they are highly represented in the Arab sector [Eidelman and Hazzan, 2005].

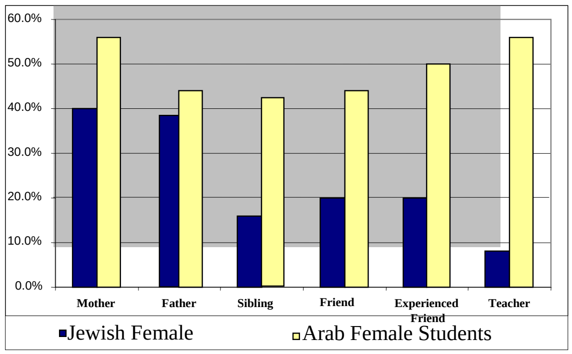
In order to illustrate the Women-CS fit, the focus here is on one specific cultural factor, ‘support and encouragement’, which is one explanation for the difference in the participation of female students in the two sectors [ibid.]. One of the questions students were asked was: “Who encouraged you to choose computer science studies?” Figure 6 presents the distribution of the answers to this question, showing an unequivocal conclusion: Arab female high school students receive much more encouragement to choose CS than do their Jewish counterparts. Specifically, Arab female high school students are encouraged more by their mothers (56% vs. 40%), fathers (44% vs. 40%), siblings (44% vs. 16%), friends (44% vs. 20%), acquaintances who had studied CS (50% vs. 20%) and – with the greatest difference – by their teachers (56% vs. 8%). This broad based network of encouragement that the Arab female students receive is supported by additional data [ibid.].

The noticeable differences in the extent of encouragement Arab female students receive from various agents can be explained by looking at findings from other studies that have explored *cultural and familial* differences between Arab and Jewish adolescents [Peleg-Popko, Klingman, and Nahhas, 2003]. According to these studies, since Arab students are part of an Eastern collective culture, as well as a minority group in Israel, it is likely that they are strongly encouraged by their parents to higher scholastic achievement in order to improve their social status. In addition, Arab students perceive their family environment

[56] The high-level CS course offered in Israel is similar to the AP course in the USA but offers broader material than the AP course. However, the high-level course does not exempt students from the introductory CS course on entrance to Israeli universities.

as more authoritarian than do their Jewish counterparts. The hierarchical structure of the Arab family is based on age and traditionally requires the young to obey the old and adhere to their expectations [Peleg-Popko *et al.*, 2003].

Figure 6. Percentages of Females' Encouragement by Others



As this case study reveals, different social and cultural attitudes towards support and encouragement of female students studying CS can contribute to different levels of participation.

- **The Case of Carnegie Mellon Qatar**. Another Eastern case is taken from Qatar and is based on the work of M.B. Dias and included in our joint paper [Blum et al, 2006]. In the fall 2004, Carnegie Mellon opened a campus in Qatar (CMU-Q), offering an undergraduate major in CS with the same curriculum as its campus in Pittsburgh. We have yet to determine how cohorts of students on each campus can be compared, because of newness of the Qatar program and since there are so many variables to consider. Certainly, as the program progresses and evolves, this will be interesting to study. But in the cultural context of this chapter, we can already present some interesting observations, particularly since women outnumber men in the Qatar CS program. While the reasons for larger percentages of women students are not entirely known, this is most likely due in part to families traditionally allowing more sons to travel overseas for their higher education while encouraging daughters to study in Qatar. Although this tradition appears to be changing, it most likely accounts for the higher percentage of women undergraduate students in Qatar. As for CS attracting more women, anecdotal evidence suggests that women in Qatar see CS as a means of interacting with, impacting, and experiencing the world without defying their cultural traditions.

Preliminary observations at Carnegie Mellon Qatar (CMU-Q) indicate that Qatar Arab students' perceptions of CS and of women's ability in math/science studies align with many of the observations from our case studies of the Israeli-Arab high-level CS classes and of the micro-culture in the School of Computer Science at Carnegie Mellon Pittsburgh. While some students are more excited by programming and debugging, others are more excited by applications such as robotics. Also, the CS women are certainly multidimensional and many are active in several other endeavors including student government (one CS woman has served as the student-elected president), and take leadership roles in many ways. Moreover, responses to initial questionnaires given to the Qatar CS students are quite interesting. Women students completed the sentence "I chose to learn computer science because" with "It has to do with logic", "I loved computers since I was a kid", and "Computer science is important in every domain of life".

Family and teachers were the most important influencers for all students, men and women, in their decision to study CS. Another strong influencing factor is that all of the Qatari students are fully sponsored by industry to obtain their degrees at CMU-Q, and it is apparent that these industry partners are willing to sponsor women to obtain CS degrees. Surveyed women students overwhelmingly disagreed with the statement: "In my country, an equal number of men and women choose to study computer science". The reasons were surprising, elaborated as follows: "I believe in my country females feel that computer science is more important; men go to engineering and business field[s]" and "Women are [represented] more than men because they are 'more genius' than men". When asked why more women seemed to be interested in CS, one woman student responded "I think that the women here probably have more patience....so yes, while the guys are drawn to engineering...the women are discovering a new path through computer science".

Surprising to some, prior programming experience was not a factor that influenced these women (or men) to pursue a degree in CS – many of them had no prior programming experience and more women than men had some exposure to programming in high school. Future careers also did not influence most women to pursue a CS degree – in fact, most of them are unsure what career, if any, they will pursue following their graduation. While the men generally have more options and directions for what they wish to do post-graduation, many of the women wish to make a significant impact on their country or in the Gulf region or globally and are seeking ways in which they can do this within their cultural boundaries. Most of them seem to have selected and continue in CS (despite very heavy workloads compared to their peers in some other undergraduate programs) because they wish to succeed in the challenge they undertook and because they enjoy the intellectual challenge of CS.

Longer-term discussions with students revealed that most of the CS students feel torn between their families and their educational demands. While their families are supportive of their higher education, CS is not a well-understood discipline in Qatar, and cultural requirements in terms of time spent with family, relatives, friends, and in community service are very high. Thus, the highly demanding CS program causes friction between the students and their families because the families don't fully understand why their children need to spend so much time on academic work. Despite the tremendous pressures that arise from not feeling like they are understood by anyone, the students rely on each other for support and encouragement, and persevere in their quest for a degree in CS with courage and determination against many odds.

3.7. History as a Cultural Case. We can see that history and time, as another case, contributes to our argument that factors outside of gender help determine women's contribution –or lack of contribution in computing. Historically women have played a role in the development of the field of computing, a role which has been largely determined by the culture and social needs of the times. Here we offer a very brief history of some of the women pioneers in computing, but first we provide a reminder of the trends.

From the 1970's to the mid-1980's the USA saw an increase in students (men and women) choosing to major in CS. In 1984 women comprised 37.1% of students graduating with a bachelors' degree in CS. This was followed by a decline as the economy took a downturn and continued until around 1990; by 1994 women comprised 28.4% of students graduating with a bachelors' degree in CS. Men starting enrolling again as the economy picked up in the 1990's, but women's interest never returned to the level it had reached in the mid-1980's. Currently, enrollment in the CS major is falling for all students: "Total enrollment in Bachelor's programs is down nearly 14% from last year and 30% compared to three years ago" [Taulbee, 2004-2005], and women's enrollment in CS majors across the nation stands at around 15% for the PhD granting universities.

In the early history of computing, Ada Byron Lovelace, a mathematician, played a significant part in the development of the concept of computation, translating a lecture, on Charles Babbage's design of the Analytical Engine, from French to English. Lovelace added her own notes which ended up being much longer than the original article. The collaboration of Lovelace and Babbage on the Difference and Analytical Engine, could be seen as leading to the forerunner of the modern computer. Lovelace developed structures that resemble today's programming structures. She visualized how to program the engine to calculate and how to store sequences of operations [Gurer, 2002, Matsui and Chilana, 2004].

Wartime often provides us with good examples to illustrate the changing levels of women's contribution in predominantly male fields. Connie Field's documentary "The Life and Times of Rosie the Riveter" is a wonderfully graphic example[57]. The field of computing is no exception. In the 1940s during the World War Two, women and men, who became known as "computers", worked on calculating weapons trajectories. In 1943 almost all "computers" were women, and, ironically, women were perceived as best for the job: "Programming requires lots of patience, persistence and a capacity for detail and those are traits that many girls have" [Gurer, 2002, p.176].

Some of the women recognized for their work at this time were Jean Jennings Bartik, Kathleen McNulty Mauchly Antonelli, Frances (Betty) Synder Holberton, Marlyn

[57] See http://movies2.nytimes.com/gst/movies/movie.html?v_id=29199

Wescoff Melzer, Frances Bilas Spence, and Ruth Lichterman Teitelbaum. These women pioneers were involved in building the Electronic Numerical Integrator and Computer, ENIAC, the first general-purpose electronic digital computer (used for the Manhattan project). The contribution of these women was ignored at the time that ENIAC was launched and was invisible for 50 years [Todd, Mardis and Wyatt, 2005].

Betty Holberton was involved in programming the first commercial computer UNIVAC and helped produce the software for the US Census Bureau for the UNIVAC. During the 1950's Holberton produced programs for sorting and merging files. Adele Mildred Koss developed the Editing Generator, an early sorting algorithm, for the UNIVAC.

Perhaps the most well-known woman in computing was Admiral Grace Murray Hopper, who built the first compiler[58] setting the stage for higher level programming languages, such as FLOW-MATIC (shorthand English), the first working widely used business programming language. Hopper's work influenced the development of COBOL, which involved the contributions of 3 women: Jean Sammet, Betty Holberton and Mary Hawes. Betty Holberton also played a key role in developing FORTRAN into a product that could be used on different machines and be more widespread. Judy Levenson Clapp worked on one of the first real time computers at MIT.

Denise Gurer suggests that historically, praise for computer pioneers has tended to focus on hardware (developed by men), while ignoring the early programmers and inventors of programming (women), but she points out "(t)oday's achievements in software are built on the shoulders of the first pioneering women programmers" [Gurer, 2002, p.120].

3.8. Other Cultural Examples: the USA. From our survey of cross-cultural examples in the USA, we found several researchers who remind us that there is no single category of women, yet all too often our research findings and subsequent recommendations rest on this assumption. In their book *Talking about Leaving: Why Undergraduates leave the Sciences*, Elaine Seymour and Nancy Hewitt note that "black women, older returning women, women from working class families, and women who described their families as

[58] Writing a program to create a program.

having equally high levels of expectations of daughters and sons" were less likely to leave a science major [Seymour and Hewitt, 1997, p.278]. Lynette Kvasny suggests we need to broaden the research on women in IT to *include a more diverse range of women before deciding that women as a whole are turned off the area*. Kvasny notes that most studies coming out of the USA look at white, educated, middle class women. Although the question "what are we talking about when we discuss computing fields?" returns, it is worth noting that inner city African American women present an interesting story. Contrary to what is happening with white women in the USA, increasing numbers of African American women are looking to IT training and careers as a way of improving their lives "economically and socially" [Kvasny, 2003].

A study by Antonio Lopez and Lisa Schultz looked at African American students of CS in Historically Black Colleges and Universities (HBCUs) and in non-HCBUs during the period 1989-97. They found that at HBCUs, consistently more African American females were awarded bachelor's degrees in CS than their male counterparts, while the opposite was true for African Americans (as well as for non African Americans) at non-HBCUs. They concluded: "For African American females, this might suggest that being awarded a bachelor's degree in computer science has less to do with gender differences and more to do with cultural factors" [Lopez and Schultze, 2002].

Evidence for the successful experience of some African American women in CS comes out of Spelman College, an all women's HBCU, which has gained national attention for the successful efforts of its Robot Soccer team. The "Spelbots" qualified for a second year in a row to compete in the international Robocup tournament.[59] Not only are they the first African American students' Robot Soccer team but also the first all women's team. More recently Carnegie Mellon, under the direction of CS research professor Dave Touretzky, teamed up with Spelman College on the robot soccer project which now uses Touretzky's Tekkotsu robotics. This partnership was funded by NSF's C.A.R.E.[60] (Computer and Robotics Education for African-American Students). In informal conversations with members of Spelbots during a 2006 visit to Carnegie Mellon, we were

[59] Spelman News: http://www.spelman.edu/_ezpost/data/22280.shtml
[60] See http://www.spelman.edu/~care/CARE/Robotics.html

impressed with their dedication, long hours of work extra to their regular studies, and their love of either tinkering around with the hardware or persistence in getting a program to work, characteristics which challenge myths about women's attachment to CS.

Section 4: Stereotypes and Computer Science

An Orbitz.com advertisement that ran on national television in the USA featured two male opponents, one a busy but clearly loving, friendly father complete with several happy, active kids, the other a single computer scientist. They were paired off in a "humorous" sketch to see who could get the best vacation package in the shortest time. The busy well-rounded father won. By using Orbitz.com, or so the message goes, using the computer becomes quick and simple for any user, regardless of distractions. On one hand the viewer sees a progressive/young image in the father-plus-happy-children representation. At the other extreme, (and clearly they are set up as opposing views of masculinity), we see the stereotypical image of the computer scientist as an isolated, anti-social, somewhat incompetent figure --from head-to toe the complete geek. At the same time the notion that the computer scientist should be set up as an expert at searching the web suggests a very odd and limited view of CS. To those of us in the field, the image, though not surprising, is somewhat frustrating in its persistence of old familiar stereotypes. All in all, the advertisement took advantage of, and perpetuated, the negative stereotypes and lack of understanding that surround the field and the people in it. We suggest that for the most part these images predominate in the public consciousness.

Our research with CS undergraduates in the class of 2004 at Carnegie Mellon confirmed that such stereotypes are still entrenched in mainstream culture. Our students know them only too well, and for the most part, they are happy to remove themselves from these stereotypes. This is nothing new. The 1990's study found similar accounts of stereotype "recognition and distancing", from the students they interviewed [Margolis and Fisher, 2002]. However, our 2004 case study revealed some significant changes in the relationship between students' self-identity and stereotypes. As the micro-culture of the department evolved and became more diverse, both men and women were re-defining what it means to be a computer scientist embracing a range of (primarily) non-stereotypical, along with a few stereotypical, characteristics, which they attach to themselves and their peers.

Student members of *Women@SCS*[61] have been particularly observant about the images of computer scientists that they see around them on a day-to-day basis, and have been pro-active in challenging old stereotypes. Over the past few years they have developed two major outreach programs driven by a desire to diversify the images that surround computing-related disciplines and those who work in them. Our students were particularly concerned that so few images of CS showed the breadth and excitement of the field and its potential for diverse participants. They saw this as a challenge, and an opportunity, to develop new outreach endeavors aimed at changing how computing-related fields are perceived in the public consciousness, especially among young girls (and boys). In Chapter 4, Section 2, we will tell the story of two such student initiatives, but first we will discuss some of the more interesting literature on stereotypes, and how it relates to CS. In Chapter Three we will show how our 2004 research findings can contribute to new understanding of CS stereotypes.

4.1. How Stereotypes Work. Margaret Matlin points to four primary factors that contribute to the influence of *gender* stereotypes on our cognitive processes (*our summary*):

- Gender Polarization: which is the way we try to divide the world into two very distinct groups, male and female.
- Different Expectations for Males and Females: this begins at, or even before, birth and is evidenced in our responses to babies and whether or not we believe them to be male or female.
- The Normative Male: we tend to believe that male experience and behavior is the norm and we explain gender differences in how women deviate from this norm.

[61] For more information about the organization, *Women@SCS*, please browse the web site: http://women.cs.cmu.edu/

- Remembering Gender-Consistent Information: we have a tendency to recall “gender-consistent information more accurately than gender-inconsistent information” [Matlin, 1999].

Matlin claims the four factors work together “to strengthen and perpetuate our existing stereotypes” and the media (movies, printed texts, television, etc.) help us to develop and maintain stereotypes through the types of images and levels of (mis)representation they produce [Matlin, 1999]. Also, we would add, one of the dangers of stereotypes is that they work synergistically with, and fit very well into, essentialist and “difference thinking” to produce what many of us see as reality.

4.2. Stereotyped Representations in Science. We live in a culture in which symbolic forms serve as a primary source of information, knowledge, and understanding. It is, therefore, not surprising that research on cultural stereotypes has attracted the attention of many researchers from a variety of disciplines, looking in particular at representations of race, ethnicity, and gender. There is a considerable amount of research examining how African Americans, Asians, and Hispanics, are represented in the popular media, but it is the portrayal of women that appears to have attracted most attention. Jocelyn Steinke’s extensive survey of the literature noted in “Cultural Representations of Gender and Science: Portrayals of Female Scientists and Engineers in Popular Films” testifies to this. Steinke suggests that as girls grow up in a “gender-polarized” culture the images of women that they are *most likely to see, and be influenced by*, are the ones representing *traditional gender roles* [Steinke, 2005]. She also points to the potential harm of such cultural representations: “(r)esearch shows that gender-role stereotypes restrict the professional aspirations of girls and young women, causing them to avoid high-status careers in mathematics and science” [ibid.].

Steinke’s work centers on the interaction of movie images and the formation of female identities, and in particular how images might shape girls’ choices of study and occupation. For our purposes Steinke’s work, although not specific to CS, is particularly interesting for its examination of movie images of women characters in science and engineering. She found a fairly mixed bag of representations, including one robotics engineer whose focus on her career wins out as she tries to balance work and family issues.[62] The "image" message is somewhat mixed. The positive image of the woman scientist is dampened by her shortcomings as a mother, thus perpetuating the idea that women cannot manage both career and family successfully.

Steinke points to a surprising number of positive images, portraying women as leading professionals in a variety of science and engineering positions. At the same time, most of these characters also reinforce traditional notions of femininity ensuring that beauty and romance figured largely in the portrayals. Steinke's work suggests that portrayals of women scientists both reinforce traditional images of femininity and break new ground by showing women in non-traditional careers. In this way images of women in science and engineering are shaped by, and re-shaping, the prevailing culture, confirming and challenging stereotypes at the same time, opening the way for change. In spite of the stereotypes, Steinke emphasizes the *positive* benefits of bringing such images of women in science careers to those viewers, who, more than likely, have had little or no chance of seeing or experiencing first hand. "(T)hese images have the potential to shape adolescent girls' perceptions of gender roles and their own future roles, including their perceptions of scientists and engineers and interest in scientific and engineering careers" [ibid. p.52]. Research, Steinke tells us, has already shown that using images of female scientists and engineers can provide effective strategies for changing girls' perceptions and for countering the harmful effects of stereotypes. For example "girls from low socio-economic backgrounds chose less traditional occupations after exposure to television portrayals of female characters in non-traditional occupations" [ibid.].

Steinke's findings offer encouragement to *Women@SCS* for our efforts to diversify the images that surround CS. The absence of images of women in CS together with the predominance of *stereotypical images* represent just one among many issues that cloud our understanding of the field, and may well be serving as a deterrent to attracting girls and women (boys and men) to the field. In contrast, *Women@SCS* brings new images of women in CS to the forefront and provides many opportunities for our young women

[62] The movie is *Eve of Destruction*, 1991, mentioned in Steinke, 2005, p. 51

computer scientists to present themselves, their work, and new images of the field to young audiences, their teachers, and others. We will elaborate on this aspect of our work in Chapter 4, Section 2: Outreach and Diversifying the Images of Computer Science: Images of CS, the People and the Participants.

Many researchers who have examined gender and CS issues include the topic of CS stereotypes.[63]

> "A number of researchers in this field are interested in the image of computing. The image of computing is its public face, the way it is represented to and perceived by those outside the field. It consists of the stereotypes that serve as shorthand for the type of people who are in computing and the type of jobs that comprise the practice of computing" [Cohoon and Aspray, 2006].

For the most part they conclude that the "geek" stereotype, the image of the (white, male) computer obsessed intelligent individual who has poor social skills, and pays little attention to hygiene and appearance, is pervasive and potentially harmful in deterring women from considering the field. For some researchers the geek stereotype, although something of a myth, is viewed as a major source of gender difference having a "differential impact on male and female students" such that "women enter the field in smaller numbers than men, and are more likely to leave".[64] Not surprisingly, many interventions have been launched to address stereotypical images by trying to change girls' perceptions of CS, including videos like the ones produced by the Center for Women and Information Technology [65] and by the University of Washington.[66], and

[63] There are many researchers who address the issue to a smaller or greater degree: Borg, Margolis and Fisher, Greening, Camp, Kshiti, Schmidt, Kuhn, Cuny, Cohoon and Aspray, Gurer, Keisler and Sproull, Townsend, Spertus, Blum and Frieze.
[64] Margolis, Fisher and Miller. "Geek Mythology", http://www.cs.cmu.edu/afs/cs/project/gendergap/www/geekmyth.html
[65] CWIT http://www.umbc.edu/cwit/video.html
[66] University of Washington http://www.cs.washington.edu/WhyCSE

summer seminars like the one for high schools girls held at University of Waterloo.[67] We might add that such interventions may also work well for dispelling the stereotyped perceptions that some boys, teachers, school counselors and parents hold too; this could be a source of common ground rather than a source of gender difference. These stereotypes, after all, impact us all; they are entrenched in the cultural images that surround CS and the people in the field.

4.3. Stereotype Threat. Some of the most well-known articles on stereotypes and their serious implications, “A Threat in the Air: How Stereotypes Shape Intellectual Identity and Performance” [1997] and “Thin ice: ‘stereotype threat’ and black college students” [1999], are by Stanford psychology professor, Claude Steele, who studied the effects of social identities and racial and gender differences in standardized test performance. He was looking for explanations for why able women and able African American students (*these were students who also cared about math and were self-identified as good at math*) performed less well than white students. Steele coined the phrase "stereotype threat" to describe:

> “(T)he threat of being viewed through the lens of a negative stereotype, or the fear of doing something that would inadvertently confirm that stereotype. Everyone experiences stereotype threat. We are all members of some group about which negative stereotypes exist, from white males and Methodists to women and the elderly. And in a situation where one of those stereotypes applies--a man talking to women about pay equity, for example, or an aging faculty member trying to remember a number sequence in the middle of a lecture--we know that we may be judged by it” [Steele, 1999].

What Steele found in his research was that when African American students identified with their race and the associated negative stereotypes surrounding African Americans and academic ability, they performed poorly on standardized tests. When the same

[67] Sandy Graham and Celine Latulipe. “CS Girls Rock: Sparking Interest in Computer Science and Debunking the Stereotypes”
SIGCSE 2003, ACM: http://hci.uwaterloo.ca/students/clatulip/Publications_files/p322-graham.pdf

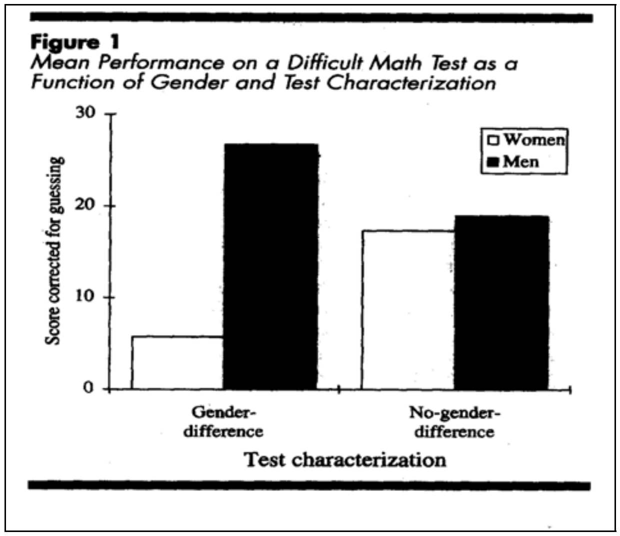
African American students were told the tests were not testing academic ability they were less impacted by the negative stereotype and performed as well as their white peers. Steele points out that some may argue that these students have internalized the stereotypes, and are illustrating the theory of “self-fulfilling prophesy”. But Steele and his colleagues predicted something different was going on. By testing students who would have little, or no, self-image of poor ability in a particular subject, they showed that stereotype threat was linked to external factors: (our italics):

> “According to the theory (self-fulfilling prophesy), black students internalize negative stereotypes as performance anxiety and low expectations for achievement, which they then fulfill. The "self-fulfilling prophecy" has become a commonplace about these students. *Stereotype threat, however, is something different, something external: the situational threat of being negatively stereotyped*” [Steele, 1999].

Steele and his colleagues also worked with women and found that “stereotype threat depresses the performance of accomplished female math students on a difficult math test, and how that performance improves dramatically when the threat is lifted” [ibid.]. Women doing difficult literature tests were not affected in the same way, suggesting that stereotype threat is domain related. For the math tests Steele told participants that either a) the test tended to reveal gender differences in math (thus opening up the possibility of stereotype threat) or b) the test did not reveal any gender differences (thus reducing the chance of stereotype threat). In the latter case women’s performance improved to the level of their male peers (see Figure 7).

Clearly, *stereotyped gender and math ability identification* can have real implications in determining test results, results which can be improved when the context is changed and the stereotype threat is eliminated. From the point of view of our own research, this confirms our understanding that factors outside of gender (and race) play a very significant role in the social and academic experiences of our students.

Figure 7. Testing Stereotype Threat [from "A Threat in the Air: How Stereotypes Shape Intellectual Identity and Performance" Steele, 1997]



For the most part, stereotype identification has a negative impact on the lives of those categorized. But stereotypes can have some positive impact. Most obviously, the positive aspects of the geek stereotype (and there are some—intelligence, passion for the field) may impact those men who have a strong sense of geek identity. But what happens when stereotypes overlap, or are in conflict? Margaret Shih points out that our identities and stereotype vulnerability can shift according to the situation in which we find ourselves [Shih, et al, 2005, Shih, 2003]. Shih and her colleagues found that Asian American women *performed best on math tests when their ethnic identity was made public.* In this case the stereotyped relationship between Asian-Americans and strong math ability took priority over the gender stereotype and worked to the advantage of these women, leading Shih and her colleagues to conclude that "identities are not universally adaptive or maladaptive, but rather are adaptive or maladaptive in different domains". Such findings may help to explain (among other factors) the high level contribution of Asian-American women in CS. Shih's work concurs with Steele's proposition that once *academic identity* is claimed over and above racial and gender stereotyped identities associated with that particular academic domain (in both cases that domain is math), it can have a powerful influence over a student's academic outcome. Both Shih and Steele provide evidence that factors external to the individual, such as those at work in specific environments, can impact both academic performance and how individuals see themselves.

Another interesting component of Steele’s studies showed that students working on tests under stereotype threat often cared more than their peers and worked harder to the point of depressing their performance by being inefficient, i.e. re-reading questions, rechecking answers, in an effort to disprove stereotypes by not making mistakes. Stereotype threat proved to be a major obstacle to African American students’ performance, much more so than factors that were previously thought to play such a strong role, e.g. confidence boosting and raising expectations, although he does not dismiss that these factors have value. So how do we lift or remove stereotype threat?

> “What did raise the level of black students' performance to that of equally qualified whites was reducing stereotype threat--in this case by explicitly presenting the test as racially fair. When this was done, blacks performed at the same high level as whites even if their self-confidence had been weakened by a prior failure” [Steele, 1999].

The primary intervention that Steele recommends to ensure that stereotype threat does not hinder the performance of students is to help students create “strong academic identities” in a climate of “racial trust”. Steel knows that stereotypes in the larger culture will be difficult to change, but he suggests that “it is possible to create niches in which negative stereotypes are not felt to apply. In specific classrooms, within specific programs, even in the climate of entire schools, it is possible to weaken a group's sense of being threatened by negative stereotypes, to allow its members a trust that would otherwise be difficult to sustain” [Steele, 1999]. We believe Steele’s work has relevance to our own research findings and especially to the creation of a “niche” or micro-culture that has allowed for a Women-CS fit.

What we see in Steele’s work is that racial and gender differences in test results are not produced by any deep-rooted characteristics of race or gender, nor necessarily by internalizing specific racial or gender identities. The source of some of the differences may lie outside of individuals in the *context* of the test situation. Ultimately, this means that results can be improved or worsened by the conditions in which the test is given. If the sources of differences are external to individuals then environmental and cultural interventions may well lead to change. Other researchers have reached similar conclusions, some of which we noted earlier in other sections [Shih, 2005; Thorne, 1993; Hyde, 2005; Halpern, 2000; Inzlicht and Ben-Zeev, 2004].

4.4. In Sum. In our "A Cultural Perspective" chapter we have argued the need for a new direction in how we think about, and act on, women's participation in CS. In particular we have shown the limitations of a research paradigm that focuses on gender, and on identifying (perceived) gender differences especially. In contrast by taking a cultural perspective we seek greater understanding of the *sources* of these perceived differences by looking outside of gender to the environments and cultures that we inhabit. We have shown a variety of research evidence to support our argument, evidence ranging from dispelling gender myths, and showing gender similarities, to illustrating the different (and often positive) levels of women's participation in CS in different countries and cultures.

This range of evidence sets the stage for our next chapter in which we present findings from our own research at Carnegie Mellon, findings from a case study based on interviews with undergraduates from the class of 2004. *Our work builds on the evidence and arguments we have made thus far and adds to this body of knowledge.* Using a cultural perspective our major findings show that interventions in the environment have contributed to changes in the computing culture leading to a Women-CS fit. In line with the evidence shown in our "A Cultural Perspective" chapter we reveal evidence of gender similarities, evidence dispelling gender myths, and evidence of a culture and environment that allows for women's successful participation in CS.

CHAPTER THREE: INTERVENTIONS AND RESEARCH FINDINGS

Chapter Overview: In **Sections 1 and 2** we provide an overview of some major interventions carried out at Carnegie Mellon. These interventions opened the way for a more diverse student body, including an increased number of women (and the establishment of *Women@SCS*) leading to the development of a more balanced CS environment and changes in the culture of computing. We relate the improved gender balance to the emergence of a Women-CS fit and the improved experiences and performance of women undergraduates. In **Sections 3 and 4** we describe the findings of our *preliminary research*, findings from interviews with seniors in the class of 2002, and the findings from our *primary research, a case study based on interviews with seniors in the class of 2004.* These findings show strong evidence of change since the early research of the 1990's. Most notably we found that as the environment has become more balanced in three domains -- balanced in terms of gender, students with a breadth of personalities, and professional support for women -- we see women and men relating to CS through a spectrum of responses, including many gender similarities, rather than a gender divide.

Section 1: Background and Interventions for Cultural Change at Carnegie Mellon

When we examine the background of changes in the culture of computing at Carnegie Mellon it soon becomes clear that interventions leading to change went on at the individual level, the departmental level and the institutional level, and had institutional support as well as departmental and individual support. To paraphrase Kanter: "institutional *phenomena* require *institutional-level intervention".* Thus, change was not confined to the efforts of individuals, although individuals provided the vision, the impetus and the means for implementation.

1.1. Diversity at the Institutional Level. By 1999 the value of diversity was entering the Carnegie Mellon culture at the institutional level. This was clearly indicated when the university president, Jared Cohon, established the Diversity Advisory Council as part of his strategic plan for the university. Two years later he noted that "Carnegie Mellon's highest goals will be well-served by raising the consciousness of the entire university community about the inherent benefits of creating a more diverse institution and educational environment".[68] As in industry, where diversity is being encouraged for its value to entire companies, *diversity at Carnegie Mellon has not been embraced solely on behalf of women or minorities, but rather for the benefit of all.*[69] This perspective opened the way for changes in the student body in the School of Computer Science and changes in the culture of computing. Clearly these changes did not emerge in isolation, nor did "change" simply happen. Rather it has taken great effort, resources and shared vision, in order for the culture of computing at Carnegie Mellon to evolve.

1.2. Diversity and the School of Computer Science. The Carnegie Mellon School of Computer Science reflects and embodies the philosophy that CS thrives on the interaction of diverse perspectives and expertise. Faculty within the School of Computer Science's six interdisciplinary departments[70] represent a growing range of areas including: CS, software engineering, robotics, artificial intelligence, human computer interaction, entertainment technology, linguistics, psychology, computational biology, operations research, business, rhetoric, public policy, security and privacy [Blum and Frieze, 2005].

Although the connection between this philosophy and having a diverse student body may not be apparent to all at first, these perspectives clearly mesh and can serve to support each other. Thus with time, this connection is more likely to be understood and accepted, even championed, by a significant constituency of the community, as is happening at Carnegie Mellon [ibid.].

1.3. Interventions for Change. Between 1995 and 1999 Carnegie Mellon made several interventions to allow for changes. These changes incorporated some of the findings from

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[68] President Cohon's Statement on Diversity: http://hr.web.cmu.edu/drg/overview/statement.html
[69]For a full discussion see Hazzan's paper "Diversity in Computing: A Means or A Target" http://edu.technion.ac.il/Faculty/OritH/HomePage/FrontierColumns/OritHazzan_SystemDesigFrontier_Column7.pdf
[70] The School of Computer Science houses the Computer Science Department as well as five other departments: the Robotics Institute, the Human Computer Interaction Institute, the Language Technologies Institute, the Institute for Software Research International, and the Center for Automated Learning and Discovery. It has close ties with the Entertainment Technology Center and many other departments on and off campus. While the undergraduate computer science major was historically housed within the Department of Computer Science, the educational program now is a School wide enterprise.

the Margolis/Fisher study, which showed that prior experience with programming was not a pre-requisite for success in CS [Margolis and Fisher, 2002]. Another factor that proved to be vital was an outreach program for high school CS AP teachers that combined technical training with discussions of gender gap issues [Blum, 2004, and Margolis and Fisher, 2002]. At the same time, Raj Reddy, then Dean of the School of Computer Science, asked the undergraduate Admissions Office to develop criteria that would select for future leaders and visionaries in the field. One subsequent criterion gave value to "evidence of giving back to the community". Thus, the school adopted *a broadened admissions policy*, emphasizing diverse interests along with high achievement in mathematics and science (high SAT scores were still required) and de-emphasizing prior programming experience.[71]

All of the above interventions opened the way for the development of *a balanced environment* in the post-1999 computer science department at Carnegie Mellon. By this we mean balanced in three major domains: in terms of gender, in terms of students with a breadth of personalities/interests, and in terms of professional support for women to reflect implicit professional support for the majority. The concept of a *more balanced environment* is critical to our argument. Next we explain what we mean by this term.

With regards to *gender balance*: the students in our 2004 case study enrolled in 2000 in a class with 39.5% women and continued throughout their CS studies with at least one third women in the undergraduate student body. Prior to 1999 the women in the student body comprised well below 20%, indeed most of the time below 15%. Thus, the students we interviewed from the class of 2004 had experienced a much improved gender balance.

With regards to *balance in terms of student personalities and interests:* this was enabled by Carnegie Mellon's *broadened admissions policy* for the CS major, emphasizing leadership potential and diverse interests along with high achievement in mathematics and science while de-emphasizing prior programming. The new admissions criteria not only opened the doors to more women but also to many men who did not fit the

[71] For a full account of these interventions see Blum, 2002.

programming-focused personality that had been dominant in previous years. The CS department started to see more men and women with broad interests and personalities. This meant that the students we interviewed for our case study, from the class of 2004, had experienced their school years among a more diverse student body.

With regards to *balance in relation to professional support for women:* the organization *Women@SCS* was established in 1999 to ensure that the increased numbers of women entering the CS major could thrive and have the professional and social opportunities (e.g. peer advice, mentoring and networking), often taken for granted by those in the majority.

Thus, during their school years, the students in our case study, the class of 2004, experienced a more balanced environment than students in CS at Carnegie Mellon prior to 1999. This is significant because research findings from our case study will show that when men and women are exposed to a more balanced environment, many of the perceived gender differences noted in early research studies at Carnegie Mellon (1995-1999) are not in evidence and instead *we see men and women displaying many gender similarities in how they relate to CS.*

In a meeting with the Director of Carnegie Mellon Admissions Office, we found that the admissions criteria was continuing to focus on the "student as a whole", looking for such things as giving back to the community and indications of leadership potential, while all the time keeping high SAT scores as a primary criteria. Although the numbers of applications has remained high for the 130-140 incoming places in the undergraduate major, Carnegie Mellon is not immune to the national downturn in applications to CS programs, indeed total applications dropped from around 3200 in 2001 (peak) to around 1700 in 2005.[72] For women the numbers of applications peaked at around 430 in 2001 and were at 232 in 2006.

As we have noted the post 1999 interventions not only opened the doors to more women but to a more diverse student body overall [Blum and Frieze, 2005]. To meet the needs of

[72] There are, however, early signs that the applications for places in the CS major are up for 2007. As yet we don't know what this means in terms of women's enrollment.

students entering with varying backgrounds, *multiple entry routes* were created into the first year programming courses. It is important to note that academic entry level standards were not lowered to accommodate this increase in student diversity, nor was the curriculum contextualized to support what are perceived to be "women's ways of learning". Any changes to improve the curriculum have been made for the benefit of *all students*, and are the kinds of changes that go on in any department committed to providing the best academic program possible. These changes were not aimed at women specifically, nor would we want them to be.

However, we are often asked to explain how Carnegie Mellon changed the curriculum to make it "female-friendly". We believe such questions derive from the school's success in attracting and retaining a critical mass of women and from the way that the early research findings *have been interpreted to suggest that contextualizing the curriculum is recommended to attract more women to the field*. In discussions with faculty, and in particular with senior teaching professors, we have had confirmation that any changes were made for the benefit of *all students*. Some senior faculty members have been at Carnegie Mellon for many years, and have been in an ideal position to observe, and indeed affect, any changes in the undergraduate curriculum.

1.4. *Women@SCS.* 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 in what was then a very traditional CS atmosphere. The organization took on the name, *Women@SCS*. It has since become catalytic in building an environment in which the new student body could flourish. *Women@SCS* also embraced graduate women students who had become pro-active prior to 1999 in recognizing the need for connecting women across all six departments in the School of Computer Science. They organized professional discussions and socials, started a sisters' program, and set up the forerunner of the current web site[73]. The appointment of Blum, along with funding for a program of

[73] See the *Women@SCS* web site at: http://www.women.cs.cmu.edu

professional and social activities for *Women@SCS*, indicated the department's commitment to women's success in CS at Carnegie Mellon.

Thus we see that *Women@SCS* was not left to develop as a marginalized women's group, but rather was integrated as a professional organization and as a valuable asset to the school. We believe these multiple-levels of commitment were crucial for changes to be successful.

> "Thus, while the need and methodology for change might be motivated by the interests and needs of an underrepresented group, it is our view that, for programs to succeed and become part of the institutional fabric, ultimately they must mesh with the sensibilities of the institution, even serve to enhance the enterprise in general" [Blum and Frieze, 2005].

1.5. Faculty and the Changing Culture of Computing. We met and carried out informal interviews/discussions with eight faculty members to collect their observations on computing culture, diversity, the student body, departmental atmosphere, and any changes they had noticed over the years. Six of these faculty members were directly involved in teaching the CS undergraduate core courses and had been in the department since the mid-1990's, placing them in a very good position to observe changes in the student body and departmental atmosphere. These meetings raised some very interesting points and helped confirm some of our speculations and findings. For example several faculty members noted that the 1999 interventions for change and the shift towards a more balanced environment had benefited the department as a whole. Other faculty commented specifically on the blurring of the programming/applications divide among women and men. Faculty also noted that in general students had moved from being very CS focused to showing a range of cross-campus and general outside interests.

Several faculty members thought the increased numbers of women had significantly improved the quality of student social life. This was most noticeable in terms of students' complaints to faculty advisors. Before the increased numbers of women the major source of complaints revolved around *social life*, afterwards the major source of complaints revolved around *grades*. This was regarded by faculty as a much healthier situation! Indeed, when we think back to the pre-1999 culture and the early research findings it is easy to accept that the women students, being in a minority, felt like they did not fit into the unbalanced environment, but it is also misleading to think that all the men were content, even though they shared the camaraderie of other male students with similar interests. *This gender unbalanced environment was not a particularly satisfactory environment for male students either*.

On a similar note at least two faculty members pointed out that it wasn't just women who felt like they didn't fit into the pre-1999 culture, some men felt the same way. One faculty described the general environment as a "sink or swim" situation which worked against the handful of *men and women* who were admitted with little programming background. He suggested that when the department started to address gender issues in the late 1990's it raised the possibility of making *improvements for all students*. According to one faculty member the subsequent changes in the department had brought a 180 degree turn around in climate and student happiness.

Several other faculty members noted that students had become increasingly grade obsessed and felt it tied into the current "no child left behind" education policies which are focused on improving students' test taking ability, to the detriment of teaching critical thinking skills. The students, said one faculty member, often struggled with reconciling their high school understanding of CS and the new understanding of the field as it is taught at Carnegie Mellon especially when they first came up against the abstract thinking courses like 211.[74] But when they "got it" they were thrilled and excited.

Another faculty member felt that the biggest impact the increased numbers of women had on the department was to change the self-image of the department and the school, as well as impacting outsiders' views of CS at Carnegie Mellon. In terms of self-image, the improved gender balance had opened the way for all faculty and students to shift from

[74] 15-211, Fundamental Data Structures and Algorithms, teaches fundamental design, analysis, and implementation of basic data structures and algorithms, along with principles for good program design.

being fairly "one-dimensional", to showing their diversity. The implementation and success of SCS-Day[75] is a good example of this new image.

Faculty agreed that there is no one "template" for a computer scientist at Carnegie Mellon, echoing the student's own perceptions of themselves and their peers that CS students are a diverse bunch (see section 4.14. in this chapter). Several faculty mentioned that while there was no "typical" CS student any more, for students to be successful in CS they needed to have some specific skills in common: a strong work ethic, and a strong sense of self, enabling them to ensure a balance of work and other interests. One faculty pointed out that these skills were expected campus wide, reflecting Carnegie Mellon's criteria for success, not skills confined to the CS department. Students in our 2004 representative cohort also linked the CS work ethic to a university wide characteristic.

One senior faculty suggested that changes in the classroom were being observed mostly in the freshmen and sophomores years and that women students were still spread thinly in the upper level classes. For example, the *sounds* of the classroom were often predominantly male, male voices literally drowning out any female voices.

Faculty in the School of Computer Science have worked to improve the environment in the CS department making it comfortable for all students, women and men. One woman from our 2004 representative cohort commented that "the advisers are amazing", while another noted that the undergraduate student advisors "create an extremely comfortable atmosphere". Indeed, when asked to comment about the atmosphere in the department, comments which we report later in this chapter (4.7.), a very positive view emerged from both men and women.

Several faculty (and administrators) commented on the valuable role played by *Women@SCS* in ensuring that women students were well integrated into the department.

[75] SCS-Day, started in 2003 by *Women@SCS*, is a major school wide initiative celebrating the diversity in the School of Computer Science. The event has been embraced by faculty, staff, and students throughout the school, and the Dean of the School is master of ceremonies for the events. See http://www.cs.cmu.edu/~scsday/

One senior faculty member stated strongly that *Women@SCS* has been crucial in the retention of women in the undergraduate CS student body. While *Women@SCS* works primarily to improve the social and professional opportunities of women, faculty applauded the organization for helping to bridge the various departments within SCS, building a community and program of events that strives to be inclusive of *all* students.

Other indications of broad cultural change within the school were noted. Young faculty from throughout the School of Computer Science (men and women) have started to meet as a group to share ideas and discuss their social and professional interests. Young women faculty have started to meet as a group also, bringing together non-tenured women from across all six departments of the School of Computer Science. This is reminiscent of the early days of *Women@SCS* when graduate students from throughout the School of Computer Science starting meeting and making connections.

One faculty member pointed out, and we agree, that while Carnegie Mellon has had success in improving the gender balance of the CS department, there is much work to be done in terms of diversity beyond gender. Increased gender diversity has already made an impact and has shown to fit well with the philosophy of the department and the school; working towards broader diversity would seem to be the next natural steps for a school which embraces and thrives on creativity and innovation.

Section 2: Numbers, Gender Balance and Signs of Success

We believe this thesis can make a unique contribution to the "numbers" dialogue mentioned earlier (Chapter one Section 1.10., Chapter two Sections 1.8., and 2.5.) because we have witnessed a dramatic increase in the numbers of women in the undergraduate CS program at Carnegie Mellon thus changing and improving the gender balance. We can also point to specific examples of our successful recruitment, retention and graduation of women students in CS.

2.1. Numbers and the Improved Gender Balance. According to the Taulbee report which looks at PhD granting universities women's enrollment in CS majors across the nation stands at around 15% and has been in a serious decline for several years [Taulbee, 2004-2005]. At Carnegie Mellon, however, we have witnessed an interesting and quite unique story of women's enrollment in the CS major.[76]

Figure 8. Carnegie Mellon Undergraduate CS: Applied, Admitted, Enrolled Fall 1994-Fall 2006

Year	Applied	**Women Applied**	Admitted	**Women Admitted**	Enrolled	**Women Enrolled**	**Women Enrolled%**
F1994	1118	**121**	426	**42**	106	**10**	**9.4%**
F1995	1485	**160**	382	**54**	98	**8**	**8.2%**
F1996	2222	**247**	476	**86**	136	**20**	**14.7%**
F1997	2222	**248**	481	**87**	137	**17**	**12.4%**
F1998	2364	**274**	462	**96**	140	**27**	**19.3%**
F1999	2680	**342**	454	**122**	129	**48**	**37.2%**
F2000	2884	**406**	388	**158**	134	**53**	**39.5%**
F2001	3237	**435**	402	**157**	132	**49**	**37.1%**
F2002	2328	**285**	379	**113**	133	**33**	**24.8%**
F2003	2066	**257**	385	**128**	136	**42**	**30.8%**
F2004	1872	**190**	393	**100**	130	**29**	**22.3%**
F2005	1734	**200**	384	**107**	141	**33**	**23.4%**
F2006	1912	**232**	409	**100**	141	**30**	**21.3%**

We can see from figure 8 that between 1995 and 1999, the percentage of women entering the CS major rose from 8% at the beginning of the Margolis/Fisher research timeframe, to a sudden jump to 37% by the end of their study. This meant that for most of their student years the women in the student body during the years of the study comprised well below 20%, indeed most of the time below 15%. We consider this to be unbalanced in

[76] We need to take into account that culture is multi-faceted and many factors (other than those we focus on in this thesis) may have been impacting increases and decreases in admissions at Carnegie Mellon. For example, has internationalization and the effects of 9/11 impacted admissions? What has been happening with NSF support for innovation in undergraduate education? Have students across the US been moving from CS to the other sciences?

terms of gender. The students in our 2004 case study, enrolling in 2000 (highlighted above in red) with 39.5% women and graduating in summer 2004 (prior to the downturn in the 2004 fall enrollment), enjoyed the highest percentages of women in the CS student body with at least one third women overall throughout their years as students in the major.

Since 1999 we have maintained a much higher than national average proportion of women students in the undergraduate student body. Figure 8 above shows that Carnegie Mellon is not immune to the national declining trends. By fall of 2004 applications to the 150 places in the CS major at Carnegie Mellon had dropped *for both men and women*, and more noticeably for women. In 2002 we saw a noticeable but unexplained decrease in the numbers of women enrolling. We believe that the intensive summer programs directed at teachers of our target potential students that were carried out in the mid-1990's were a very effective recruitment tool. Sadly these programs had been dropped by 1999. CS faculty are currently establishing a new outreach program, CS4HS.[77] This program for high school teachers aims to provide practical resources and ideas for teaching computer science principles. CS4HS was first implemented in summer 2006 and will be available again in summer 2007.

We have found evidence to show that numbers, *among other factors*, could prove to be a major determinant in the positive experiences of undergraduate students in the undergraduate CS program. The numbers of men and women in the program have become more balanced in the last few years, or to use Kanter's categories, the numbers have shifted from a *skewed group* to a *tilted group* (see chapter two: section 1.7.), which means that both the majority and minority groups have the potential to form alliances and change the culture. Prior to 1999 when the numbers of women in the CS major were very low, the experiences and attitudes of women appeared to be very different to their male peers. Findings from the 1995-1999 study reported that women felt they did not fit into the computing culture, their confidence was low, and many smart, capable women left the program without completing their studies [Margolis and Fisher, 2002]. In contrast, after 1999, as the student body became more gender balanced, the experiences of women

[77] For more information on CS4HS see http://www.cs.cmu.edu/cs4hs/summer/index.html

improved, they started to feel comfortable in the program, and were graduating successfully. But perhaps the most interesting change since 1999 is that *the improved balance of numbers of men and women has allowed for similarities in students' experiences and attitudes towards CS to emerge*[78].

These changes became clear in the preliminary interviews we conducted with CS seniors in 2002 (see Chapter three: Section 3). They were further confirmed in interviews from our 2004 case study (see Chapter three: Section 4). In our 2004 seniors' interviews we asked students many questions relating to their experiences and attitudes towards CS. Instead of gender differences, we heard some striking gender similarities, in fact the way these students were relating to CS cut across gender in a spectrum of attitudes. Clearly, as Kanter maintains, *the degree to which an environment has gender balance* can be an important factor affecting whether we perceive gender differences or similarities.

The gender balance in the class of 2004 case study was particularly good (relative to other places in the USA) with women comprising more than one third of the class throughout its four years. We also suggest that as numbers become more gender balanced opportunities for women to adopt an academic identity[79] were increased, over and above any gender identity, which reduced stereotype threat, and allowed for the Women-CS fit. This has important implications for how we view women's (and men's) relationships to computing, and suggests the value in examining culture and environment.

Of course numbers alone do not guarantee that the experiences of women will be positive, nor that a good gender balance will be sustained. Other interventions, as we have noted earlier, may be important to ensure that women entering a specific micro-culture can do so as full participants in the evolving culture of the department.

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[78] Here we emphasize numbers but it should be made clear that there are other factors at work which we will discuss later.

[79] Both Claude Steele and Margaret Shih provide theory, and evidence, to support the idea of reducing stereotype threat by increasing academic trust and academic identity. See Stereotypes: Chapter 2, Section 4.

2.2. Signs of Success. Figure 9 illustrates another sign of quantifiable success at Carnegie Mellon. The percentage of Bachelors degrees in CS granted to women at Carnegie Mellon was roughly on a par with the national percentage (18%) in 2002[80]. By 2005 the percentage of women gaining bachelors in CS at Carnegie Mellon had more than doubled the national percentage.

Figure 9. Bachelors in CS Awarded to Women Nationally and at Carnegie Mellon (CMU) 1997-2005

Year	Total Number of CS Bachelor's Awarded to CRA Institutions (CS only)	**CMU**	**Number Awarded to Women**	**CMU**	Number where Gender is Unknown	Percent to Women (of those whose gender is known)	**CMU**
1997- 98	8,860	**85**	1,396	**8**	703	17.1%	**9%**
1998-99	10,809	**78**	1,745	**4**	1,065	17.9%	**5%**
1999-00	12,660	**108**	2,372	**12**	1,021	20.4%	**11%**
2000-01	14,427	**116**	2,679	**14**	845	19.7%	**12%**
2001-02	16,907	**125**	2,891	**23**	1,519	18.8%	**18%**
2002-03	16,633	**105**	3,041	**36**	986	19.4%	**34%**
2003-04	17,876	**115**	2,972	**44**	1,050	17.7%	**38%**
2004-05	15,137	**112**	2,186	**37**	674	15.1%	**33%**

We have highlighted the relatively high numbers of women graduating in the 2003-04 academic year at Carnegie Mellon. This is significant because the students in our case study at Carnegie Mellon who had entered in the fall 2000 graduated spring 2004, with a few graduating end of fall 2003. As previously discussed we believe that numbers played an important role in shaping the micro-culture of the CS department.

Section 3: The Class of 2002: A Class in Transition

In this section we provide a brief account of the findings from our 2002 preliminary research which in many ways provided both the impetus and groundwork for a further

[80] National figures courtesy of Tracy Camp.

study i.e. our principal research: the class of 2004 case study. The 2002 research was based on interviews with CS seniors in the class of 2002 at Carnegie Mellon [Blum and Frieze, 2005(b), and Larsen and Stubbs, 2005].

3.1. 2002 Preliminary Research Findings. Changes in how our students were relating to CS were already being observed by 2002 when we conducted interviews to examine the perspectives of a class in "transition" [ibid.]. We called this group a class in "transition" because this was the last class to have entered the program before there was anything close to a critical mass of women. The number of women was on a par with the low number of women entering CS programs nationally. The classes following behind them, however, had a very good gender balance.

With a grant from the Sloan Foundation we interviewed 33 seniors (17 women and 16 men) from this class. In our analysis of the interview data, we found that the gender divide that characterized the 1995-1999 findings had largely dissolved and in its place we saw students demonstrating a spectrum of attitudes, and men and women appeared to be very similar in how they were relating to the field. Indeed the two social scientists, Larsen and Stubbs, who were hired to analyze the 33 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].

Larsen and Stubbs concurred with our own conclusions in stating that they found "considerable evidence of similarities among the perceptions of these women and men, as well as differences among men and among women" [ibid.].

When we compared our findings to the 1995-1999 studies we found several similarities but we also found *some significant changes*. Most notably we found that the perspectives of our men and women students were often more alike than different. We also saw students whose views of their field had broadened quite dramatically from seeing CS as *programming* to seeing the field as *an exciting range of possibilities*. What was most encouraging was that the self-doubt and the lack of confidence that had previously dominated women's experiences in CS (as chronicled in *Unlocking the Clubhouse,* [Margolis and Fisher, 2002]) were gradually being replaced by confidence and enthusiasm.

3.2. 2002 Challenging Stereotypes. By 2002 changes in the student body were affecting the culture of computing at Carnegie Mellon such that the familiar "geek" culture, reflecting the larger computing culture, was losing the dominance it once had. Perhaps one of the most obvious indications of this evolving culture was the way in which CS students were challenging traditional CS stereotypes and redefining their own self-images and the images of their peers.

The 2002 findings suggested that both men and women were moving towards a new identity with respect to CS based on a well rounded image which challenged the traditional stereotypes that surround CS and those in the field. For example, we saw strong challenges to the image of "dreaming in code" [ibid, p. 5] as representing the male CS student's attitude towards computing. Men seemed just as likely as women to appreciate computer applications and want more from the field than programming. We found men who were as socially outgoing as women, and women who could be just as "geeky" as men. Although no interview question category specifically addressed the issue of stereotypes, all eleven of our categories had questions that elicited responses related to CS gender stereotypes. We were struck by how frequently the seniors' responses did not fit traditional patterns. This woman senior voiced the same perception, "Some (women) were just as hard-core as the guys. And the guys, it's the same thing, some of them really want to spend all their time on the computer and not think about anything else, and some of them are really not like that, and [are] really interested in making it more appealing".

The picture of a narrowly focused CS student did not emerge. To the contrary, we found students with a variety of interests and with social circles both inside and outside of CS, students who were involved in outreach activities and community service, students who enjoyed both humanities and science classes, and students who were aware of the old “hacker” stereotypes and determined not to be like that. Our cohort included students who played the violin, wrote fiction, sang in a rock band, participated in university team sports, enjoyed the arts and were members of a wide range of campus organizations. We found that both men and women appeared to be moving towards a more well rounded identity which embraced academic interests and a life outside of computing. Students described themselves as “individual and creative, just interesting all around people”, “very intelligent…, very grounded, not the traditional geek…”, and “… much more well rounded than people five or six years ago”.

This is not to say that students who enjoy coding did not exist, nor that programming wasn’t still an important part of their world, it certainly was …and had to be. But this interest seemed to be placed within a broader context, with respect both to the field of study as well as participants. We found men and women who enjoyed programming and the “geekier” aspects of CS, and we found men and women who didn’t. “[The geeks] give a bad rap for everybody else”, said one young man. Another claimed he and his friends “were as interested in things that had nothing to do with computer science” and in “trying to apply computer science to completely different things”.

In terms of programming and the image of males obsessed with coding *this was one area in which our cohort showed strong gender similarities.* Almost all students saw programming as one part of their interests and the computer as a “tool” for their primary focus which was applications. For example, two men and two women who had maintained an interest in programming expressed their continued interest in very similar ways; they particularly enjoyed being in control and making the computer do “what you want”. But just as we found women who could be “geeky” we found men who seemed just as likely as women to appreciate computer applications and want more from the field than programming. This man acknowledged his own change of attitude, “I still find computers to be very interesting. But because the field of computer science has grown as I've learned more about it, it's no longer the computer itself and the programming that is interesting. It's what can be done with the programs that is now interesting. …The computer I see more as a tool now, as opposed to this neat toy", while another man claimed, "I like having the ability to create something useful that people can use to save them time, or to make doing something easier".

The longest interview and seemingly most "sociably outgoing" student in the cohort was a young man who talked for over one and a half hours, while the "geekiest" of students interviewed was a woman who recalled that as a child she had kissed the computer in much the same way as she would kiss a fond toy. This student had originally "wanted to fit the stereotype" but finally adopted a more self-assured attitude as she claimed some aspects of the geek stereotype, while maintaining a feminine identity, "You know a girl can be good looking and still be in computer science and still be smart goddamnit". One student summed up the situation in this way, "There isn't a typical student any more. There are some traits that you have to have. They have to know how to use computers, but there is such a range of students".

What seems clear is that these students were constructing a new image. We might speculate that the culture in which they spent more than three years of their studies, a culture with an increasingly diverse student body *and* which supported this diversity, had shaped their image of themselves with respect to CS. We might speculate that such a transitional culture gave "permission" for the men to explore their non-geeky characteristics and the women encouragement to be both feminine and computer focused. For the most part, our cohort seemed to be identifying with the newer, more diverse aspects of the student body, while retaining some of the traditional aspects.

Thus, even in 2002, we found some significant challenges to the more common stereotypes. As we will illustrate in Section 4 of this chapter, by 2004 we found students becoming increasingly confident with their self-image and ready to acknowledge that their academic and social community was indeed a diverse community.

Section 4: The Class of 2004 Case Study: Principal Research Data

In this section we provide the findings from *our 2004 case study and principal research* based on interviews with seniors in the class of 2004. Our research methodology (Chapter One, Section 2) describes how we arrived at the findings presented in this section. In sum we found that in the more balanced environment, balanced in terms of gender, students with a breadth of personalities, and professional support for women, the Women-CS fit had become visible and women were shown to be successful without any compromise to the intellectual integrity of the program. We believe it is worth repeating that the CS academic curriculum *was not adapted to become "female-friendly"*, and in fact continues to be one of the most rigorous CS programs in the USA.

In Sections 4.1. through 4.8. we provide evidence for our argument by illustrating the *major changes* since 1999, changes in the following areas: *definitions of CS, confidence levels, attitudes to programming, confidence and programming skills, students' sense of fitting in, balancing CS and other activities, perspectives on the CSD atmosphere,* and *being a woman in CS.* We illustrate this shift with data collected from interviews with seniors in the class of 2004. We use transcripts from the representative cohort that were closely analyzed.[81] Our findings are revealed (verbatim) through the voices of the students participants, undergraduates who are viewed as the "expert informants" on their experiences and attitudes [Seymour and Hewitt, 1997, p.13-14].

In Sections 4.9. though 4.19. we show more evidence of change and the Women-CS fit as revealed through the representative cohort in the context of the 2004 interviews. These sections include *students' thoughts on switching out of the major, what students like best about the CS major, what aspect of CS interests them most, what interests them least, stereotypes, stereotype threat, and characteristics of CS students.* We conclude the 2004 findings section by discussing the value of *Women@SCS* and student perceptions of the organization.

[81] Please see methodology section Chapter One, Section 2, for details of the student body and how the representative cohort of 20 women and 20 men was selected.

4.1. Students' Definitions of Computer Science. Findings from our 2004 seniors' interviews, aimed at capturing the way some of our students were relating to CS, show how their understanding of the field had broadened as they were exposed to the breadth of CS as it is conceptualized and taught in the CS major. Most of the students claimed that when they came to Carnegie Mellon they would have defined CS as programming. Indeed in the representative cohort, 16 women and 15 men confirmed this notion. Among the ones who thought otherwise several had forgotten their early thoughts, one man thought it was math and applications, one woman thought it was playing with computers, and one woman claimed she had no preconceptions saying "CS was a new venture for me and I pretty much let it shape itself around me".

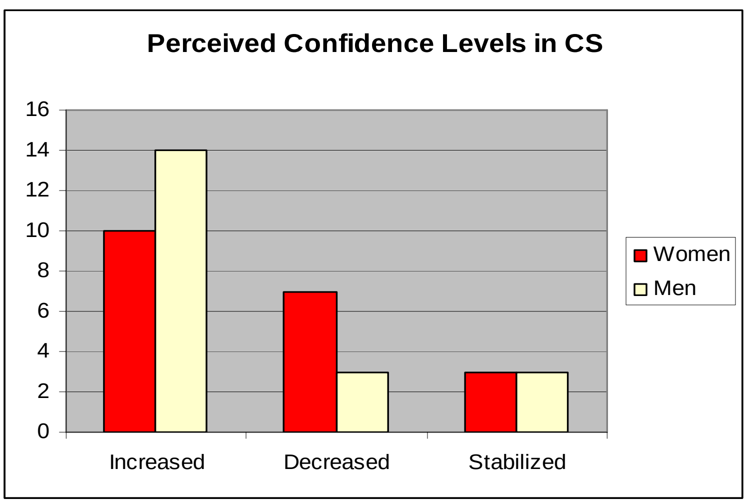
However, by their senior year, all 20 men, and 18 of the women, said their views on CS had changed. The students now struggled to define CS after being exposed to both the breadth and the depth of the field. This woman commented on the evolution of her own understanding: "My idea of what computer science is has evolved so much over the past four years", while this man explained his dilemma, "I want to make a definition that doesn't include the word computer in it, because it's definitely a lot more than that". At least two students referred to Dykstra's quote that computers are to CS like a telescope is to astronomy. Another student managed to capture the ubiquity of the field with quite an elegant description: "too big of a discipline to be defined but …a very specific way of approaching problems and dealing with them".

For most students in the representative cohort, men and women, CS had come to mean a challenging and complex field. They described it as: "applicable to everything", it's about "algorithms and (the) theory of computation", "math and other philosophical things", "problem solving", "it's a tool box, a set of tools for being able to reason methodically about all sorts of problems", and "a way of thinking". These are the core aspects of CS that have captured their interest, their intellect, and their enthusiasm. This woman explained "I've always been interested in solving puzzles." For her, CS was "a sort of logic based way to solve problems". The computer itself and programming were now seen as "really good" tools for solving problems "really fast".

At the same time, several students echoed this man's emphatic comment "it's not programming, computer science is not programming! I think that's really important and it's a misconception". Students agreed that the concepts they learned in high school, that CS means programming, concepts which shape the public misconception, are narrow and misleading, and fail to capture their new understanding of the field. These perceptions from our students suggest that if the broader concepts of CS could be designed for, and implemented at, the middle and high school levels we may well find that CS would be of interest to a broad range of girls and boys. The CS department is making outreach efforts to help teachers design such a program.[82]

4.2. Confidence Levels. In 2004 we found that while men were still reporting higher confidence levels than women, most women in this cohort reported an increase in their confidence levels (see Figure 10 below). The confidence gap had narrowed significantly since the pre-1999 studies were carried out, when some women's confidence was noted as being "extinguished" as they progressed through the program.

Figure 10. Students Perceptions of Increase/Decrease in Confidence Levels



While confidence levels for women still appear to be lower than the men's, it seems that *confidence* becomes more of an issue when "confidence" is specifically addressed in the

[82] See the CS4HS Summer Workshop mentioned earlier: http://www.cs.cmu.edu/cs4hs/summer/index.html

question. For example, in the question “Do you feel that your confidence in your ability to do well in CS has increased or decreased?” women’s confidence appears lower than the men’s.

In contrast when asked about specific skills, women appear to be equally as *confident* as men in claiming them. This became clear in the rating of programming skills (see Figure 12.). 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.[83] Our students’ attitudes, while shaped by the micro-culture of the department, are not isolated from broader, prevailing cultural messages.

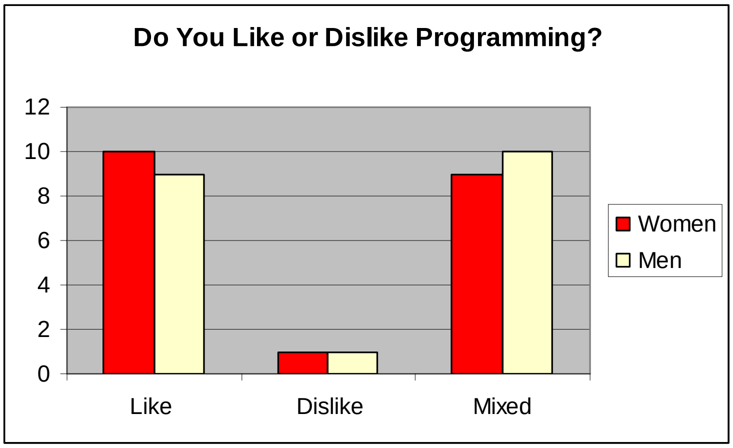
Students, men and women, stated that although their confidence increased overall, levels varied greatly over the years, depending on the classes they were taking. Several students, 3 men and 3 women, said their confidence had fluctuated or remained stable, or as this woman said it can do both: “It’s probably remained about the same actually. I was pretty confident coming in and I’m pretty confident now, in between it has gone up and down.” We categorized this group under “stabilized”. One woman in the class of 2004 acknowledged “bumps along the road, but overall I think I’m pretty happy with the way it went”. Another woman in that class gave a roadmap for her increased confidence: “Once you start working on different projects or having more projects under your belt you just feel a little better. ... Public speaking and having a more professional front is all part of it. And joining a group like *Women@SCS* really helps because there are plenty of chances to speak, talk and I think just growing more as an individual” [Blum and Frieze, 2005a,b].

4.3. Attitudes to Programming. In the following section, based on the work of Blum and Frieze (2005), we provide one of the strongest illustrations of emerging similarities and the Women-CS fit. The representative cohort was specifically asked about their attitudes towards programming. In answer to the question, “Do you like or dislike

[83] 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.

programming?" the responses from students revealed some striking similarities with 10 women and 9 men saying they liked programming, while just one man and one woman saying they disliked programming (see Figure 11 below).

Figure 11. Students' Perceptions of Liking or Disliking Programming



One woman explained her attachment to coding: "I like programming. I guess it's also this kind of instant gratification feeling again where if you can code something and then just clicking that one button and seeing it actually happen right there it just kind of okay wow I got that to (work) .. the feedback that you get that quickly is what I like about it. And then there's all this problem solving skill that you have to go through, and if you can do that yourself and by coding it you prove to yourself that you could do it, that you could solve the problem. I think that's what I like about it". This man shows a similar attachment: "I love programming, very much ….in programming you are limited by the time you spend, not the computer. And, so I like that sort of fast feedback and being able to see things immediately".

Initially, we sorted the responses into two main categories, "like" and "dislike", but it soon became clear that this was an oversimplification; indeed it was quite obvious that a third category had emerged, a category in which the responses were "mixed".

The "mixed" category was particularly interesting in that it showed the limitations of a simple oppositional yes/no answer. Gender similarities emerged again with 9 women and 10 men providing thoughtful, mixed responses as they tried to explain their views. This woman answered “a little bit of both” while this man said “I have to say I’m kind of in the middle”. Another woman pointed out “I like higher level programming … (but) I dislike systems level programming, so it’s a mixed bag”; this man also qualified his response “I think it more depends on actually what I’m programming. It depends on the language and the field that it’s being applied in …so, yes, I like programming in some cases, but not for everything”.

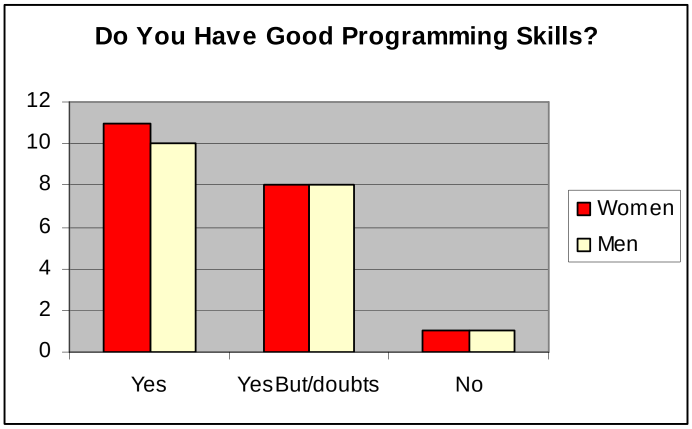
Answers to the question of liking or disliking programming revealed a spectrum of attitudes which cut across gender and many students *qualified* their attitudes. Thus, liking and/or disliking programming was determined by a variety of factors, primarily what kind of programming was involved, what the purpose of the programming was, and the number of hours spent actually programming. While most students in this cohort, said they liked programming, or had mixed responses, most did not see themselves with future careers focused solely on programming. As one woman in the class of 2004 put it, “I enjoy programming. … I really like it. I guess I don’t really enjoy it on a daily basis, for example if I had to do it 50 hours a week I don’t think I would enjoy myself”.

The findings illustrated in Figures 10 and 11 led us to look at the connections between confidence and programming skills.

4.4. Confidence and Programming Skills. When asked if they had the skills for good programming, this same cohort of women and men reported a set of very similar skill factors: you have to be well-organized and able to think ahead; you need good problem-solving skills; you need to be able to think logically and analytically and have lots of patience. Women reported slightly ahead of men, 11 and 10 respectively, in rating they had good programming skills (see Figure 12). This woman illustrated the confidence she felt in her programming skills and some surprise at the question: “as you get more exposure to programming it’s impossible not to develop these skills”.

Once more an interesting category emerged as we tried to understand the complexity of students’ answers. This category, which we called “YesBut/Doubts”, covered a range of attitudes in which students either qualified their sense of having good skills with comments like “yes, to an extent”, or expressed some doubts saying such things as “I did at some point”. Again a strong gender similarity emerged with 8 men and 8 women falling into this middle ground category.

Figure 12. Students’ Self-Rating of their Programming Skills[84]



Clearly, this cohort of women showed a high level of confidence when it came to programming skills; and strong gender similarities emerged in all categories.

At the same time, 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. This man explained: “Programming is a tool like a ruler is to an architect”. The image of “dreaming in code” as the dominant characteristic of male CS students and “computing with a purpose” as a primary focus for women were clearly being challenged. As one woman in the class of 2004 put it, “it’s always fun to sit down in front of a computer and kind of producing code until something is done and it’s such a good feeling. A lot of time once I sit down and do programming I find myself living in the cluster for a day without eating or sleeping”. A male student showed his interest for the applications of programming “I like programming. I think it’s a good tool to reach an end. But I mean, on that note, I don’t like programming just for the sake of programming. …if I’m not interested in what the ultimate goal is then I don’t like programming”. This man made a

[84] One man did not answer clearly so his response was not counted.

similar point: “when I got into applications that’s when I started to say oh, ok, yea I knew this is where it was at!”.

These findings suggest that any gender divide in how students relate to CS, particularly with respect to programming vs. applications, is not a product of any meaningful gender characteristics but rather a product of aspects of micro-cultural and environmental conditions and personalities.

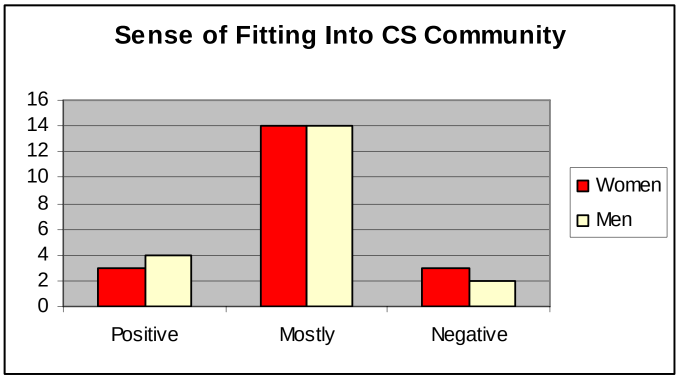
4.5. Sense of Fitting In. By the time we interviewed seniors in 2004 women were showing the same sense of fitting into the CS community as the men (see Figure 13). These women in CS at Carnegie Mellon illustrated a positive Women-CS fit, in contrast to the findings of the 1995-1999 study where the few women who persisted in the program had to “reject and find alternatives to the dominant culture of the field” [Margolis and Fisher, 2002, p.107].

After being asked to describe the characteristics of CS students (question 10[85]), the seniors in the 2004 representative cohort were asked where they fit in, or not fit in, with the self-described picture. The results showed a strong gender similarity with 4 men and 3 women voicing a very positive sense of fitting in, 2 men and 3 women making negative comments about fitting in, and the largest group of 14 men and 14 women, who felt they had found their place within one, or more, of the different groups who shared their characteristics and interests.

The students in the positive category appear to have found an overall balanced fit. One man claimed to fit all the characteristics he had named, while one woman felt she fit both academic and social aspects of the community. The “Mostly” category, the largest group for both men and women, referred to those students who had found a place for themselves in one group or another. These were students who saw the CS community as diverse, made up of several groups with specific characteristics, had outside interests, and had friends in other majors.

[85] The results of this question will be discussed later in this chapter.

Figure 13. Students' Perceptions of Fitting in (or not fitting in) with their CS Peers



Among those who felt they did not fit in one woman commented that she felt people were not generally very helpful, while another woman retained her interest and ability in CS but had moved towards Art taking her CS interests with her. One woman said she felt "intimidated" at times by other students, "I didn't feel like I knew as much as they did". Interestingly, this woman had come into the program with a good background in programming, "really liked the programming courses in high school and I felt that I was good at them". In contrast one woman who came in with no background had found her niche among a group of women she called the "CS chicks". She clearly felt at home during the early Intro classes with "this group of 30 girls and we were all fairly clueless." The two men who did not feel like they fit in commented on social aspects, one finding the other students "immature" and the other wanting more social diversity.

These findings indicate a marked change from the earlier environment at Carnegie Mellon where the "majority of women struggle to find a place where they can feel comfortable in the prevailing culture" [ibid. p.102]. Indeed, the early studies showed that in the pre-1999 atmosphere, women did not feel comfortable, academically or socially, while male students were found to have great camaraderie and, by virtue of their programming strengths, could perform well academically.

4.6. Balancing CS and Other Activities. One of the interview questions specifically gave students the opportunity to address whether or not they had managed to balance their interests with the heavy workload of the CS major[86] (see Figure 14.).

[86] Q.40. Have you felt any problems with mixing CS and the rest of your life?

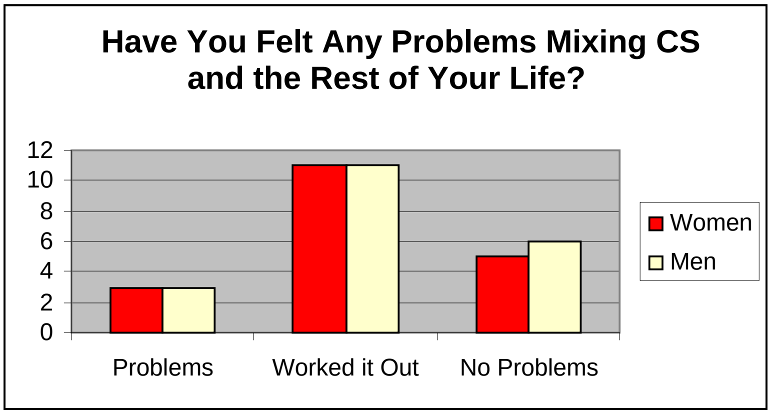
In answer to the question, “Have you felt any problems with mixing CS and the rest of your life?”, student responses fell into 3 categories: those who had problems, those who had none, and, in the largest category, those who had to work on time management but eventually felt they had worked out some balance. (One response was not clear at all, so it was left out.) Gender similarities were quite striking. Of the 3 men and 3 women who had felt problems, 2 of the women and 1 of the men expressed a sense of regret at not having done things they wanted to do. This man felt he had focused too much on CS work, “there were opportunities to get out and socialize and see different things that I really missed because I was just focused”. This woman expressed similar regrets “I feel like there were things I gave up to finish this major”. The 4 women and 6 men who had no problems balancing work and “life” seemed very confident in their responses as evidenced by this woman’s comment, “No, not at all”.

By far the largest group, 11 men and 11 women, felt they had to work at time management but had eventually succeeded in mixing CS and their outside activities. For the most part, this group accepted that at times the workload would be heavy such as when projects were due and lab time increased. This woman’s comment exemplified many responses “I think it’s all in time management I guess. But yea, I never had a problem with doing CS and living life. I guess there are times when you have to give up a weekend or two and spend all weekend in the cluster but otherwise overall no”.[87]

Student responses to this question stand in sharp contrast to the early studies which suggested that limiting extracurricular activities would work against women and in favor of men who were happy to focus on computing [ibid. p.61-75]. McGraph Cohoon corroborates our findings [McGraph Cohoon, 2006, p227]. The majority of women and men in our representative cohort were ready to forego extracurricular activities when workload demands were high, but by managing their time effectively they could still lead a balanced academic and social life.

[87] The clusters are rooms which house “clusters” of computers for students to work on. The clusters are also used as classrooms.

Figure 14. Students' Impressions of Having (or not Having) a Balanced Life in the CS Major



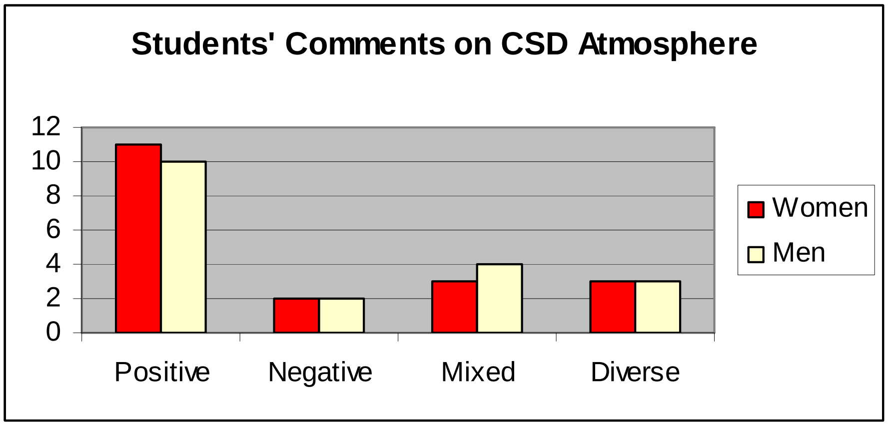
We found no evidence to suggest that men in CS were not outgoing, or not especially interested in activities outside of CS. Indeed most of the men in our representative cohort made it clear that they wanted to balance school life with opportunities to explore their outside interests; this man claimed "in everything I do I look for the social side". Another man illustrated the point that *time* has been the factor affecting his activities, *not lack of interest*: "I do a lot of things outside of CS. Like for example right now I'm writing for Tartan …I'm a peer tutor, but there's always more I wanted to do. I wish I could've maybe taken a class in CFA or something when I was here. You know, like there's always lots of things I want to learn about, there are lots of things I want to be involved in and I don't have time to do all that".

4.7. Student Impressions of the Computer Science Department Atmosphere.[88] When we asked students to describe the atmosphere (see Figure 15) in the CS department 10 men and 11 women came up with very straightforward positive comments saying such things as "pretty friendly, pretty relaxed", "social", "supportive", "very cooperative", "helpful". This man stressed the sense of community: "we all try to help each other out both educationally, emotionally and so on and so forth". This woman made a similar comment: "we cooperate a lot and help each other out with the work and other stuff too".

[88] Part of this section on atmosphere appears in the Methodology section, Chapter 1, Section 2, as an example of categorizing student responses.

There were 3 men and 3 women who commented (positively) on the diverse range of students with *diverse* interests, so we included this as a category.

Figure 15. Student Impressions of the Atmosphere in the CS Department



A number of students, 7 women and 6 men, referred to the atmosphere as collaborative or non-competitive, and several suggested students were self-competitive. This woman, for example, said “If there’s competition, it’s always with ourselves trying to be better”.

Only 2 women and 2 men made negative or non-committal comments. One woman who was negative/non-committal said she felt “peripheral” to the department, while 1 man said he found the atmosphere very competitive, but he also said it was “stimulating”, suggesting that *competitive* might not be so negative from his point of view. Several students (4 men and 3 women) fell into the *mixed* response category making both positive and negative comments about the atmosphere.

Most students had not noticed any changes in departmental atmosphere since their freshmen year, of those who had 3 students (2 women and 1 men) thought it had changed for the better pointing to reasons such as feeling it was “competitive” early on, and “less of a community” early on. There were 3 students (2 men and 1 woman) who thought it had become a little worse. This man felt there was a sense of community building during his freshman year and it was “a lot more personal”. One woman felt that some of her professors were more “caring” during freshmen year. At the same time she pointed out that they “care how you are doing and you have these great advisors who will take care of you, and that has always been true throughout these four years”.

In sum, this question revealed, again, gender similarities in the responses, and the majority of students in this cohort, both men and women, appear to find the atmosphere very comfortable and friendly. Carnegie Mellon’s CS department provides an example of the “locally supportive environments” that J. McGraph Cohoon found played a major role in the retention of women [ibid.]. Our findings provide further evidence of a good academic and social fit for both women and men. Pre-1999, this was not the case for most of the women, and many of them left the program at much higher rates than the men. Once again we see the influence of culture and environment on students’ sense of fitting in.

4.8. Being a Woman in CS at Carnegie Mellon.

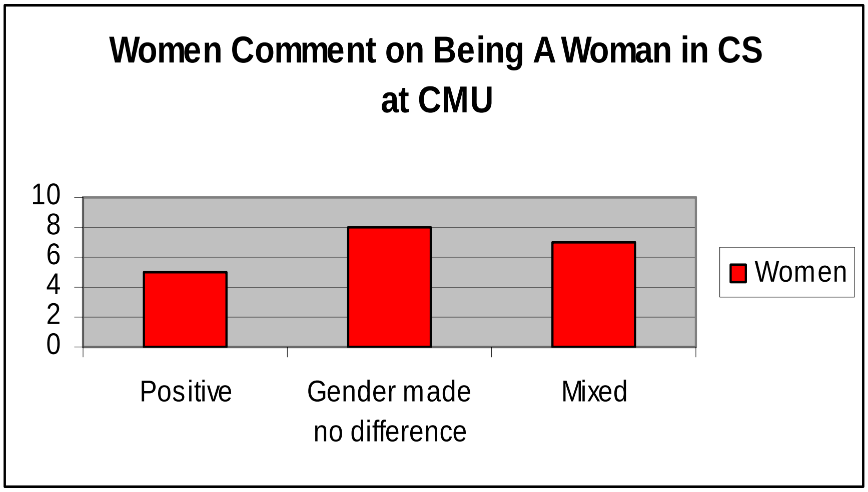
> “I came in at a time where it was changing; there was still that lingering idea that this was new that women were here, and it’s a problem. I think now it’s just sort of yea, women are here. By now the class with very few women is already gone, all the classes now have plenty of women. So I think it’s not as big of an issue anymore. …But even when I was a freshman I always felt totally in place. I had both girl and guy friends in computer science and there would be study groups where there would be an equal number of us girls and guys” [Woman Senior, Class of 2004].

Perhaps the strongest evidence to illustrate women’s sense of what it’s like being a woman in CS at Carnegie Mellon, is revealed throughout the interviews by an absence – *the absence of comments on gender related issues.* There were many opportunities for gender to be raised, but, for the most part, gender arises as an issue only when it is addressed in specific questions. *We see this as a positive sign of the Women-CS fit.* An example of this might be when students were given such open ended questions as “What was the best thing about doing this major?” and “What was the worst thing about doing this major?” In both cases gender factors did not emerge. However, gender similarities did. Women referred back to academic factors; in fact some of their responses mirrored the men's responses. For example 7 men and 6 women pointed to the heavy workload as one of the worst things in the major. Our findings suggest that the women in the representative cohort felt their gender has not had a significant impact on their experiences in the CS program at Carnegie Mellon.

Further evidence for the Women-CS fit emerged as women students answered two questions specific to gender issues: "What has it been like being a woman in computer science overall?" (see Figure 16.), and "Have you experienced any problems in the program because you are a woman?" The overwhelming sense of being a woman in CS at Carnegie Mellon was positive. The spectrum of responses ranged from simply affirmative, to feeling gender had not played a role in their student lives, to mixed reactions which were usually positive with a reservation. In the simply affirmative group, 5 students voiced such comments as: "I think it's really awesome", "it's been cool", and "I've have had an excellent time". Other women (8) voiced their attitudes by suggesting their experiences were no different to the men's: "I don't really know if I can say it's been any different than a male's experience here in computer science", "Most of the time I don't think I really noticed", and "I think it's been pretty much the same that it would be for a guy". Such responses *appeared to be positive responses* but we have categorized them separately.

Four of the women mentioned positively the fact of having more women around: "I think it's definitely been nice to have the support here for the women in computer science", while another commented "I was lucky enough to come at the stage where you did have enough women enrollments. But sometimes, I definitely was in a class where there was only three of us out of 60 people. So it was a little bit challenging". This woman felt less on show: "Nowadays I go in (the cluster) and I think I count pretty much equal number of men and women, just that alone, not having the guys stare at you as you go into a cluster as a girl, I think helps". Four of the women mentioned positively the sense of feeling special, e.g. being a woman in CS often impresses others: "I've felt here kind of like I was special…when people meet you who aren't CS majors and they'll say what's your major and you'd say computer science and they're like, you're a girl doing computer science!"

Figure 16. Women Students Give Their Impressions of Being A Woman in CS



Seven women gave mixed reactions comprised of mostly positive comments with an additional reservation. The reservation usually concerned hearing that women were accepted into the program because of their gender (5 out of these 7). "I think it's been pretty much the same that it would be for a guy. Umm, except some people say I got in because I was a girl, although, this was from a guy who got rejected from the School of Computer Science". For the most part such comments were hearsay and not first-hand experience (and usually early in their years at Carnegie Mellon) but one student had taken it to heart: "I actually took it like they were telling the truth". However she noted later: "But my views definitely changed over the course of the four years that I've been here", perhaps indicating that for some women it just takes a little longer to feel the Women-CS fit. We had hoped that comments on "getting in because you are a woman" had disappeared completely and while they are receding, they still appear from time to time, showing that there is more work to be done.

This man made an interesting observation on the evolving acceptance of women in the program: "I do think there's a much more general acceptance of women than my freshman year. I haven't heard people say as often, 'I'm opposed to admitting more women,’ or lowering admissions standards…. Individuals still feel that way but it’s not a part of the culture any more”. Certainly, the change of attitudes regarding women in the program seems to be going in the right direction. By her senior year this woman felt that having women in the department had become quite normal: “I think in general whereas it was more of a new thing when we (first came) here. Like it was all these girls are here – Wow! Now it’s kind of expected, it’s just normal, which is kind of nice”.

As we review the comments of our students on being a woman in CS, it becomes clear that they present a range of perspectives reminding us that we cannot generalize to all women. We also have to remind ourselves that prior to the late 1990’s the School of Computer Science had elements of the “locker room mentality” that Denise Gurer found common at that time.[89] Indeed, some male graduate students felt quite at ease having pornographic screen savers in full view.[90] This practice was part of the computing culture, although we suspect it was not just women who found it inappropriate. Nowadays, not only would such a practice be frowned upon, we suggest it would simply not be considered. Clearly, cultural change at Carnegie Mellon has been quite dramatic. This change has resulted from specific interventions at a multitude of levels, and most importantly, without “compromise to academic integrity” [Ramsey and McCorduck, 2005, p.17]. We can see that a micro-culture *can* change and indeed be quite pervasive.

4.9. Thoughts on Switching Out of the CS Major. On the whole students, men and women, perceive themselves as fitting into the CS department very well. However, at some time during their years of study, many students had thought about the possibility of switching out into another major. Most of the women (15), claimed they had thought about switching out of the major at some point although 10 of them had not been really serious about it. The women who said they had never thought about it were very definite,

[89] See http://www.cnn.com/TECH/computing/9811/11/womenit.idg/index.html

[90] “In 1989, a collection of computer science graduate students and staff members at Carnegie Mellon University wrote a petition, asking certain members of the program to cease leaving screen savers of nude women on their computers. While many people understood the position of the writers and made efforts to alter their behavior, others reacted poorly, calling the writers "Nazis" and refusing to succumb to their "censorship."” Quoted from Attitudes of Women in Computer Science: 1991 – 1999 http://www.bluepoof.com/Colloquium/attitudes.html

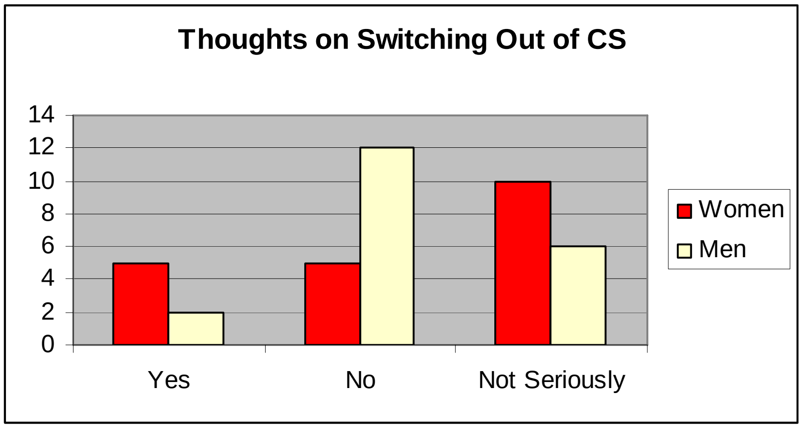
but this attitude – “No. Definitely not”, “No never”—was much more common among the men (see Figure 17).

The overwhelming reason for thinking about switching out was academic, sometimes relating to a particular course, or timeframe, as this woman explains: “Oh yes, that would be because of 212[91]. 212 was horrible and that was the end of my Sophomore year and I sat there thinking to myself I enjoy Psychology so much more than this”. This particular class was also a landmark for this woman: “I was like I am not cut out for this I don’t think I can do this for the next four years and, again at that time I still thought that I wasn’t as smart as the rest of the people in my class. So I really was, I don’t think I can do this but after 211 and 212 I started to see that I can do this and that’s what made me stick with it. And I saw how my intelligence was changing, how my thought patterns and logic ability and ability to solve problems had just gone up so incredibly that I was like I think I should just stay”. This man had a similar sense of doubting his interest and ability: “I looked around me and I saw people that seemed a lot more interested in computer science than I was. Then I got worried that maybe it’s not right for me. I wasn’t doing badly in anything but I just felt, maybe I should have studied English somewhere, government or whatever”. For many students thoughts of switching out were fairly fleeting: “It has crossed my mind once or twice, but that’s when you’re in the middle of a 6 hour program”.

This woman on the other hand pointed out “I never thought of switching out because there was nothing else I wanted to switch into”. This man made a similar comment: “I would say that I’ve never really thought of switching out because I can’t really think of any programs that I would be more interested in”.

[91] The courses 15-211 and 15-212 (quoted as 211 and 212) are probably the first that many students take involving abstract thinking. 15-211, Fundamental Data Structures and Algorithms, teaches fundamental design, analysis, and implementation of basic data structures and algorithms, along with principles for good program design. 15-212, Principles of Programming, teaches high level programming techniques, with an emphasis on abstraction and reasoning about programs.

Figure 17. Students Indicate Whether or Not they had Thoughts on Switching out of the CS Major



Given that quite a number of the women had considered switching out –but had not- it was interesting to hear what kept them going. The primary reasons were “the challenge”, “the challenge is part of the fun”, and the decision to “stick with it” (13 of the women and 6 of the men mentioned these factors). This woman expressed it as a kind of “stubbornness”, she “wanted to prove to myself that I can do it no matter how much behind I (was when I) started out”. As mentioned earlier, it seems that it may have taken the women longer than the men to see they could be successful in CS, but once given the opportunity to be in the CS major at Carnegie Mellon, they were determined to see it through. Many of the same women who had had thoughts of switching eventually felt a tremendous sense of accomplishment as seniors. “Basically, once I finish this school, all the doors will be opened for me, and it’s just…it’s a pain, you know, at some points, and some classes I don’t like, but overall, I mean, it’s such a great experience, and it’s such…It’s just something that, you know, if you get the opportunity to do you just have to do it. There’s no looking back”.

The main reason that 9 of the men gave for not thinking about switching out was simply a strong interest in the field of study, as evidenced by this man “I’ve always been interested and I don’t think that interest has even weakened in fact it’s gotten stronger”. While this strong sense of interest was not heard as often from the women it was evident in 4 of the women although not articulated with quite the same passion, as this woman illustrated: "I still really enjoy the topics I've learned and keep learning in the classes".

All of the students in this cohort did eventually graduate but of course this is not always the case. Indeed research shows that women *leave* the sciences, including computer science and other non-traditional fields for women, in greater numbers than men. [Seymour and Hewitt 1997, McGraph Cohoon, 2006].[92] We suggest that thoughts on switching out do not occur in isolation and *in a different environment such thoughts may not have been so fleeting.* Given that we have already seen that students in this cohort had a strong sense of fitting into the CS department at Carnegie Mellon, and held positive views about it and the networks of support, *we might speculate that without this environment, some women students in our cohort (and some men) would have left the major*.

4.10. Students' Perspectives on the Best Thing About Doing This Major.[93] When students were asked their thoughts on what was the best thing about doing the CS major at Carnegie Mellon, a range of responses emerged (see Figure 18). Some students mentioned specific courses or areas of study but the 7 most frequently mentioned factors were: confidence building, the people, the breadth and variety of classes that the program allowed for, developing new ways of thinking, opening up of opportunities and possibilities, exposure to research and research opportunities, and the outstanding reputation of CS at Carnegie Mellon. The latter was very important for this man: "I think definitely the best part has been the tag that comes with it, the CMU tag ..it's a tag that gets the first step in the door when you need to get in the job market and I think the CMU name tag does help". One man felt he had been exposed to "new ways to think about things, new things to think about", while this woman suggested the program had "opened me up to a whole new world of possibilities".

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[92] We do not have *exact* data on the attrition rate of this specific cohort but the majority of their class enrolled with 39.5% women in 2000 and graduated with 38% women in 2004. This suggests that the attrition rate for women in this class was quite low.
[93] Q. 29. What was the best thing about doing this major?

Figure 18. Areas Mentioned by Students When Asked to Comment on the Best Thing About Doing the CS Major

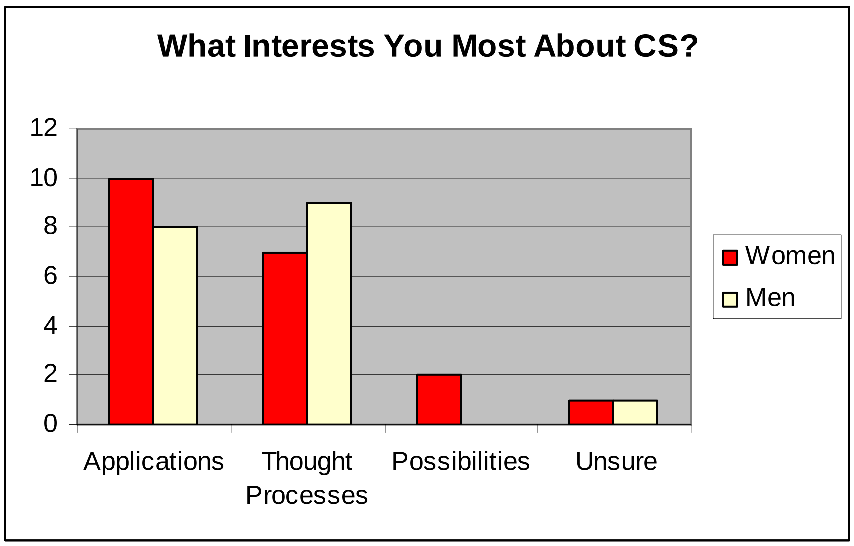
	Confidence Building	People	Breadth and Classes	Opps. and Poss.	New Way of Thinking	Research Opportunities	Quality CS Dept.
Men	1	7	6	3	3	3	4
Women	5	1	9	4	3	1	2

Men were more likely to mention "people" as the best thing, "I'd even say the people in the program have been the most enjoyable part", possibly providing further evidence that men in CS can be just as social as women, and/or that they simply enjoy being around smart people. Women were more likely to mention confidence building than men but this man's comment "just the fact that knowing that you made it through one of the most difficult programs, you survived …So that's also very rewarding", sounds very much like this woman: "it was just so tough that thinking that you could do really well in it kind of made me feel better about myself, my abilities".

4.11. Students' Interests in Computer Science. Students were also asked **what interested them most** about CS, and what interested them least. Here again a range of interests appeared with very few gender differences. Many students mentioned several areas. For the purpose of charting we use the major choices of interest. (see Figure 19.)

From Figure 19 we can see that the representative cohort of students claimed to be *most interested* in two primary areas: applications (10 women and 8 men) and what we have put under the umbrella of "Thought Processes" (7 women and 9 men). Applications mentioned ranged from specifics like graphics and robotics, to the breadth of CS applications as this woman explains, "I think the most amazing thing is that CS is integrated in every aspect". This man commented similarly, "I think its breath and its applications to so many other fields". The broad area which covered "Thought Processes" included interest in logic, algorithms, solving puzzles and problem solving, with women more likely to refer to problem/puzzle solving as this woman illustrates, "I think, I really don't think computer science has anything to do with computers. It's more of, here's an interesting problem, here are some ways to solve it". The men, on the other hand, were more likely to refer to algorithms as this man illustrates, "I'm more interested in the algorithm stuff". For some students the thought process and applications of CS were nicely integrated as this student shows, "I think the practicality of computer science, also the challenges in solving a problem and also like a very abstract idea, or algorithm, can be solved to, can be applied to solve the most practical, everyday problem". One man and one woman referred to their interest in logic.

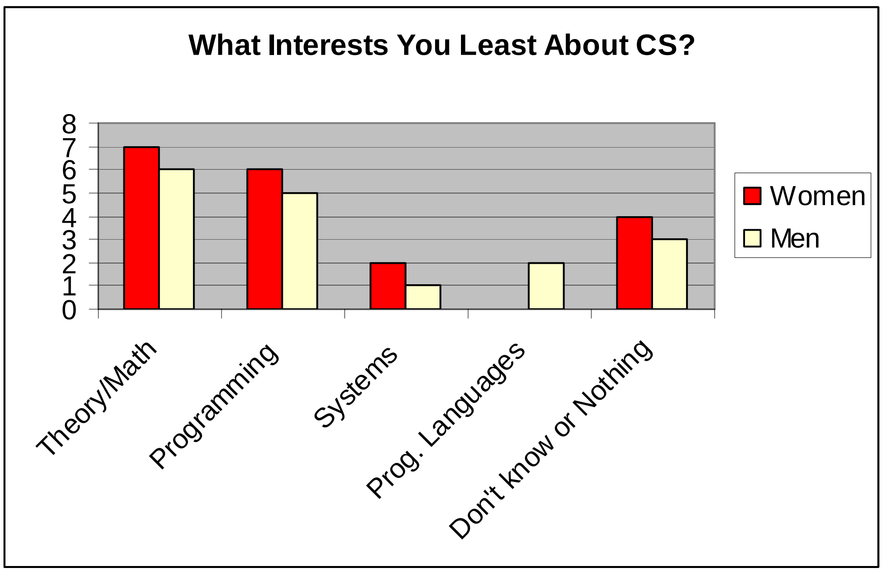
Figure 19. Students' Choices of Areas of Most Interest in CS



In the unsure category there was one man and one woman who couldn't seem to pin any one interest down. Two women focused on future possibilities, one was "interested to see what will happen next", while the other felt that because the field was so fast paced and modern it might allow for her to make a contribution in a way that other fields would not. Two men were left out of the chart as outliers: one had a specific interest in hardware and one in physics. Overall men and women showed a range of interests in CS and once again we saw no real evidence of a gender divide.

Similarly, when students were asked about **what interested them least** a spectrum of comments emerged (see Figure 20). The largest area of *least* interest was theory and math, with 6 men and 7 women pointing to this category. As these two men explained their least interest they also showed again how applications-oriented many of the men in our cohort tended to be. This man claimed “I see proofs sometimes that don’t have application and I don’t see a point. It’s just like, yes, it’s nice to exercise the act of proving things. But ah if there’s no point, then don’t do it”. Another man explained “least appealing would be I guess the higher, the more theoretical aspects of it. I’m the kind who needs to see stuff happen, who needs to take that and create something that will help people”. This woman explained “I really did not like algorithms class. It’s sort of the theoretical discrete math part of computer science. I got through it but that was my least favorite part by far”.

Figure 20. Students’ Choices of Areas of Least Interest in CS



Programming figured largely as an area of low interest for 5 men and 6 women. (Note that in section 4.3. we found that 10 women and 9 men said they liked programming.) For several students it was the low level, systems level programming, dealing with the “minor technical details”, that they had least interest in. One man was unclear in his response while 2 other men “couldn’t think of anything”. Of the 4 women in this “don’t know or nothing” category, 2 women also could not pin anything down, while 2 other women seemed to have a positive interest in CS generally. This one commented “I’m certainly as upset as anyone else is when things don’t work. I think that’s the closest I can get to something that doesn't interest me", and this one said "a lot of things interest me about it. I can't really think of any negative aspects".

In contrast to the early Carnegie Mellon studies 1995-1999, conducted in a situation with *very few* women, *our findings show a similar spectrum of attitudes and attachments amongst women and men rather than a gender divide.* We argue that the experiences and perspectives of the women in these other studies were in part shaped by their minority, and sometimes token, status rather than by gender. To borrow Kanter's analysis of men and women (from the Indsco corporation) we suggest, "It was rarity and scarcity, rather than femaleness *per se*, that shaped the environment for women in the [departments] mostly populated by men" [Kanter 1977, p.207]. Likewise, our findings serve to confirm the importance of micro-culture and environment as major contributors to student perspectives on computing.

By taking a cultural perspective, including being open to seeing gender similarities and a spectrum of attitudes, we conclude that the gender differences observed in the early research were actually *perceived* differences. These perceived differences were products of the culture and environment of the time, and specific to the student body of the time. They were not produced by any meaningful gender differences. The observed gender differences from the 1995-1999 study tell more about the *biases in the former admissions criteria* into the CS program at Carnegie Mellon, and a narrow conception of the undergraduate program, rather than significant or intrinsic gender differences in potential computer scientists.

4.12. Stereotypes 2004: Breaking with, and Living with, Stereotypes.

> "Last spring we tried mixing social groups so we actually got a group of CS majors and sort of tried to get a couple people from some of the other majors to hang out and spend some time together. One of the observations that we actually got was the CS majors were actually more social than the others. … I'm much happier to go and spend time outside and play sports or go hiking or other things like that rather than actually doing any really extra bit of time on the computer" [Male Senior, Class of 2004].

By 2004 much of what we found in the 2002 interviews relating to stereotypes was further confirmed, and in some cases taken to new levels with students showing a range of attitudes from some who clearly broke with stereotypes to some who found stereotypes non-threatening.

Earlier in this chapter, we presented data showing how students had shifted away from the stereotypes of men “dreaming in code” and women “computing with a purpose”. We also provided evidence of changes in relation to other stereotyped characteristics, including students’ definitions of CS, confidence levels, confidence and programming skills, students’ sense of fitting in, perspectives on the CSD atmosphere, and being a woman in CS.

In our 2004 interviews, the representative cohort, was asked specifically to say a few words about CS stereotypes.[94] Not surprisingly, we heard some familiar comments, from both men and women, confirming that the old stereotypes still persisted in the general culture. The stereotyped geeky computer scientist sits in front of the computer all day programming, is odd looking, unhygienic, nerdy, and anti-social. This woman described stereotypes as follows: “guys (laugh), nerds, big glasses, sitting in the cluster all day, programming all day, playing video games”, while this man described them this way: “the people that never leave the cluster, that never shower, that have poor hygiene and long hair. … typically guys, well always guys, who don’t care about women or having a social life or anything like that. They’re just focused solely on the computer”.

Two women (one quoted above) and one man (quoted above) made a point of noting that the stereotype referred to men only, and almost all students in our cohort, men and women, distanced themselves from stereotypes which is not surprising. This woman, however, appeared to include herself as part of the stereotyped community: “a lot of stereotypes are that *we’re* nerds who spend all *our* time in front of computers and that *we*

[94] Question 13 “Can you say a few words about computer science stereotypes?”
Please see section on methodology for details of the interviews and how the cohort was brought together.

also have hobbies that sort of go with computer science and technology, you know, *we* don't play sports, we're lazy, unkempt, things like that".

Several students appeared to be quite happy to have some connection to CS stereotypes (or part of them). This man claimed "there's definitely an overall tendency towards nerdiness and I mean that in the best way possible. I guess considering myself in there and very proud of it". This woman commented on "nerdy jokes, making jokes about Linux and things like that and I see no problem with that. I think it's funny too. … I think that the stereotypes aren't malicious. I think that they are fine. … to a certain extent I think that people embrace them here and that's fine. I think that people don't mind. They know that this is what they are like and they're not going to hide it and I like that a lot". Another woman readily admitted fitting the stereotype: "I do think that we are a big bunch of nerds ….we all love technology in some form or another and we all love to play with a computer and I think that alone is a good indication that we're all nerds". This woman was not surprised to see some stereotypical types among her peers: "in general people who choose this major do have some personality traits in common, which is why we all gravitated towards this. And you know that might be what people typically consider geeky or nerdy".

These students from our 2004 representative cohort voiced a sense of comfort with some aspects of the stereotypes and did not appear to be too upset by them (in 2002 some students had indicated some intolerance for what they perceived as offensive stereotypical images). For the most part, both men and women, suggested that stereotypes had not impacted their experiences in any significantly harmful way. It was as if by their senior year they felt comfortable with themselves, their peers, and the images around them. Two women suggested that nerdy characteristics could also be applied to *Carnegie Mellon students in general*. This woman said "I think that describes actually all of CMU if you think across all majors. I think every person here at Carnegie Mellon has some sort of nerdy aspect", while another woman commented along similar lines, "I do think that we are a big bunch of nerds. That much is true. I mean you have to be in some ways to be a CS major here or just to be here at CMU (laugh)". One woman explained the range of student interests from technical to artistic, pointing out the only thing they all have in common is "we all happen to write code".

One woman and two men epitomized this comfort level in noting that the negative geeky image might be losing its edge, possibly as more and more people become frequent users of computers and the internet. This woman, for example, said "I think (the stereotype) is not as prevalent any more just because, people are learning more about computer science and it's basically in every aspect of their lives, so everyone has had exposure to it". The two men also suggested that computer expertise was becoming "*cool*", as people become "more generally interested in computers than they were 10 years ago….. it's more popular now to be interested in computers". "Everyone now uses a computer. Everyone wants to be proficient on the Internet in doing things. So it's becoming a little bit more in fashion I think to be geeky. I read it somewhere too, so it's not just me. (laughter)".

Another stereotype surrounding CS students is their supposed 24/7 attachment, *by choice,* to the computer. Contrary to this, as evidenced earlier in our section on balancing CS and other activities, we found that students in this cohort really wanted to try to have a balanced life and include extracurricular activities in their schedules even though time was often a challenge. Other activities, they claimed, were important to them. Our students were not only striving to have a balanced life but seemed to be *succeeding*.

With respect to the *time* factor several students, men and women, pointed out that time spent "connected" to the computer in what might appear to be an obsessive way, was actually when homework and lab projects were due. At that time they agreed that (as this woman noted) "all you can do is your project" and work took priority (as this man noted) "…social life is completely disrupted by the fact that they have to go sit in the cluster for twelve hours and work on something". Time management, then, became a very important skill for these students so that they could maintain a balance of social and work lives, but the stereotype that they "just sit in front of the computer all day" was clearly not true for this cohort. For many of the students true "geekiness" now referred to the amount of *time* spent at the computer. In other words *"hard core"* now seemed to refer mostly to time rather than any other stereotypical feature, looks and anti-social characteristics were not mentioned nearly as much. In fact time issues cropped up in many answers.

Furthermore, as this man and woman explained (quoted here consecutively), when time spent working became intense, the group work effort could become *a source of common ground* and fun: “There’s always this sort of sense I get when we’re like in the cluster working on big projects and there’s like a ton of people there and we’re all working on the project that’s due at midnight and everyone’s like, we’re all working together cause we all have this common enemy and this project and everyone just gets along laughing around”; “I got the impression, you know, when I’m sitting in the cluster at like, you know, 2 o’clock in the morning and I can’t (laugh) I can’t get this thing to work or whatever, you know, the people around me who are stuck there too are like, you can see those problem is difficult for them there um, they wouldn’t rather be doing anything else”.

Another stereotype that lingers is that men in CS are anti-social, “someone who talks to a computer more than talks to people”, or disinterested in anything outside of computing. In contrast to this we found many men in the 2004 cohort who were busy with a variety of social and other activities, which often simply meant hanging out with friends as this man mentioned, “what I enjoy most outside of anything technical is probably what I enjoy most period, just chatting, spending time with people”.

One man pointed out that for some students their social circles shifted as they moved from the social environment to the work environment, usually finding themselves in the clusters prior to a project deadline, “…then their social life is really kind of bound to whoever else is also working at the same time. And so there’s kind of a camaraderie that builds up there and then other social circles begin to become neglected in some sense …. the real friends that a student like this will make will be the people that they’re working along side. And then that seems antisocial from the outside”.

We did not find stereotypes contributing to a gender divide as noted in the early research of the 1990’s. We suggest, however, that a perceived gender divide was quite likely to have emerged in the kind of computing culture examined at the time. That said the 1990's researchers did claim: "our research reveals successful computer science students, both male and female, with a wider variety of interests and ways of relating to the computer than the stereotype portrays …. Male and female students can sound alike in this regard".[95] Quite possibly the focus on gender differences marginalized such important *emerging gender similarities.* Interpretations of the early findings appear to have focused on the gender divide such that (intended or not) stereotypes of CS men "dreaming in code", and CS women, "computing with a purpose", have been created and perpetuated.

4.13. Reducing Stereotype Threat. We suggest that as the micro-culture has changed and the differences between men and women have dissipated to reveal more similarities, gender identity with respect to CS appears to have receded, and been replaced by identification with the CS community. This positive identification ties in with Steele's theories for increasing academic trust and reducing stereotype threat[96] by helping students create "strong academic identities" and micro-cultures (Steele uses the term "niches") of trust. We discuss Steele's work in more detail in Chapter two, Section 4.

Our work with students in CS at Carnegie Mellon has, we believe, helped create such a "niche", in this case a micro-culture that allows for the Women-CS fit. We (the department, *Women@SCS*, the school, faculty staff and students) have worked to provide an environment in which women can develop trust in the institution, and in particular, trust in the institution's confidence that women, *given the right environment*, can participate in CS as well as their male peers. We believe this trust developed gradually following the 1999 increase in the numbers of women in the CS program. In the couple of years following this increase, women students had to deal with backlash, questioning whether they belonged in what was perceived as a male-appropriate program, but also, more importantly they questioned whether they were *admitted* because they were women. In a 2002 interview this woman voiced what many other women grappled with at the

[95] See http://www.cs.cmu.edu/afs/cs/project/gendergap/www/geekmyth.html

[96] The term "stereotype threat", which we discuss in detail in Chapter two, Section 4, was coined by Claude Steel to refer to "the threat of being viewed through the lens of a negative stereotype, or the fear of doing something that would inadvertently confirm that stereotype" [Steel, 1999].

time: “At first I felt like an outsider in CS. I also had people telling me that I got in because I was a woman and that I was in their spot. That hit hard when I wasn’t doing so well in class”. These kinds of comments served to question the degree of trust that women (and men) had in the institution.

We suggest that such questions of trust were eventually diminished, although not eliminated completely, through several strategies, including women’s rebuttal, but more importantly, through various institutional messages along with efforts to improve the environment for the benefit of everyone. Over the years the department has fostered the sense that men and women belong and are equally capable of doing CS. Students heard repeated formal and informal assertions (e.g. at freshmen orientation sessions) that entrance criteria for CS at Carnegie Mellon, were exceedingly high and that students were admitted on the basis of ability. Students heard from the university president, Jared L. Cohon, that diversity brought tremendous value to the school: “I want Carnegie Mellon to be a place that celebrates these diversities rather than merely tolerating them, because being a more diverse institution will make us a better institution. In the classroom, studio, laboratory, office and dormitory, a multitude of experiences, perspectives and beliefs will enrich all that we do”.[97] On top of this, students *witnessed* more women coming into the program and graduating successfully. Students also saw that *Women@SCS* was a respected and professional action oriented organization working for the benefit of the community within the School of Computer Science …and not a marginalized women’s organization. We believe that the development of *Women@SCS*, and its credibility within the school, has helped to give students and faculty, men and women, a strong sense of women’s value within the department.

As our case study findings reveal, by the time we interviewed seniors in 2004, women were feeling like they belonged, academically and socially, in CS at Carnegie Mellon, thus showing what Steele might describe as an increased sense of trust and a move towards academic identity building. Women in CS at Carnegie Mellon now illustrate a positive Women-CS fit, breaking with the stereotype that the field is suited only to men.

[97] President's Statement on Diversity: http://hr.web.cmu.edu/drg/overview/statement.html

Steele's work on stereotype threat, and the notion that black students want "fairness", "*explicitly presenting the test as racially fair"*, provides evidence for caution against adopting "female-friendly" strategies for increasing the numbers of women in CS. *Gender fairness* seemed to be a source of common ground among our cohort of students. Both men and women wanted to feel that things are *fair,* even if they are not. This is indicated in their responses to the question "Do you think Carnegie Mellon should make any further efforts to attract and retain more women in computer science?" (Question 47 on the interview questionnaire). Many students struggled to answer the question because it opened up the issue of "fairness" and their natural urge to conform to a broader culture dominated by a belief in egalitarianism i.e. we have equality and freedom of choice. Nevertheless, the question raised an interesting range of responses, for the most part falling into 2 sets of viewpoints that cut across gender.

Here we list several quotes to show the variety and pervasiveness of these viewpoints.

The egalitarian viewpoint: to some students fairness meant not discriminating between men and women.

From women students:

- "I think it's important to retain all students, and not just women … I think it's sort of important to focus on everybody".
- "I don't really think that the school should make any special effort to get any specific sort of people here. I think if women want to come, they will come and it seems unfair to the men if more attention is being paid to (the women)".
- "I think people should get in based on their merits not their gender".

From men students:

- "I'm (against) any sort of affirmative action whatsoever, it should be strictly a merit based system".
- "(CMU) should get the best students that it can get".
- "I think that they should make efforts to attract and retain the most qualified individuals whether they be men or women".

The balancing the bias viewpoint: to other students fairness meant keep working towards balancing the obvious male bias.

From women students:

- "I think they've been doing pretty well so far but I don't think they should stop their efforts. …. when you stop, people lose interest, or people don't know about your school, and then they stop coming. So, they should continue whatever they are doing right now. It seems to be working and I think they should stay with it".
- "I think one of the things is just keeping it in the forefront, that it is a priority, that it is an issue. I think as soon as you stop talking about it then it gets pushed under the rug and people don't realize that there's an issue there and they don't pay attention to it and they revert back".

From men students:

- "You want to make sure there's no inherent bias in the way you are admitting people, but my initial reaction is to say if it's not 50/50 or 49/51 or whatever the population average is then clearly there is bias".
- "I think they should continue current efforts. I think it's very important especially in the poor academic development of younger children, and the way we teach children, and how women tend to get second place to the men".

The middle ground viewpoint: this man admitted his struggle with the two positions to find fairness:

- "Yes and no. I would say yes because I think it's something that plays more into a high school thing. …even just sort of a cultural thing, women can do science just as well as men or anything else like that … But, part of the no is, I in some way feel like I've been unfairly treated in the sense that of well, I'm a male."

The question of gender fairness clearly impacts women's perception of belonging in CS. Women, especially women entering a male dominated environment, do not necessarily benefit from what they perceive as gender difference strategies, or anything they might feel is insulting to their intellectual integrity. This woman spoke for many of the women in our cohort: "we get treated just like the guys which is a good thing. Like it's uniform and that's the most that you could ever hope for. You don't want a special treatment, or you don't want the worst treatment", while another woman suggested the department was succeeding in being gender-fair: "I know it's working well when you don't notice a difference between how the guys are treated and how the girls are treated".

For the most part, women in CS have already (consciously or unconsciously) broken the codes of perceived gender appropriate routes, and do not want to be in the spotlight by virtue of their gender. At the same time, in order for women to thrive in a minority situation, we believe that it is important to formally provide those opportunities and advantages that are available naturally to the majority community. On the surface such strategies may sound "female-friendly" but our approach and outcome are quite different. Traditional female friendly strategies, for the most part, are grounded in a belief that men and women are basically *different* (whether from an essentialist or social development perspective) and therefore we need to accommodate the differences to make things equitable. One such accommodation, arising out of gender difference research as we noted earlier, is to gear the curriculum towards what are perceived as *women's* interests, attitudes and abilities. We believe this serves to marginalize women, and perpetuate stereotypes, even further.

Our approach, on the other hand, is grounded in the belief that it is *experiences* that are different and under appropriate circumstances men and women show a range of similarities and differences in their interests, attitudes and abilities. This intellectual spectrum can be seen to cut across gender when women and men are given similar opportunities, similar cultural messages, and similar levels of encouragement. But when women (or men) are subject to a culture of polarization, gender differences become emphasized, and both men and women are easily "stereotyped", and limited to experiences and opportunities that are thought to be gender appropriate. Such stereotyping can be most evident when women, or men, find themselves in a minority situation; the *experiences and opportunities available to them can be different and more often than not are limited*. Thus, leveling the playing field requires providing these opportunities and experiences for those who may have missed out. However, it is important to note that such strategies may not work well if they open the door to stereotype threat, for example, if women believe these strategies are linked to the cultural perception of women having little ability in CS.

4.14. Characteristics of Computer Science Students at Carnegie Mellon. As well as being asked about CS stereotypes the students were also asked, in question 10, "Can you describe the characteristics of computer science students here at CMU?" Students in the research cohort suggested overwhelmingly that the CS student body at Carnegie Mellon was made up of a diverse range of people. As mentioned earlier faculty members also expressed this view.

Some words and phrases were heard repeatedly in response to the question as they discussed the overall characteristics among Carnegie Mellon's CS students: "intelligent", "creative", "hard working", "passionate", "focused", "smart", "diverse". The range of descriptions included: students are well-rounded, involved in activities outside of computing, and generally not conforming to the CS stereotype. In the words of this man: "I'd say there's a huge range of people who actually like computer science". The most common indication of diversity took the form of students struggling to answer the question with specifics. This woman replied "I guess I can't specify one thing because I think everyone is different so I can't really pinpoint certain characteristics from one computer science major to another". This man made a similar comment: "You can't just say, these are the characteristics". Finally, he decided "one thing that's shared among almost all of them is hard working and not afraid to take on challenges". One perception, noted by this man, that seemed consistent among both the men and the women respondents was that even though some students fit the geeky stereotype, they were just one group among the "great diversity in personalities and things people are into". This woman made a fitting remark: "They are no longer the unwashed geeky masses".

The CS major at Carnegie Mellon allows for multiple interests, and before students can graduate they are required to fulfill coursework to satisfy a minor. Indeed, this man suggested that *the field itself allowed for this diversity*, "computer science allows you to have other interests”. This woman felt that CS at Carnegie Mellon was special in the way students were allowed to explore a breadth of interests. As she described how important this was for her she also noted the broader understanding of diversity that characterizes the School of Computer Science: “I do remember though, when I was visiting schools before I decided on Carnegie Mellon, I did get a sense from other schools that they were not as open to diversity maybe. And I don’t mean diversity in terms of minorities and women, but I mean in diversity of interests. I remember visiting I think it was the Other School[98] and their computer science department felt so rigid and technical and that’s not at all what I wanted. I wanted it to be more open and allow me to try interdisciplinary work and stuff. So, so I think there was sort of this traditional computer science that was very technical theory based hard core programming thing. And I think it’s maybe still around in places, but in my experience I just don’t see it here as much”.

In an attempt to pull together the characteristics noted by the cohort, we have charted (see Figure 21) the repeated characteristics we heard in the responses to the question “Can you describe the characteristics of CS students here at Carnegie Mellon?”

Figure 21. Students Suggest the Major Characteristics of Computer Science Students at Carnegie Mellon

	Men	Women
Hard working	3	3
3 sub-groups: into CS/into other things/in between	6	9
Intelligent	2	3
Diverse	6	7
Friendly	2	1
Balanced: well rounded (or trying to be)	2	4
Motivated (driven), focused	1	4

We found that the most common characteristic perceived by this cohort was that the community was made up of 3 different sub-groups (6 men and 9 women commented on this). The details of such comments suggested there were those students who were totally

[98] Other school is inserted here to keep the anonymity of the actual school mentioned.

into computing, those who preferred their outside activities, and those who occupied the middle ground. In Figure 21 we refer to this characteristic as 3 sub-groups. The next most common characteristic perceived by the cohort was that the student body was diverse (6 men and 7 women commented on this). Another characteristic noted was "hard working" (3 men and 3 women commented on this). Several of these characteristics were noted fairly equally by both women and men.

One woman commented "it seems like the people who saw CS as something they're studying and not like a way of life …. I see more and more of those with every incoming freshman class. And the other type it seems like in high school they weren't the most social people so they're learning to be social as well as learning computer science at Carnegie Mellon. And the other people are more formed, whole people when they come in". Her comments indicate that she identified 3 groups of students who *were all being shaped by the evolving culture during their years in the CS department* at Carnegie Mellon.

4.15. The Value of *Women@SCS*. On a day to day basis we witness the seemingly boundless energy and enthusiasm of the *Women@SCS* Council[99] members as they design and implement an extensive program of activities for the on-campus community and beyond. We never cease to be amazed at the commitment and creativity of these students, especially given the demanding, and time consuming, academic programs they are pursuing. But we also see how much they benefit from their involvement with the organization, growing more confident, gaining leadership and public speaking experience, meeting professionals in their field, designing and implementing specific events, while all the time passing along sound advice and strong mentorship to younger students.

For the most part these "growth" and benefit factors are intangible, difficult to measure, nor have we had the funding and resources to evaluate our program in any professional way. Indeed, we have focused our resources on action, and on *developing and providing*

[99] For more information on the makeup of the *Women@SCS* Council see Chapter Four, Section 1. For the most part in this section we refer to *Women@SCS active members* rather than council members.

those opportunities and experiences that just seem to make sense! Several studies, however, have provided evidence for the value of having the kind of program in place that *Women@SCS* provides, especially in relation to mentors, role models, and network systems. Gloria Townsend's paper on mentoring and role modeling points out: "The literature of gender issues in computing steadfastly and uniformly has advocated the use of mentors and role models (M&RM) for recruiting and retaining women in computer science" [Townsend, 2002]. Townsend notes the contributions to this literature by some of the notable women and organizations in the field: Tracy Camp, Vicki Almstrum, Denise Gurer, the Association for Women in Science, the Mentornet organization, among many, many others.

We mentioned earlier that *isolation* is a primary factor *negatively* impacting the experience and performance of women and minorities in computing [Eskovitz, 2000, Valerie Taylor, 2002]. Other studies note the importance of same-sex peers. Jo Sanders' study of girls' attitudes about computer use notes "I found that it wasn't the predominantly male cast of the computer room that kept girls away, as I had thought, but rather the absence of their girlfriends" [Sanders in "Teaching the Majority", 1995]. A 2004 British think-tank publication, "Girlfriends in High Places: How women's networks are changing the workplace", suggests that networking is an *essential professional tool*, arguing that "professional networks can enhance individual career prospects while enabling women to work together to tackle workplace inequality. Women's professional networks can provide the kind of confidence-building support which men are good at providing for each other through their informal networks" [McCarthy, 2004]. This perspective is very much in line with the mission of *Women@SCS* which has evolved *not* as a "handholding" support group, *but rather as an action oriented organization in which women have taken leadership roles that have enhanced the entire CS community*.

A 2006 nationwide study of undergraduate departments by Joanne McGraph Cohoon, concluded that numbers of women peers and the potential for available same-sex peer support had a strong impact on women's attrition rates [McGraph Cohoon, 2006, p.216]. At Carnegie Mellon we are fortunate, and quite unique, in having both "available same-sex peer support" and a strong "female portion of enrollment" (at the undergraduate level). Our unique situation has opened the way for *Women@SCS* to develop, and for our students to benefit from the opportunities provided by the organization.

In the following sections we illustrate **students' perceptions of *Women@SCS*** through the voices of the 2004 representative cohort. Students were given an opportunity to explain their perceptions of the *Women@SCS* organization. They were asked whether they had heard about the organization, if they attended events, or been involved with the organization, and whether it had impacted their experiences, or not, as they proceeded through their years at Carnegie Mellon. Below we illustrate the predominant responses of the representative cohort beginning with the women *non-council* students, followed by the *male students*, and finally the *Women@SCS Council members*.

4.16. Women's (non-active members) Perceptions of *Women@SC*S. All women said they had heard about *Women@SCS*. One woman pointed out "one of the advantages of it that I see is just the visibility". Indeed we believe that visibility can be a source of value to women in a minority situation, so that even those not actively involved in *Women@SCS*, can benefit from a sense of community and valued presence in the department. This was illustrated by one woman who felt that the organization had impacted her experiences positively at Carnegie Mellon "even in ways I don't really realize". Most students had very good impressions of the organization. Of the 15 women in the cohort who were non-active members, 8 of them had very positive things to say, 2 had mixed responses, 4 were unclear or non-committal, and only one woman held a negative view.

Women@SCS had impacted the lives of these women in many ways. Several women mentioned how much they enjoyed the events, and many noted appreciation for the Sisters' program, the pre-registration advice sessions, and especially for the networking events such as the faculty/student dinners, events with graduate students, and invited speakers. For some students, the most important aspect was simply the act of connecting "the different classes like freshman, sophomores, juniors". For one woman, the

Women@SCS events helped build her confidence and gave her the opportunity to hear from other women "one step ahead" of her: "It definitely helped me in the first couple of years. Yes, trying to find my place and getting more confidence. I think that's where I definitely got it from was from *Women@SCS*". Another woman commented that seeing women professors and graduate students helped to counter her impressions that only men were successful in the field: "I especially like the events (with) women computer science professors and students ….when I see there are women PhD's and they are teaching at Carnegie Mellon University, they must be really smart too, I really liked seeing (and) getting to interact with them". One woman felt she did not need *Women@SCS* personally: "I was doing fine on my own as a woman in computer science" nevertheless she "appreciated that they were there and what they were doing for other women".

This cohort of women students was admitted in 2000 under new admissions criteria that de-emphasized prior programming. This meant that during their first couple of years some had heard, or experienced, backlash comments suggesting they were admitted because of their gender. *Women@SCS* council members often addressed this issue at meetings and events. For one woman who had been questioning why she had been admitted (when she had no programming background) hearing other women explain the reasons at a *Women@SCS* event had made a difference: "after I figured out what the real reason was, which they explained at one of the meetings, …..(it) made a lot of sense".

The one woman who voiced negative comments said she felt she "would rather be a person at SCS than recognized as being a woman at SCS". I believe this is a commonly held view among some women, and on one hand shows a healthy resistance to gender separation paradigms, but it can also exclude such women from taking advantage of opportunities that may be of benefit to them. Several women in our cohort had heard, or felt, that the group of active members was somewhat "cliquey". This was an understandable perception as this particular group of active members (who led the *Women@SCS* council), had developed very strong bonds over the years and were very close friends; in many ways this became a *strength* for the organization, but also a negative perception that needed to be addressed. In fact, the group was aware of this "exclusionary" image and made extra recruiting efforts. One of the major issues for the organization (and we think one that applies to many organizations for women and minorities) is communicating what you do/who you are, and *what you don't do*. *Women@SCS* has made determined efforts to announce its positive mission of offering many opportunities and new experiences, and has tried to dispel any mis-representation. These efforts need to continue.

4.17. Men's Perceptions of *Women@SCS*. All men said they had heard about *Women@SCS*. The men voiced an interesting range of impressions, with 6 men having very positive impressions, such as this man who said: "I think it's a pretty good organization, I mean it's trying to bring more opportunities to women in computer science which is a good thing because I think it's kind of imbalanced in this field". Several noted the "action-oriented" aspects of the organization and the fact that some events were open to all students, men and women. In fact, 8 out of the 20 men had attended at least one event organized by *Women@SCS*. However, many of the men (10) knew little about the organization. Mixed impressions came from 3 men. For example, one man described the organization as "the women mafia of CS" but also noted they had "done a lot of positive things". Another man had a rather vague, but fairly positive, impression: "it's sort one of those organizations I know exists, and it's out there, and they do good stuff, but I'm not really sure about the details". Only 1 man was specifically negative claiming the organization was not political enough, and needed to make its mission clear, and if he was running the program he said "I might do it differently". It seems evident that *Women@SCS* needs to work harder at getting its message and mission out to *all* students.

It is worth mentioning that although it did not apply to the 2004 cohort, *Women@SCS* has had men participating actively on the council. Two men from the class of 2006, for example, were very actively involved on the *Women@SCS* council throughout their years at Carnegie Mellon. One male student had been involved because he was a minority student and wanted to contribute to *Women@SCS* and to SHPE (Society of Hispanic Professional Engineers). The other student was an active student, campus wide, and joined the *Women@SCS* council because he felt it was the only student organization with any action-oriented presence in the CS department. This student eventually became the *Women@SCS* web team leader for almost two years and proved to be an outstanding member of the organization.

4.18. *Women@SCS* Active Members' Views. Not surprisingly the *Women@SCS* active members were the ones who benefited most noticeably from their involvement with the organization; for some the organization had proved to be pivotal as this woman said "For me it's helped me get through a difficult four years of college". In the 2004 representative cohort 5 of the 12 active members of the *Women@SCS* Council were included. All 5 council members talked enthusiastically about the opportunities they had, and the friendships they had made, through their involvement with *Women@SCS*. Freshman year was when 4 of the 5 students got involved with the organization, the other during her sophomore year; 3 council members were encouraged to be involved by other students and friends, while 2 others attended meetings, felt a good fit and decided to stay. All 5 students gave a sense of both *giving and gaining* from their involvement as council members.

This reciprocal "giving and gaining"[100] revolved around specific aspects of the organization but all combined professional *and* social activities:

- *Mentors and Role Models:* all 5 council members had been involved with the BigSister/LittleSister Program[101]. One student had headed up the program for a couple of years, "it was nice to be able to be in charge of something. It kind of made you motivated to stay involved and do more stuff because you were in charge of a project". Another student suggested "there are advisors out there, but some people don't feel comfortable talking to their advisors. Or they don't think they have big enough questions to go to (their academic advisors) to ask. And that's where your big sister can come in and offer advice about little things that the freshman don't think are that important". The faculty/student events that *Women@SCS* have organized have also provided opportunities for council

[100] This observation also serves as a reminder that admissions criteria in place by 1999 and applicable to the research cohort included looking for students who showed signs of "*giving* back to the community". *Women@SCS* provides many opportunities for such efforts.
[101] For more information about this program see http://women.cs.cmu.edu/What/Sisters/.

members to make personal connections with potential mentors and role models: "I've gained so much exposure to stuff just by listening to the grad students talk about their projects, meeting the faculty at the dinners".

- *Advice:* Be it professional or personal, council members have also turned to each other for advice, and meetings have provided a wonderful forum for informal advice sessions, as this student noted "it's just been invaluable learning from their experiences, they're giving you a heads-up". This student said: "When I was really confused about how I should start getting internships or where should I start, there were a lot of girls who were going through the same things as I was and everyone had a different perspective, different advice on how to approach it and it helped a lot to discuss strategies".
- *Confidence and Leadership Skills:* Being a committee member played a role in improving at least one council members' confidence: "It helped my confidence in the sense that I saw that other people were having the same problems and so it wasn't just me". Taking responsibility for organizing events helped with their organizing skills and having leadership opportunities. Indeed, 2 students became TA's as a direct result of encouragement from more senior *Women@SCS* council members. This woman explained "for example the class that I TA, I wouldn't have taken it if I hadn't met (another council member) who TA'ed it before me and told me oh you would love this class. You should take it. And it's one of the highlights of my whole academic career here".
- *Professional Opportunities:* Invited industry visitors have provided personal contacts and recommendations that students may not have had otherwise: "Actually I once got an internship just based on a speaker that came to talk to us". At one event this woman "took like pages of notes and I looked them over before I started my job search". Council members have also been encouraged to attend and present at conferences, and *Women@SCS* has funded many conference attendees. Such opportunities are rare for undergraduate students generally. For one woman, attending the Grace Hopper conference had been a memorable experience: "that was an incredible experience….just meeting again professionals

in industry, meeting educators, other women who've been through tougher roadblocks than we have, kind of paved the way for us. That was incredible".

- *Social:* Council members formed very close friendships and *Women@SCS* meetings connected women from different years who may not have met otherwise, as this student explains: "I'm always learning from the girls, but it's just been a very close network of friends I've had that, maybe I wouldn't have really met otherwise …some of the girls we're not in the same classes, or we're not pursuing the same track, and if it wasn't for this group I don't think I would have met them. Or even if I had met them in a class, it wouldn't really be the same. Here in the group you're more free to talk about your interests and what you like to do".

- *Outreach:* Several council members had taken part in the annual Expanding Your Horizons[102] workshops for middle school girls. But the pride and joy of this group was the Outreach Roadshow[103], which was started by students from the class of 2004, and has been developed further by later students. This student explained her sense of ownership: "my biggest contributions though have been through the Roadshow which actually I guess, I don't want to say I'm a founding member of the Roadshow, but I am. (laugh) Just like the other 3 girls …It just came from one presentation. I was one of the people who did that presentation, so I kind of feel like it's our little baby, you know The Road Show (laugh)." Another student pointed out the value that the Roadshow might have to young audiences: "I think the Roadshow is very worthwhile, just because I can picture myself, in the kids' shoes. ….I feel like we're helping out the kids, just sort of showing them the interesting aspects of computer science, showing them what they can do with it, and how computer science is in everyday life, and sort of teach them a few things". We found that as students prepared their Roadshow presentations they also learned more about the field themselves and were then able to teach others: "It's just given me a lot more exposure to the different areas of computer science".

[102] See the Expanding Your Horizons web site at http://www.expandingyourhorizons.org/
[103] For more on the Roadshow please see Chapter Four, Section 2.

- *General:* This student explained the value of being a council member: "I think it's really important to be on an advisory board if you want to have an active part in *Women@SCS*. It's also where you're going to get the most out of all the interactions. ….we have weekly meetings and it's a good down time to talk with all the other girls and all the advisors. ….It's also important to have input into all the programs and sessions we provide".

Through the combined efforts and dedication of faculty and students, *Women@SCS* has proven itself to be an effective and valued organization within the School of Computer Science. For the most part, the organization has avoided being marginalized in the way that many women's groups often are, and instead it has become a respected, action oriented, community-building organization working to improve the quality of the school experience for *all* students. The organization has benefited from taking a cultural perspective on the student experience. This has meant helping to balance the opportunities of those in the minority situation, but also taking a broad view of how *Women@SCS* might benefit the student body as a whole, and the department in general. Some of the impetus for taking a broader perspective came from the *Women@SCS* advisory council, whose members, rather than feeling driven by any sense of a gender divide, recognized that many of the events and activities planned for the women had the potential to benefit all. As the gender divide has lessened a move towards mutual concerns and benefits has emerged. In this way *Women@SCS* has contributed to the changing culture within the department.

4.19. In Sum. In his 2002 paper "Race, Sex and Nerds: from Black Geeks to Asian-American Hipsters" Ronald Eglash talks about the "normative gatekeeper" as he examines the relationships of race and gender to the figure of the nerd or geek (he uses them somewhat interchangeably). He concludes that it's not easy for blacks or women to simply *adopt* the geek identity, because the geek image acts as a "normative gatekeeper", but rather they need to re-invent a new identity. We saw this process of re-inventing identity among Carnegie Mellon CS undergraduates as early as 2002 as 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 means to be a computer scientist. By 2004 this new identity appears to have 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. This woman summed up what so many others voiced:

> "I've been surprised by the number of cases where people who are computer science students but put a lot more effort into studying artistic endeavors, or studying a language, things like that. I know there's the common stereotype of people who don't get out very often, (who) sit in front of a computer. But I think if you look around enough, that's not really what most computer science majors are doing with their lives".

As noted earlier the findings from our 2004 case study and 2002 preliminary interviews indicate 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 these often became a source of common ground for both men and women. More often than not any hint of stereotypical behavior was tempered with other characteristics as this woman illustrated; she could spend time "drooling over new laptops" but she also discussed "Taiwanese politics" with her friends. Another woman showed her Women-CS fit through her love of video games, "I want to make video games. And I figured since I'd doubt I'd be able to get in on the artistic side of it I might as well go for the coding side. And hopefully eventually I'll end up creating my own games and having a good time with it …. I just said to myself I'm going to make video games! And so then I went off and applied for a CS degree!" This was the same woman who came into the program with very little background in CS, and who considered herself "one of the *CS chicks* ….we were behind a semester from everyone else". She goes on to explain "there were 1 or 2 guys but it was predominately girls" and "after 211 I think we were pretty much (caught up). Well, once we got past all the intro classes and we went onto the upper levels I think we were fine". Her comment about the "CS chicks" reminds us that many women (and a few men) came into the CS program with little or no background in the field, and yet by the end of the sophomore year, most of these students had caught up, and sometimes surpassed their peers, showing the many levels of the Women-CS fit.

We have provided evidence of important changes[104], changes which illustrate that in *the post-1999 more balanced environment*, embracing improved gender balance, a broader range of student personalities, and professional support for women students, *gender similarities have emerged along with the Women-CS fit.* As noted earlier our 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. 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 clearly indicated in 2004 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. Clearly our students are both shaped and shaping this new culture as they challenge old stereotypes and redefine what it means to be a computer scientist.

[104] Further data supporting our argument can be found in the appendix where we have included charts illustrating the analysis of all 55 interview transcripts. The charts show comparisons of the 3 sub-groups that made up the research sample: i.e. *Women@SCS* active members, other women, and men.

CHAPTER FOUR: ACTION AND RECOMMENDATIONS

Chapter Overview: Our research findings suggest that *interventions in the environment* opening the way for *an evolving culture of computing* at Carnegie Mellon have paid off with substantial benefits for *all*, but most notably for women. Women in CS at Carnegie Mellon can now experience a sense of their value and a belief in their CS capabilities so that they can contribute to, and be part of, the evolving culture of computing. We have argued that in a balanced environment -- balanced in terms of gender, students with a breadth of personalities, and professional support for women -- the way has been opened for a broad range of students, including a significant number of women, to participate, and be successful, in the CS major, *without resorting to contextualizing the curriculum.* This Women-CS fit was not evident in the mid to late 1990's. In this chapter we focus on one of the major interventions, *Women@SCS*, and the organization's contribution to a balanced environment. *Women@SCS* is, above all, an *action-oriented* organization providing women with a range of social and professional opportunities, including networking, mentoring and leadership opportunities. Over the past few years the organization has increased its outreach activities quite substantially in the belief that *Outreach and Broadening Participation in the field go hand in hand*. In **Section 1** of this chapter we provide a tool kit for how we have built the CS student organization *Women@SCS*. We explain how and why the organization was developed and the way it has evolved. We describe the events and activities implemented, and the ways in which *Women@SCS* has contributed to both the evolving culture of computing and the success of our women students. In **Section 2** we describe two of our successful outreach programs: the *Women@SCS* Outreach Roadshow and Creative Technology Nights for Girls (TechNights). Both of these programs incorporate valuable outreach *interventions* along with many of the opportunities we have found beneficial for our own students. Thus these programs operate on many levels and accomplish a variety of important goals.

Section 1: Building an Effective Computer Science [105] Student Organization: The Carnegie Mellon *Women@SCS* Action Plan[106]

The following section is based on a paper by Frieze and Blum and aims to provide *a practical guide for building a student organization and designing activities and events* that can encourage and sustain a community of women in CS. This guide is based on our experience in building *Women@SCS*, a community of students and faculty in the School of Computer Science at Carnegie Mellon University. Rather than provide an abstract "to-do" or "must-do" list, we present a sampling of concrete activities and events in the hope

[105]Throughout this chapter "computer science" is used as an umbrella term for the range of computer sciences and related IT fields such as robotics, human computer interaction, software engineering, etc.
[106] Published in Inroads SIGCSE Bulletin Women in Computing; vol.34.no.2, 2002, June, p. 74-78

that these might suggest possibilities for a likeminded student organization. However, since we have found it essential to have a core group of activist students at the helm, we provide a "to-do" list of features that we feel are essential for forming, supporting and sustaining creative and effective student leadership.

1.1. Brief Background. In 1999, the number of undergraduate women students entering Carnegie Mellon's CS Department reached 37%, up from 8% in 1995. The factors that contributed to this dramatic increase have been well documented by Fisher and Margolis [2002] and Blum [2002]. Briefly, between 1995 and 1999 a number of ***key actions*** came into play:

- Summer workshops for high school teachers of Advanced Placement CS were held on campus.
- Allan Fisher, (then) Associate Dean for Undergraduate CS Education, advised the Carnegie Mellon Admissions Office that prior programming experience was not a pre-requisite for success in the CS major.
- About the same time, Raj Reddy, (then) Dean of the School of Computer Science, requested that the Admissions Office develop criteria that could help select future visionaries and leaders in CS.
- The Admissions Office started placing high value on activities that demonstrated commitment to "giving back to the community" in addition to top grades and SAT scores.

In Chapter 3, Section 1, we provided a detailed account of the interventions for cultural change that started to evolve from 1999 onwards and which allowed for a Women-CS fit. In sum, a new vision for the CS undergraduate student body emerged involving changes that would lead to the increased enrollment of women and *indeed* to a significant transformation of the culture of computing at Carnegie Mellon. Importantly, these and subsequent developments have been undertaken with *essential support from top administrators, including the President of the University.*[107]

[107] J. McGrath Cohoon stresses the importance of institutional support in "Toward Improving Female Retention in the Computer Science Major," *Communications of the ACM*, May, 2000.

The new admissions criteria have not affected our students' ability to succeed in the CS major. Indeed, other than creating various entry points into the freshman programming courses, no major changes have been made in the undergraduate curriculum. We attribute this positive outcome in large measure to the student organization *Women@SCS*, and in particular, to its Advisory Council.

1.2. The Role of *Women@SCS*. *Women@SCS* explicitly provides *crucial* educational and professional experiences generally taken for granted by the majority in the community, but typically not available for the minority participants [Blum 2001, 2004, Frieze and Blum 2002, 74-78]. Many of these experiences are casual and often happen in social settings. For example, in an undergraduate CS program, male students often have the opportunity to discuss homework with roommates, with friends late at night, or over meals. Course and job information and recommendations are passed down from upperclassmen, from fraternity files, from friends. Women students being in the minority, do not have access to, in fact are often excluded from, these implicit and important advantages. As one proceeds into the professional world, similar phenomena occur [Blum and Frieze, 2005].

The proportion of women faculty in the School of Computer Science has increased very little since 1999 and currently runs close to the national average of 18%. This means that many undergraduate students go through the CS major without having been taught, or mentored, by women faculty. This is especially true in the early years when introductory classes are taught by CS department teaching faculty, none of whom (until 2006) have been women. Nevertheless, women students have thrived in the program. We suggest that the faculty/graduate/undergraduate community building of *Women@SCS* has, to a large extent, helped to compensate for having few women faculty around in the classroom, a view that this woman made clear: "the *Women@SCS* events and that kind of thing is an advantage because you get to expand your network, meet more people, meet more faculty and graduate students". We implement a program of faculty/student events including the Big/Little Sisters' program (a mentoring program run by upperclass undergraduates), the graduate BigSisters' program (where undergraduate students get to meet and be mentored by graduate women), faculty-student mixers, and the faculty/graduate lunch series (where faculty and graduate women get to meet each other across the 6 departments within the School). In sum, our students get to see and meet lots of women with a wide range of backgrounds and interests.

As Blum observes, an important but nevertheless little acknowledged component of professional training, and success, consists of the professional interactions that take place in social settings. Thus, the events designed by the *Women@SCS* Advisory Council generally combine professional *and* social activities that help foster community, confidence and growth.

1.3. Student Leadership: The *Women@SCS* Advisory Council. With the dramatic increase in the number of women entering the CS program in the fall 1999, the school was faced with a great opportunity, and a great challenge. It seemed clear we would be in danger of losing many of the new recruits if we were to conduct business as usual within the atmosphere of a traditional CS department.[108] Hence it seemed critical to work closely with students who might guide us to appropriate action. By 1999 graduate women students from the School of Computer Science had already recognized the value of bringing together the women who were spread thinly across all six departments. Representatives from among the newly increased numbers of women undergraduates came on board and the *Women@SCS Advisory Council* (known here simply as 'the Council') was born. *Women@SCS* has since become catalytic in building an environment in which the new student body could flourish. Since its inception the council has been action oriented. We believe the best way of overcoming any problems is by just *doing* and this philosophy has been welcomed by faculty and students alike [Blum and Givant, 1980].

[108] At Carnegie Mellon, students enter the CS major as freshman.

By the fall 2000, the Council had a total of 23 students and had separated into a graduate sub-Council of 12 students and an undergraduate sub-Council of 11 students. The separation was necessary because of divergent interests between the younger students (who preferred a combination of social and mentoring activities) and the more professional/research oriented graduate students (who preferred focused discussions and professional networking activities). Connections between the sub-Councils continued to be maintained by holding regular joint meetings and events.

By October 2001, the Council had doubled to a total of 46 students (22 undergraduates and 24 graduates). All four years of the undergraduate level are now represented, and most of the graduate departments. We have found that a core group of Council members are extremely active and participate on a regular basis while other members attend meetings and help out with events whenever they can. This situation has proved to work well. Council members are under no pressure to do Council work but will happily help out when called upon. At the same time, the more regularly active members can hold leadership positions within the Council, direct meetings, instigate discussions, and plan events.

The Council has turned out to be *the* driving force behind our pro-active efforts to improve the academic and social climate for all women in the School of Computer Science. As the Council has grown and thrived, so have the numbers of women students who attend the Council's programs of events and activities. As the Council has become a respected part of the School of Computer Science the atmosphere for all students has greatly improved. Thus we strongly believe, *building an energetic, action-oriented Advisory Council is key to building a successful community of women in the computer sciences.*

1.4. Some Essentials for Building an Effective Council.

- *Faculty and Institutional Support:* The Council needs a dedicated Faculty Advisor who is willing to spend time and energy listening, advising, and promoting the interests of the group throughout the department, school and the university. Our

Faculty Advisor has formed strong ties and support networks on behalf of women students. At the same time she has formed a close and mutually respectful relationship with Council members. This gives them a strong sense of self worth and provides a bridge for communicating with other faculty and administrators.

- *Program Coordinator:* Hire a Program Coordinator to help with the day-to-day organization of activities, events, and meetings and work closely with the Faculty Advisor and the Council. Members of the Council are keen to invest their time, energy, and ideas for the good of the community. However, it is vital that the Council has organizational support so that its members maintain good academic standing and do not “burn out”. Currently the Director of Women@SCS (formerly the Program Coordinator) oversees the Women@SCS web site, networks throughout the University with staff, faculty, and administrators (and beyond) in arranging the Council’s events and activities, and has become a sounding board for members’ ideas and questions. It is crucial that the program coordinator/director has a good and close relationship with the students.

- *Meetings:* Arrange regular Council meetings with an agenda and a set time. Our Council holds weekly (one hour) meetings for undergraduate members, twice monthly for graduate members, and joint meetings once a month. Members organize future events, review past activities, comment on classes and curriculum issues, brainstorm and share ideas, and review the web site. Meetings also provide a safe, non-judgmental environment where members can ask for help, and give it in return. We hold recruiting sessions once a semester to inform all women in the School of Computer Science about the Council and its goals. Occasionally a guest, usually faculty or administrator or campus visitor, is invited. This allows Council members to meet faculty and administrators on an entirely new level for an exchange of ideas and information. Research suggests that this kind of personal involvement with faculty and administration has been found to be particularly important to women students [Cuny and Asprey, 2000, Fox, 2000].

- *Elect Council leaders.* We have found that Council members are happy to have leadership from the senior members, and that it works best to have two leaders (within each sub-Council) who will be responsible for collecting meeting agendas, leading the meetings, acting as general spokeswomen and coordinating with the Faculty Advisor and Program Coordinator.

- *Set up a student-run web site to represent your organization and increase its visibility.* The *Women@SCS* web site, with a link from the School of Computer Science home page, has become a focal point for announcing activities, for highlighting and celebrating the many special accomplishments of women throughout the school, and for providing resource information to women students and beyond. The web site is reviewed at Council meetings and all members are encouraged to submit event announcements and items of interest. See: http://women.cs.cmu.edu/

- *Make sure you are given a real meeting room* and not a classroom. We have found that the venue has helped to affirm the worth of the Council and its decision-making.

- *Set up distribution lists of all women in the department or school* (faculty, staff, graduates, undergraduates). The D-lists have become an essential tool for our voluminous amounts of email communication. D-lists not only provide an efficient tool for disseminating ideas, getting feedback, announcing meetings and events, but also for tracking the numbers of women throughout the department/s.

- *Funding from the department, school, and especially from the highest levels within the university, is essential for the Council to put its plans into action.* Funding at this level also gives value and credibility to the goals of the Council, credibility to women's issues and the need to improve the quality of life for women in CS. Funding of *Women@SCS* has proved to be a very positive investment for the department and the university as a whole. We have been fortunate in having administrative and financial support from the University, via the President, from the School of Computer Science, and, on one occasion, from the Alumni/External Relations office. The many computing-related companies, who are keen to recruit on campus, have also been a great source of funding for us, especially with helping to send students to CS-related conferences.

- *Open the Council to men who share the goals of your organization. Women@SCS* has benefited from being an inclusive organization. Several undergraduate men have been actively involved with the organization. For example one man, who became involved as a freshman, became an excellent *Women@SCS* web team leader throughout his junior and senior years. Other men have taken a more casual approach and have attended the occasional meeting, probably out of curiosity. Nevertheless they have been welcomed, and the group, in turn, has welcomed their help with events and activities.

- *Your Council can become an asset to the department, school and the university as a whole.* Carnegie Mellon's CS Department has called upon the *Women@SCS* undergraduate sub-Council to provide direct input on issues such as the curriculum, advising, and climate. In 2002, members of the Council were invited to participate on a panel discussion, held in San Francisco, to examine future practices for Alumni development. In 2001, the *Women@SCS* Council was featured in local newspapers and on public television (www.pbs.org/ttc/hottopics/compsci.html). It is clear that our Council, and by extension the community of women in the School of Computer Science, have now become a very articulate and visible asset.

1.5. Building a Community of Women in Computer Science: Events and Activities organized by the Women@SCS Advisory Council. The Mission of the Women@SCS Advisory Council is to create, encourage, and support women's academic, social and professional opportunities in computing-related areas, and to promote the breadth of the field and its diverse community.

There is no dearth of ideas generated by the Council and, indeed, the level of energy expended is extraordinary.[109] This is mitigated in part by the fact that a fresh crop of students joins forces each year. But even more, we have observed the paradoxical, and yet clichéd, outcome: namely that 'energy produces energy' and that 'to give is to receive'. Indeed, Council members are the greatest beneficiaries of their involvement in running the show, for example, in terms of their increased professional experiences, contacts and growth, their self-esteem, and their academic and leadership successes and awards.

1.6. Professional and/or Mentoring Events and Activities (Events and Activities[K]):

- **Freshmen Orientation Session (U, WM):** In a social gathering, Council members meet and talk to freshmen about their work and life in the CS Department. More recently we have invited representatives from other CS organizations to introduce themselves and say a few words about their work (e.g. Robotics Club, Society for Hispanic Engineers). [y]

- **Big Sisters/Little Sisters (U, G, W):** This program pairs a more "senior" Big Sister with a Little Sister and provides an informal, but organized, set-up for support, mentoring, and friendship, centered around a number of social events. Sisters are encouraged to email and meet outside of the organized activities. We have found that some students prefer this one-on-one set up while others prefer group-mentoring activities –we feel both formats are important. (A sample of our initial Sisters' letter/questionnaire can be found on our mentoring web page. See, http://www.cs.cmu.edu/~women/resources/mentoring.shtml.) [f]

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[109] We are reminded that the CS admissions criteria changed in 1999 to look for students who showed signs of leadership potential interpreted as those who were involved in "giving back to the community". This is certainly evident in the Women@SCS Council members.

[K] Key:
U= Undergraduates G= Graduates W= open to Women only WM= open to both Women and Men
y =Once a year (or will be) s =Once a semester m =Monthly
f =Frequently (between m and s) o =One time event (so far)

- **Graduate BigSisters (U, G, W):** In 2005 we set up the Graduate BigSisters' program, the initiative of one of the graduate women who saw a gap in our sisters' mentoring program. The new initiative pairs graduates with juniors and seniors in CS who are thinking about going to graduate school, with the aim of offering general encouragement and specific advice on the process. The students meet together 2 or 3 times a semester and communicate and meet as Sisters as often as they choose. [f]

- **Pre-registration Event** and **Passing the Torch (U, WM):** The Pre-registration event serves as a mid-semester opportunity for providing general advice on the class registration process. The Passing the Torch event is held at the end of the academic year as senior women prepare to graduate and others prepare to advance their year. *Words of wisdom* given at these events include tips on succeeding, on what works, what doesn't, and recommendations on classes and professors. Faculty are not allowed to attend the advice sessions so that students can speak freely to each other. These events serve to remind students that others have been through similar experiences, have survived/thrived, and are now positioned to embark on exciting and rewarding endeavors. These events are open to all undergraduates, men and women, and have proven to be very popular. [s]

- **Undergraduate Research and Small Undergraduate Research Grants (SURG) Initiative Information Session (U, W):** This event provides an opportunity for students to learn where, and how, to start the research process and about the rewards of an undergraduate research experience. The University's Undergraduate Research Director explains the grant application process. Women students who have been involved in research projects share their experiences. On one occasions the session was sponsored and led by industry researchers (who were also Carnegie Mellon alumnae). [y]

- **Unix Help Session (U, WM):** In this help session undergraduates who are proficient with Unix help those not so skilled. Many students have expressed a need to learn from their peers in an informal atmosphere. [y]

- **(Dessert) Study Breaks (U, WM):** Study breaks are led by women seniors and are held during exam time. They allow students a chance to hear advice, share test anxieties and give reassurance as needed. [f]

- **Invited Speaker Series (G, WM)**: Speakers from academia, business, and industry are invited (individually or in groups) by graduate sub-Council members to present technical talks, share their stories and experiences, offer professional advice, promote their workplaces, offer mentoring opportunities, and discuss gender and work issues. *Women@SCS* also has been allotted one spot in which Women@SCS chooses the external speaker for the School of Computer Science Distinguished Lecture Series. The speaker's technical research talk is open to the entire School of Computer Science community and later in the day the guest speaker joins *Women@SCS* members for an informal dinner-social. [f]

- **Advice on Graduate School** and **Reading Graduate School Applications (U, G, WM)**: In the first event, graduate students talk candidly to undergraduates about their decisions to go to graduate school, the application process, and their future plans. In the second, graduate sub-Council members read and give feedback to undergraduates who would like help with their applications to graduate school. [y]

- **Grant Proposals (G, W)**: Our graduate Council members have contributed ideas, feedback and helped to write grant proposals for women in CS/IT related projects. [y]

1.7. Conferences and Outreach:

- **The Outreach Roadshow (U, G, W):** In 2002 members of the Undergraduate Council designed and implemented an outreach program, the *Women@SCS* Outreach Roadshow, which is now our primary outreach initiative to teachers and students. (See chapter four: section 2.3. for a full account of the Roadshow.) Faculty and students have presented the Roadshow at SIGCSE conference 2005, WEPAN[110]

[110] WEPAN: Women in Engineering Programs & Advocates Network: http://www.engr.utexas.edu/wep/wepan2006/CallForAbstracts.htm

2006, and at the AAAS meeting in 2006[111]. By 2004 members of the graduate Council had taken the Roadshow to the next level and had designed and implemented a Roadshow aimed at undergraduates on campuses across the nation. This was funded by a Sloan Foundation grant. [f]

- **Grace Hopper Celebration of Women in Computing 2000, 2002, 2004 and 2006. (U, G, W)**: Council members, along with School of Computer Science faculty and researchers, have presented at the last 4 Grace Hopper Conferences. Our presentations have included panel discussions on: the Carnegie Mellon experience in increasing the participation of women in CS (2000), how the ubiquity of computing is closely linked to the ubiquity of women in computing (2002), increasing the pool of women students in graduate CS/IT programs and positioning them to become future university CS/IT faculty and leaders in the field (2004). In 2006 we were involved in 2 presentations: one a student organized workshop on sustaining outreach programs (e.g. the Roadshow), and a second organized by faculty and students from the TechBridgeWorld[112] program.

- **Expanding Your Horizons (U, G, W):** Members of *Women@SCS* have participated in EYH in 2000, 2001, 2002, and 2003. *EYH* is a nationally held one-day event aimed at increasing young women's interest in science and mathematics. Our graduate led team of SCS students have run workshops designed by graduates entitled “Is There A Robot In Your Future?" for middle school girls at the local *Expanding Your Horizons* conference. [y]

- **Girls, Technology, and Education Forum 2001 (U, G, WM)**: The Advisory Council presented an afternoon forum focusing on girls and technology in education and entertainment. The event successfully brought together more than 160 teachers, academics, students, and members of the business community for a full afternoon of

[111] We have been invited back to AAAS 2007 to present again.
[112] *Women@SCS* works closely with TechBridgeWorld (TBW) and many TBW students are involved with *Women@SCS*. TBW is a School of Computer Science initiative that innovates and implements technology solutions to meet sustainable development needs around the world. See http://www.techbridgeworld.org/

talks and brainstorming. Together, the group discussed topics ranging from girl-friendly classroom strategies, to software game development and beyond. As an added benefit, Council members were provided an opportunity to practice their public presentation skills, their teamwork, their organizing abilities, and most importantly, to share their expertise and perspectives. This event was funded, and jointly arranged, by the School of Computer Science External Relations Office. [o]

- **The Richard Tapia Celebration of Diversity in Computing**, **Houston, Texas (U, WM)**: A group of five undergraduate Council members attended the first in a series of events designed to celebrate the technical contributions and career interests of diverse people in computing fields. Since then members of *Women@SCS* have presented at the Tapia conference in 2003, and students have participated in poster sessions in 2005. [o]

- **PBS filming of Women@SCS (U, G, WM):** Bonnie Erbe, producer of "To The Contrary," a PBS news program on women's issues, came to campus with her crew to film and interview School of Computer Science faculty and Advisory Council members. Excerpts of the program can be viewed on our web site. The show provoked a lively debate among our Council members and faculty, demonstrating that while we may share many common goals, we also hold a wide range of perspectives on gender and computing issues. [o]

- **Creative Technology Nights for Girls:** This is a free weekly program of informal sessions aimed at giving real hands-on technology experiences and skills to young girls. The program was initiated and implemented by one of our graduate students from the school's Entertainment Technology Center. Graduates and undergraduates teach a different session each week, and girls from local public and private schools are invited to participate. (For more information please see Section Two of this chapter for a full account of the Tech Nights program.)

1.8. Social Activities:

- **Graduate/Undergraduate Socials (U, G, W)**: Each semester graduate and undergraduate students meet informally over dinner. We have found that many more undergraduates than graduates tend to participate, but the events are generally well attended—over 70 at one social. [s]

- **Museum/Phipps Lunch Series:** Graduates and faculty meet monthly at a local café and socialize over lunch. The lunches provide opportunities for women to meet others from throughout the 7 departments of the School of Computer Science. The lunches are hosted by at least one active graduate member of *Women@SCS* and also provides an opportunity for her to answer questions about *Women@SCS* and explain the goals and program of activities. [m]

- **Faculty/Student Dinners (U, G, W):** These dinners provide a chance for students to meet faculty in a relaxed, non-judgmental atmosphere, and to increase the visibility of successful women computer scientists. We have found that a core group of senior faculty and a group younger faculty show up regularly and are very supportive. [y]

- **Graduate Women's Welcome Potluck (G, W)**: Graduates try to have at least one organized social (Summer Get-together) over the summer while the Potluck 'officially' starts off the new academic year. The potluck has become a *Women@SCS* tradition having been one of the first events organized by graduates. It provides an opportunity for graduate students and faculty to get together, share home cooked food, and welcome the new graduate students and faculty. [y]

- **T-Shirt Design (U, G, W)**: Occasionally undergraduate and graduate student ideas seem incompatible. A polarized discussion emerged as the Council set about designing a *Women@SCS* T-shirt and new logo for the website. The more mature graduate students tended to have a feminist consciousness that affected how they want to be defined/identified. The younger undergraduates tended to see the T-shirt project as a search for a "pretty" fashion statement, and also preferred a "feminine" design for the logo. The T-shirt disagreement was resolved by allowing the undergraduates their choice, modified by input from female faculty. Professor Jeannette Wing (who has since become head of the CS department) suggested the running figure logo which everyone seemed to like!

T-shirts were given out to School of Computer Science students in exchange for donated, decent items of clothing for the local women's shelter. Surprisingly, the T-shirts proved to be very popular and the project was very successful. The more permanent, public web site image was left open to further debate. We are, after all, an evolving community.

- **Women's Self-Defense Event (U, G, W)**: Undergraduate Council members, together with School of Computer Science faculty, teach some basic self-defense moves. [o]

1.9. Additional Activities. These have included **breakfast and coffee/dessert breaks** with discussions of timely topics, **"belly-dancing",** an ice cream event at the annual CS undergraduate picnic, **rock climbing** at a local climbing wall, **ice skating**, an end of the year picnic, **Holiday Shoebox Gifts** collection for local women's shelter, and **a guided tour of the "Carnegie International"** contemporary art show.

SCS-Day[113]: There have been several major school wide initiatives to emerge from active members of *Women@SCS* including the Pittsburgh chapter of CPSR[114], TechBridgeWorld[115] and SCS-Day. (although not intended as a *Women@SCS* activity)

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[113] See the SCS-Day web site for more information: http://www.cs.cmu.edu/~scsday/

[114] Establishing a chapter of CPSR, Computing Professionals for Social Responsibility, was the idea of one of the *Women@SCS* graduate students: http://www.cs.cmu.edu/~cpsr/

[115] TechBridgeWorld hosted by SCS was initiated by a Robotics faculty member who was one of the founding members (now active as a faculty member) of *Women@SCS*: http://www.techbridgeworld.org/

has been SCS-Day, started in 2003, by a group of graduate and undergraduate students. SCS-Day is a celebration of the diversity in the School of Computer Science at Carnegie Mellon University. This is a dynamic event including workshops, exhibits, games, and a talent show with the Dean of the School acting as the Master of Ceremonies. The event has been embraced by faculty, staff, and students (and their families) throughout the school. All the members of the SCS community, undergraduate and graduate students, faculty, staff and alumni, are invited to display their talents and share their skills in a fun and relaxed atmosphere. For the most part the organizing is still done largely by members of *Women@SCS*. Plans are in the works for the 5th SCS-Day!

1.10. In Sum. Our goal has been to foster a supportive community that promotes academic success and professional growth, one that will benefit women in CS as well as the community-at-large. We endeavor to view problems as challenges to be tackled in creative and constructive ways. An active *Women@SCS* Advisory Council has enabled us to offer many events and activities to improve the academic and social climate for women in CS. With good organization, faculty and administrative support and commitment, a student organization with an *Advisory Council* at the helm, will provide the talent, energy and innovative ideas to lead the way!

Section 2: Outreach and Diversifying the Images of Computer Science: Images of CS, the People and the Participants[116]

Over the past few years we have become well aware of the declining numbers of girls and women entering the CS major. The problem has been well researched and documented, and disseminated in such well known articles as Tracy Camp's "The Incredible Shrinking Pipeline" [Camp, 1997] and "The Incredible Shrinking Pipeline Unlikely to Reverse" [Camp, 2000]. In 2005, Computing Research News reported that this downward trend has

[116] This section is based on a paper by Frieze presented at SIGCSE 2005, and a paper by Frieze and Treat, presented at the 2006 WEPAN conference: "Diversifying the Images of Computer Science: Carnegie Mellon Students Take on the Challenge!".

continued at an alarming rate: "the proportion of women who thought that they might major in CS has fallen to levels unseen since the early 1970s" [Vesgo, 2005].

But the issue of declining numbers may actually be a much needed wake-up call for those of us in the field to re-evaluate, re-think, and re-shape what CS really means, and how it is perceived in the public consciousness. We may find that some of those aspects of the field that have been deterring many women from entering are also deterring all students, and strategies for change may well result in increasing enrollment overall, and a more balanced and diverse environment.

We suggest that *images* surrounding CS are fundamental to an understanding of the field and of critical significance to girls' and women's participation. Public perceptions still seem to be dominated by stereotypes showing the field as populated largely by geeky guys doing little more than coding. Images of the field and the prevalence of CS stereotypes have raised concern among many researchers who have examined gender and CS issues.[117] The image of CS as a broad and exciting field with the potential for diverse participants is, for the most part, missing from the big picture. Needless to say changing the big picture will be no easy task. Nevertheless, Advisory Council members from our student organization, *Women@SCS*, at Carnegie Mellon University, decided to take on the challenge! We believe that our young students make the most effective ambassadors for reaching out to young girls and boys, their parents and teachers, and for changing their perspectives on CS.

2.1. Outreach Efforts of *Women@SCS*. The major outreach efforts of *Women@SCS* are the Outreach Roadshow and Creative Technology Nights for Girls, which exemplify the way that the organization has developed as an action oriented group taking on *leadership roles that have enhanced the entire CS community and beyond.* With great commitment and energy council members took on the challenge of trying to diversify the images of CS, based on a vision of how the field, and the people in it, should be represented. And

[117] As mentioned earlier this group would include Borg, Margolis and Fisher, Greening, Camp, Kshiti, Schmidt, Kuhn, Cuny, Cohoon and Aspray, Gurer, Keisler and Sproull, Townsend, Spertus and others.

since many strategies that work well for women have been found to work well for all, we may find this contribution can reach out beyond the initial goals and expectations.

2.2. The *Women@SCS* Outreach Roadshow. A few years ago a small group of our undergraduate women returned from the Richard Tapia Celebration of Diversity in Computing Conference[118] full of enthusiasm and energy for transforming the view of CS. Even at Carnegie Mellon, where we have made progress towards gender balance, we still struggle to diversify our CS student body in terms of race and ethnicity. The group reported their experiences to the *Women@SCS* Advisory Council and summed up their experiences by unanimously declaring (we paraphrase): "We must do more Outreach! ….especially to younger girls! We have to let them know there are women and minorities in the field and that it's not just about coding!" The Council concurred with a resounding "Okay, let's do it!"

The following weekend, a group of students worked together to produce a power point slideshow which tackled two "image" topics head-on: "Who can be computer scientists?" and "What can you do with computer science?" At subsequent meetings, we talked more about our goals (see below), and the logistics (see below) of putting plans into action; we improved and revised the content and added new slides, and finally began giving presentations of what soon became known as the Outreach Roadshow, a title suggested by our faculty advisor, and soon claimed.

Since then the Roadshow has become a very popular program within our organization. It continues to capture the imagination of our undergraduate and graduate students alike. We present the show on campus, and at middle and high schools. We also present to middle and high school teachers. Our web site visitors can find an online downloadable version and we welcome requests from students and teachers to use it as their model. We continually improve the Roadshow as we collect, and respond to, feedback from students

[118] The Richard Tapia Celebration of Diversity in Computing: http://www.ncsa.uiuc.edu/Conferences/Tapia2003/index.html#PROGRAM

and teachers. When Bill Gates, Chairman of the Microsoft Corporation, came to campus our group was called upon to give a demonstration of the Roadshow.

In 2003 we produced, and continue to develop, a “research focused” version that is presented by our graduate women to undergraduates. This is a more sophisticated version of the Roadshow in which Carnegie Mellon’s graduate women present at other campuses to undergraduate students, men and women. The research-focused version of the Roadshow is one part of our *Women@IT*[119] enterprise which places special emphasis on encouraging students from fields outside of CS, to consider applying to doctoral level studies in computing-related disciplines.

Perhaps the most meaningful and exciting moment for us, in terms of the Roadshow story, was going back to the Richard Tapia conference in 2003 and *presenting our Roadshow at the site of its inspiration!*

- **What is the Roadshow?** The Roadshow is presented by *Women@SCS* undergraduates and graduates from the School of Computer Science at Carnegie Mellon. They share their thoughts on CS, why and how they began studying the field, their early and current experiences, what CS means to them now, and their future hopes and expectations. The presentation includes a slide show to illustrate the breadth of the field of CS and computing related areas, lots of question and answer interaction, videos, a guessing game, and a robot demonstration.

Currently, three versions of the Roadshow separately target middle school[120], high school, and undergraduate students. They share the goals of bringing women’s personal experiences in computing related fields to various audiences, and of getting students *excited* about the science of these fields and their possibilities. Students do not address

[119] For more information about Women@IT see: http://women.cs.cmu.edu/womenIT/
[120] “Research shows that most girls first report a loss of interest in SET during the middle school years”. From J. Steinke,“Cultural Representations of Gender and Science: Portrayals of Female Scientists and Engineers in Popular Films Science Communications, Vol. 27 No 1. p29 http://scx.sagepub.com/cgi/reprint/27/1/27.pdf

“gender issues” explicitly unless specific questions arise. Nevertheless, the presentation shows (implicitly) that women can occupy technology leadership roles, have great technical skills, and have tremendous enthusiasm for computing-related fields.

Student presenters make the Roadshow effective, relating well to their young audiences. Their energy, visibility, technical know-how, and interaction with the audiences in combination with slideshow images challenge stereotypes and offer new images of the field and the people in the CS community. Below is a brief description of what the middle and high school level Roadshows usually include:

- Images of the students to illustrate their personal stories as they introduce themselves (these include their baby pictures or photos from outside of the work situation) …
- An interactive guessing game to show many diverse images of real computer scientists interspersed with occasional images of actors/non-computer scientists ...
- An interactive discussion on “what is computer science?” that stresses the *science* in CS and what you can do with it (children are asked about their use of the internet, instant messenger, etc.) …
- A step by step math puzzle, sometimes acted out, and introduction of the term algorithm, to show the problem solving aspects of CS (answers and more puzzles are provided) …
- The breadth of the field is illustrated with such slides as a “talking heads” synthetic speech demo, a robotics video, the CAPTCHA project (which serves to identify humans from robots as they log on, for example, to Yahoo), web site building, video graphics, speech recognition, CS and biology, and more…
- Depending on the age of the audience the students will add information about the classes they take, job opportunities, the companies they can work for, and graduate school options …
- After the slideshow the students introduce simple robot demos such as a “lego robot bug” and, our most recent addition, a Sony Aibo Robot dog …

- The students conclude with a question and answer session (they also encourage questions throughout). They leave handouts, pins, brochures and flyers with contact addresses, in case members of the audience want more information or have further questions …

In the graduate level presentation the students discuss the variety of programs in computing related fields available at the graduate level. They give suggestions on how to pay for graduate school and recommendations on becoming a good graduate applicant. Students tell their personal stories, give overviews of their particular fields, and provide short talks on their individual research. At Carnegie Mellon we have the advantage of having the School of Computer Science which is comprised of 7 departments representing a diverse range of research areas. Thus, in the graduate Roadshow students are able to represent such diverse areas as Robotics and Robot Soccer, Computational Neuroscience, Privacy and Security, Language Technologies, Theory, and CS.

- **Goals.** The Roadshow serves a variety of goals, in fact we deliberately aim to make the most of all such presentations!

  - to increase the *visibility* of young women in computing-related fields
  - to *challenge* traditional stereotypes and images of computing-related fields and those in them
  - to *diversify* current images of computing-related fields and those in them
  - to *show the breadth* of fields that CS and related areas can encompass
  - to *spark interest in the science* of computing and the challenges of problem solving
  - to provide an interesting and enjoyable learning experience
  - to provide leadership, role modeling and mentoring opportunities
  - to expose undergraduates to the breadth of possibilities of research in computing-related fields
  - to provide opportunities for graduate women to network with faculty and students from other schools

- **Audiences.**[121] The content of the Roadshow changes to suit audiences. The presentation for younger students is fast paced and fun with a guessing game and puzzles that can be acted out, and more time spent on the robot demonstrations. The undergraduate audience gets a taste of real research areas and advice on funding and applying to graduate school. While targeting girls and women, *we nevertheless are inclusive of boys and men*, because our primary goals include showing women in leadership and teaching roles and illustrating the breadth of the field to all audiences. Our audiences include:

  - middle and high school girls and boys
  - parents, teachers, and representatives from industry
  - undergraduates from CS and non-CS fields e.g. math, linguistics, biology
  - all who are interested in gender equity in fields where girls and women are under-represented e.g. engineering and CS

We have presented our middle school level Roadshow at science fairs indeed, our Roadshow was held in St Louis at the invitation of the American Association for the Advancement of Science (AAAS) family science days. Our presentation for undergraduates has been given at several universities including Georgia Institute of Technology (Georgia Tech), George Washington University, D.C., Princeton University, University of Pennsylvania, Columbia University, University of Texas at Austin, and at Harvey Mudd College. We have also presented at several conferences including the Richard Tapia Celebration of Diversity in Computing Conference[122], the Grace Hopper Celebration of Women in Computing[123] and at the Technical Symposium on Computer Science Education commonly known as SIGCSE.[124]

- **Logistics.** Our current motto is "Be prepared for anything!" Although our Roadshows are carefully arranged we never quite know the make-up of the audience and

[121] For a complete list of presentation sites visit: http://women.cs.cmu.edu/What/Outreach/#presentations
[122] For more information on the Tapia conference see http://www.ncsa.uiuc.edu/Conferences/Tapia2005/
[123] The Grace Hopper Celebration of Women in Computing http://www.gracehopper.org
[124] For more information on SIGCSE see http://www.cs.potsdam.edu/sigcse07/index.shtml

the setting until we arrive on the scene. The range has been surprisingly wide. We have presented to entire student bodies in splendid auditoriums. We have presented to individual classes, sometimes in school cafeterias, having struggled in with our own screen, laptop, robots, and projector. In all cases, however, we have found the audiences to be wonderfully responsive! Perhaps the most meticulously and diligently arranged Roadshow, a university level event, with numerous emails going back and forth, turned out to be the most disappointing because the session was set for a time when, unfortunately, undergraduate students were busy with classes and unable to attend. Good timing, as we found out, is crucial to a successful presentation. The rest of the day, however, was carefully thought out, with productive meetings, and our graduate women were able to network with faculty and other graduates, so that overall it became a worthwhile experience and many of the objectives were met.

- **Funding.** Funds for the Roadshow come from several sources, but most are provided by the School of Computer Science at our own university. The Graduate Outreach Roadshow is funded by a grant from the Sloan Foundation. Small industry grants have proved invaluable. A grant from Microsoft, for example, allowed us to purchase our own Aibo robot dog.

2.3. Creative Technology Nights for Girls".[125] The Roadshow has been our major outreach program for several years. It also formed the springboard for "Creative Technology Nights for Girls" (Tech Nights), a relatively new program, which we describe in less detail but anticipate will be equally popular and dynamic. While the Roadshow *aims to spark excitement about the field* of CS, its spin-off, TechNights provides *hands-on technology skills and practice*. The workshops were the inspiration of one of our graduate women who saw the potential for expanding the Roadshow. Our student organizer, then the TechNights Program Director, designed a series of workshops hosted by volunteer graduate and undergraduate women from the School of Computer Science who teach technology skills to middle and high school age girls and provide mentoring/networking opportunities in the process.

[125] See http://women.cs.cmu.edu/technights/index.html

- **The TechNights Program Gets off the Ground.** TechNights is a relatively new program with student efforts centered on action, collaboration and exploration. We have already moved forward in increasing the numbers of girls attending and we have received requests to replicate the program at other venues. Here we describe the steps taken, and the lessons learned, in getting the program up and running.

The first step in coordinating the workshops was finding a suitable venue. We began by meeting with the owners of a local gaming facility, CyberConXion[126], to discuss the program and explain our goals. The owners recognized that exposing more girls to the facility, and to games in general, could be a good business move as well as showing community spirit. They agreed to let us use the facility space, which includes two networked classroom spaces complete with internet access and projector, on a weekly basis *free of charge*. The CyberConXion owners have proved to be very generous hosts and we are very appreciative of their contribution to our program.

Once the venue was fixed, local schools were targeted for the workshop attendees, and Carnegie Mellon was targeted for volunteers to lead individual sessions. Local school administrators and teachers were solicited for support and rapidly joined in the effort to engage their female students. The primary sources for getting the word out included numerous emails, a TechNights web page on the CyberConXion web site, and announcements on the *Women@SCS* web site.

Graduate and undergraduate volunteers were invited to teach a workshop in their field resulting in a variety of classes embracing many areas of CS (see program description below). In the spring of 2005 “Creative Technology Nights for Girls” was launched and the free weekly workshops have continued. From the volunteers perspective the workshops serve to strengthen the local community of women in computing-related fields. Workshops also offer graduate and undergraduate instructors an opportunity to hone their teaching and curriculum development skills by allowing them to present in an informal environment.

[126] Pittsburgh Cyberconxion: http://www.pghcyberconxion.com/

- **The TechNights Weekly Workshops**. Each week, a different instructor leads the session, sharing skills and knowledge in an informal demo or hands on exercise, while other volunteers assist on a one-on-one basis as needed. The system works well for volunteers and young participants alike. The variety of topics and instructors thoroughly engages the girls without placing an unmanageable time commitment on student volunteers. Girls are encouraged to attend the free classes each week; however, registration and attendance are not required on the basis that the girls should attend because they want to, and not because they feel they have to.[127]

The workshops are casual to allow instructors to adapt content according to the interest level of attendees and to avoid replicating the more formal classroom experience. Girls are encouraged to progress on topics they are more familiar with, and all subjects are presented to allow for self-pacing for less qualified students. Indeed, self-paced activities and demos allow students of all skill levels to participate, to feel part of the community, and to have fun!

The TechNights program of free workshops includes (but is not limited to):

- robot design and robot programming
- internet safety
- virtual world building
- web design and web site building
- computer illustration
- programming
- 2-D animation
- programming through visual storytelling
- using Photoshop, Illustrator
- social events such as Movie Nights

[127] TechNights 2006 onwards has required sign-ins and some information from participants so we can better evaluate and track who is attending and which schools they attend.

We also include Open Houses so students get the opportunity to show off their work to friends and families.

- **TechNights Adapts to Needs of Participants.** Not surprisingly, the program has evolved since TechNights was first launched. While originally the program was open to both high school and middle school girls, it soon became clear that the age range and maturity levels of the two groups created some friction, and did not meet all needs equally. Many of the older girls, who were interested in CS, became less engaged when attention was focused on younger learners. A new structure was suggested and implemented in the fall of 2005. High school students now participate as Teaching Assistants. By offering leadership roles to older girls they were successfully reengaged within the community, as well as having opportunities to practice teaching, public speaking, and working with others. In addition, high school students are able to use this experience as part of their college application when they graduate from high school.

- **Sustaining TechNights' Leadership.** The TechNights Program Director initially organized the entire program, coordinating with volunteers and attendees, producing and distributing flyers, liaising with schools and business owners, and making sure each session ran smoothly. Arguably, this program could not have got off the ground without her amazing commitment, terrific technical skills, hard work and vision. However, her association with *Women@SCS*, and her training of future leaders to take on her role, has meant that the program could be sustained after her graduation. TechNights also provided a wonderful opportunity for this graduate student to bring her vision to life and for her to enhance her leadership and teaching skills.

- **TechNights' Funding.** Funding for TechNights came initially from a small but generous anonymous donation and has been supplemented by the School of Computer Science's funding of *Women@SCS.* We have been very fortunate in our arrangement with the owners of CyberConXion who have provided space in an excellent facility free of charge. Our most recent funding came from a grant awarded to the graduate student organizers of TechNights who submitted a proposal to our Upstart/Startup Program (for details see http://women.cs.cmu.edu/Resources/Funding/Upstart_Startup_Program.php).

2.4. Outreach Programs: Feedback and Evaluation. Our efforts to gain funding to support professional evaluations of our outreach programs have not been successful to date. Thus, we are unable to provide the usual measures and data to substantiate what we feel to be successful efforts. Eventually, we hope to have professional evaluations that explore the long term effects and impact of our Roadshows and TechNights. However, we have made a concerted effort to gain immediate feedback through questionnaires given to teachers and students who are in our audiences. From our point of view the feedback forms provide a valuable source of suggestions as we work to improve the presentations, along with some welcome kudos for the student presenters! We are particularly encouraged by replications of our programs. The Roadshows have inspired and attracted the attention of CS departments across the nation, and from student groups looking to develop their own outreach programs. TechNights has caught local attention and the TechNights Director, along with other students, worked on replicating the program at the Braddock Library in Pittsburgh.

Anecdotal feedback from high school and middle school teachers tells us how much they need, and appreciate, the examples and materials we use to demonstrate the breadth of CS. There seems to be a desperate need for teaching resources that situate programming in the wider context of the field. Teachers also seem to share our desire to try to break down the stereotypes that surround the field but they rarely have the resources to do so.

2.5. Feedback Highlights. Below are some responses from teachers and students who have seen and provided feedback on the Roadshows. *These highlights are noted here for interest value only and are not meant as qualified evaluations.*

- **Teachers:** *Among our audiences* teachers were overwhelmingly positive about how useful the Roadshow was and thought it was appropriate for students from elementary school on up through college, and for parents and educators as well.

Teachers repeatedly affirmed that the personal stories of the student presenters, “their energy and enthusiasm”, and their excitement for their topics, were what made the Roadshow so effective and unique. A number of teachers suggested adding some slides showing younger girls programming/using the computer/being involved with CS. Teachers also suggested we include a slide showing income potential.

- **Middle/High School Students:** *Among our audiences* we found that slightly more boys than girls had taken CS classes. Virtually every respondent had access to a computer at home and many listed themselves as being the primary user. Girls and boys, in fairly equal numbers, claimed to be using the computer primarily for internet and email, but also for applications and programming, with boys programming more often than girls. Boys appeared to be more interested in studying CS than girls. Among those boys and girls interested in studying CS, they listed “fun/interesting” as the top reason for doing so. Both boys and girls, overwhelmingly, found the Roadshow interesting, informative and helpful. The Robocup/ Robots/AiboDog were found to be their favorite part.

- **College Students:** *Among our audiences* affordability was listed as one of the major determinants for applying, or not applying, to graduate school. The top listed factors for choosing a graduate school were the reputation of the school, the school’s areas of research, funding opportunities, and location. The vast majority of students found the presentation helpful because of the exposure to new ideas, the information about graduate school, and the personal stories they heard. Robotics, Language Technologies, and Software Engineering were noted as some of the most interesting research topics. Many students requested that more information about the general graduate school experience be included in the Roadshow.

Quotes from Some Audience Members:

“Some day I hope to be a computer scientist just like you” (7th grade girl).

“I think what you do is really awesome” (6th grade girl).
“The show is unique, you should keep it this way” (high school teacher).
“I liked that you showed a mixture of races” (high school teacher).

At one presentation a CS professor pointed out that the “show” glossed over the grunt work of CS in favor of the exciting parts. We had to admit this was absolutely true and somewhat deliberate since our focus was always on trying to get the students excited about the science. We were rescued by a young African American woman in the audience who argued that while our culture was so intent on getting kids excited about football and sports, we paid so little attention and energy to getting them excited about science!

One of our favorite feedback comments, though frivolous, came from a young child at an on-campus presentation. The children were asked by their summer camp organizer what they had leaned about CS during the Roadshow. One little boy put his hand up and said very seriously “I’ve learned that computer scientists are very pretty”!

2.6. Benefits for Our Students. We believe that the programs we describe work best when there are mutual benefits. Our undergraduates and graduates are in very intensive academic programs. We are always amazed that they manage to volunteer so much of their time, energy and expertise to outreach work. The Roadshow and TechNights are clear examples of the activism of the *Women@SCS* council members and their strong drive to give back to the community. Our students repeatedly comment on how much they enjoy participating in the programs. They often explain that they wished they had been given similar presentations and opportunities in their own schools.

The Roadshows and Creative Technology Nights provide our students with leadership, teaching and public speaking opportunities. By having graduates and undergraduates team up together to develop and implement the presentations, numerous opportunities for mentoring and learning from each other arise. We believe these outreach programs help our students with confidence building, and provide them with opportunities to practice their skills and illustrate their knowledge in a fun environment.

2.7. In Sum. We live in a culture which specializes in manipulating our thoughts and attitudes through images. Images so easily become reality. Images can have an impact on life choices and research has shown that the relationship between gender and image can be particularly critical for women.[128] But culture is constantly changing and we can challenge current images and try to change them as much as be affected by them. Indeed, as we listen to students' perspectives (men and women) as they discuss CS stereotypes we hear them constantly redefining and reshaping the images that surround them.

The *Women@SCS* students who took on the outreach challenges described above enjoy their fields of study and want to share their enthusiasm and skills, knowing that few girls and women are exposed to the excitement of CS and/or creative technologies. This understanding inspires their efforts. The students who initiated the Roadshow did so with the aim of challenging and diversifying current images of computing-related fields and those who work and study in them. The student who initiated Tech Nights did so because she saw a need to increase the opportunities for giving real hands-on experiences and skills to girls and young women. As women they did not see themselves fitting naturally into the stereotypical images dominated by "geeky guys" but, perhaps more importantly, as students of CS, they did not see images of the field that matched their learning and exposure to an exciting field of study with so many possibilities.

[128] The number of positions offered to women in some of the major orchestras was shown to increase dramatically when the auditions were blind (behind a screen) showing evidence for gender and image as a relationship that can be detrimental to women's career opportunities [Goldin and Rouse, 2000].

CHAPTER FIVE: CONCLUSIONS

In this thesis we hope to have provided a convincing argument that alternative ways of thinking about, and acting on, gender and CS issues could benefit both the field and the people in it. We have argued the need for examining *variables outside of gender* as possible sources of differences in women's participation in CS. In particular we have suggested, and illustrated, *a cultural approach*, a specific approach which pays close attention to culture and environment, noting the factors that can allow for, or hinder, women's participation. By taking a cultural approach we have been able to account for changes in the culture of computing at Carnegie Mellon. Arguably such changes could not have occurred if the gender differences found in the 1990's research existed at any meaningful level. We have included evidence to show the limitations of the traditional gender research approach and shown through our own Carnegie Mellon case study how perceived gender differences can dissolve under certain conditions, making way for a Women-CS fit. Support for our argument has been drawn from a variety of sources, including evidence from psychology and education research, evidence of gender myths and stereotypes, evidence from gender similarities research, and evidence from other cultures and countries. In sum, we have proposed, and shown evidence to support, the cultural approach to gender and CS research.

This study informs the body of knowledge relating to CS and gender similarities and differences, and in so doing offers a unique perspective. At Carnegie Mellon, with its critical mass of women in CS, we have been able to carry out a case study of women's attitudes to computing when they occupy a "balanced" environment: balanced in terms of gender, in terms of the range of student personalities and interests, and in terms of increased opportunities for all --men and women. Under these conditions we did not find evidence of a gender divide in how students relate to CS; on the contrary we found a spectrum of attitudes including many gender similarities. We have been able to show that in this situation a micro-culture *can change*, shaping and being shaped by students' attitudes and perspectives. Most importantly we have shown that women can participate successfully in CS without resorting to traditional “female-friendly” strategies, strategies which carry with them the suggestion that women need academic handholding. Indeed, we have cautioned against interventions which accommodate gender differences, especially when gender differences can dissolve under certain conditions. In the long term such interventions may work against women, marginalizing their intellectual opportunities and ultimately perpetuating a gender divide.

We have drawn support for our argument from many directions. Kanter [1977] and Epstein [1988] point to structures of power and opportunity. Barnett and Rivers [2004], Ramsey and McCorduck [2005], Hazzan and Dubinsky [2006], reveal the myths surrounding gender differences. Thorne [1993] and Epstein [1988] point out the flaws inherent in the prevailing research methodology. Hyde [2005] and Halpern [2000] take us back to the data to reveal a distribution of characteristics and a spectrum of *similarities* (and differences) that cut across gender. Matlin [1999], Steele [1995, 1999], Inzlicht and Ben-Zeev [2004], examine the power of cultural stereotypes to influence, and perpetuate, how we think along gender lines. Steele suggests real possibilities for reducing stereotype threat. Charles and Grusky [2005] remind us of the pervasiveness, and real harm, of essentialist thinking which is still dominant in western culture. Eidelman and Hazzan [2005], McGraph Cohoon and Asprey [2006], Ramsey and McCorduck [2005], Etzkowitz et al [2000], point to positive examples of subcultures which are bucking the trend and setting up models of good practices that work well for both men and women. These researchers do not deny that we live out our lives as men and as women through different experiences, and that biological differences account for some of these lived gender differences. But though men and women have some differences, these differences are often irrelevant to professional development in general and as computer scientists in particular. Most importantly, all of these researchers, along with many others we have not included, also point to aspects of our culture as the site and source of how gender distinctions are produced and perpetuated.

We have illustrated in our Carnegie Mellon case study, how well thought-out interventions in the environment, interventions that are inclusive and aimed at broadening participation rather than at women specifically, *can allow for diversity,* opening the way for girls and women to contribute and be successful in computing fields. This kind of participation is embodied in the Women-CS fit that has evolved at Carnegie Mellon and in the organization *Women@SCS* that works to promote that fit.

But our findings have implications beyond Carnegie Mellon. There are many programs[129] working to ensure that opportunities and resources are made formally available to those in minority situations. Several other schools have recognized the value of action-oriented programs similar to Carnegie Mellon's *Women@SCS*. For example, the Grace Hopper Celebration of Women in Computing 2006 included one session in which Carnegie Mellon students collaborated with the University of Victoria and Simon Fraser University, from Canada, along with Indiana University, Purdue University, and University of Illinois-Urbana Champaign, from the USA, to discuss ongoing action oriented-initiatives. All of these schools are using outreach programs based on Carnegie Mellon's Outreach Roadshow,[130] adapting and developing them to suit their particular goals and venues.

Looking beyond the USA, we are aware of European faculty and students developing programs of opportunities and resources for women. WIT at the Technical University of Vienna[131] has a strong action oriented mission statement: "WIT has become a role model for promoting women in science and technology at the Vienna University of Technology. Its manifold approaches are aimed not only at the promotion of female junior scientists, but include career support measures for women in all stages of IT education. WIT offers measures for female high school students and graduates, as well as university students, which are well received". There are also programs at the University of Hamburg[132], and at ETH[133]. All of the above are comprehensive programs, run within traditional departments, without any compromise to academic integrity.

[129] Examples include programs run by the Math/ScienceNetwork (including the Expanding Your Horizons Conferences), the YWCA, and Girl Scouts of America.
[130] This is downloadable from: http://women.cs.cmu.edu/What/Outreach/#roadshow
[131] See http://wit.tuwien.ac.at/about_wit/index_en.html
[132] See http://www.informatik.uni-hamburg.de/
[133] See http://www.frauen.inf.ethz.ch/

We mentioned earlier (chapter four: section 4.3.) some of the action oriented interventions coming out of the Center for Women and Information Technology (CWIT),[134] the University of Washington,[135] and summer seminars like the one for high schools girls held at University of Waterloo.[136] The National Center for Women and Information Technology[137] is also working to promote gender equity in information technology and computing. These represent just a few examples of action oriented programs making a difference in the culture and environment by providing opportunities and resources for change.

We suggest that the momentum for change at the level of culture and environment is newly energized. Indeed action programs are now being lauded by NSF. A 2006 NSF $3.3 million Advance grant awarded to Cornell University[138] to increase "the percentage of women faculty members in the university's science and engineering departments" indicates NSF's welcome contribution towards action programs for institutional transformation. The 2006 National Academies study that looked at hiring and promotion processes in science and technology fields in universities in the USA, provides clear evidence to support our proposal that culture and environment are the areas that need addressing to a make a difference in women's contribution to these fields. Recommendations to decrease the gender bias and barriers that women face require universities and their leaders to pay attention to "workplace environments" and "changing the culture and structure of their institutions to recruit, retain, and promote more women – including more minority women – into faculty and leadership positions". [Press release, National Academies Report, 2006].

In designing strategies for change, we have proposed that it makes sense to take a global cultural perspective, and to look at those environmental and cultural conditions that enable the Women-CS fit. The lead for this direction is already emerging from industry as nations

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[134] CWIT http://www.umbc.edu/cwit/video.html
[135] University of Washington http://www.cs.washington.edu/WhyCSE
[136] Sandy Graham and Celine Latulipe. "CS Girls Rock: Sparking Interest in Computer Science and Debunking the Stereotypes"
SIGCSE 2003, ACM: http://hci.uwaterloo.ca/students/clatulip/Publications_files/p322-graham.pdf
[137] NCWIT: http://www.ncwit.org/
[138] See: http://www.eurekalert.org/pub_releases/2006-09/cuns-na092106.php

compete in the world market, and more and more companies are finding it imperative to pay attention to the micro-cultures within their organizations. It is being argued that future business successes will be found where the company culture allows for a well-managed diverse workforce and diverse leadership teams. Two reports, one from Europe and one from Canada, make the business case for having more women in the science and technology workforce: “Nowadays, the focus has changed from moral-justice reasons to hard economic evidence”.[139] According to the Canadian report, the rewards are substantial –*for everyone*:

- Solution to skills shortage
- Access of employers to a broader base of talent
- Increased innovation potential
- Enhanced market development
- Greater return on human resource investment
- Stronger financial performance
- Improved governance
- Increased national economic growth index

[Increasing Women in SETT: The Business Case, report by the Canadian Coalition of Women in Engineering, Science, Trades and Technology, December 2005[140]].

We have illustrated the impact of culture and environment as determinants of women’s choices and participation in computing from the perspectives of larger cultures, and micro-cultures. We have offered evidence for an alternative model of thinking about gender issues rooted in the dynamics of culture rather than the self-limiting, and often misleading, oppositional model of gender differences.

Clearly there are many more areas to investigate with the goal of enabling women and other under-represented groups to enter CS studies and contribute to computing related

[139] Women in Science and Technology – The Business Perspective, report produced by the European Commission 2006
http://ec.europa.eu/research/science-society/pdf/wist_report_final_en.pdf
[140] http://www.ccwestt.org/sett.asp#objectives

fields. These findings have broader implications both for opening up CS to a wider population and for the health and future of the field itself.

Our personal goals for future work are twofold but complementary: **action programs** for broadening participation in CS and **research investigations in the culture of computing**. The list below is quite extensive but many of our action programs are already in the works. For example, as we continue to expand our *Women@SCS* program of activities we are planning a day of technology workshops for girl scouts modeled on our TechNights program. Also, we are hosting a first of its kind research-focused conference for undergraduate women in computer science: OurCS[141].

Actions Programs:

- Work on programs designed to dispel stereotypes and introduce images that show the diversity of field and the people in it e.g. the Roadshow
- Adapt what we've learnt about women and CS at Carnegie Mellon to develop strategies for increasing diversity among all minorities
- Continue to work on expanding opportunities for ALL: e.g. mentoring, networking, leadership
- Outreach and collaboration with teachers, students, parents, and counselors. Ideally we would like to start a CS specific Outreach Center at Carnegie Mellon and include most of the above, and much more, in the activities and goals

Research Investigations in the Culture of Computing: Our work leads to various questions for consideration and investigation, questions which have clear implication for constructive and effective action.

- How might thinking about culture (as opposed to gender) help us understand and impact women's and girls' (and boys') choices of CS and computing related careers?
- How can we shift the CS and gender conversation from gender to culture?
- What can different cultures learn from each other with regards to CS education?

[141] For more information see the OurCS web site: http://www.cs.cmu.edu/ourcs/

- Are there ways in which we can share our findings from the Carnegie Mellon case study with (women and minority) students to increase women's academic identity and lessen/forestall stereotype threat?
- What can we learn from other cultures and cultural attitudes to computing that can help us encourage more women and minorities in CS in the USA?

Clearly there is much work to be done and many directions we can take as we work towards our goals.

We propose that thinking about culture, whether of geographical magnitude or a localized micro-culture, can embrace broad and complex concepts, and can remind us of the wealth of evidence relating to culture and environment as determinants of how we perceive and experience the world around us. Ultimately we suggest that the reasons for women entering – or not entering – CS have *little* to do with *gender* and a *lot* to do with *culture and environment*.

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Appendix

Additional Disaggregated Findings From All Interview Transcripts

Below we include several charts illustrating some notable findings from the total participant sample using all 55 interview transcripts. The 3 sub-groups --20 women, 12 *Women@SCS* active women members (referred to in the charts simply as *Women@SCS*), and 23 men-- from the sample of the class of 2004 are compared and charted as percentages. The analysis of the 55 transcripts was limited to those responses which related to some major post 1999 changes. They were not analyzed to the same depth as the cohorts of 20 men and 20 women discussed earlier. Nevertheless they offer a fascinating glimpse at how the *Women@SCS* group compare to the other women and to the men in our sample. In chart 1, for example, the *Women@SCS* group appear to differ quite noticeably in their responses from the men and other women who are quite similar. In charts 4 and 9 the *Women@SCS* group show more positive attitudes towards the atmosphere and CS community than the other 2 groups. In chart 6 the *Women@SCS* group appear closer to the men in their responses than to the other women. The charts illustrate a spectrum of attitudes including differences among the women, and clearly illustrate that in our sample the men and women do not fit into two gender divisive categories. It seems that however we examine this data, through the two cohorts of 20 women and 20 men, or by looking at the 3 sub-groups, overall we do not see a gender divide in how the students were relating to CS.

Chart 1. Student Responses to Q. 17. Do you like/dislike programming?

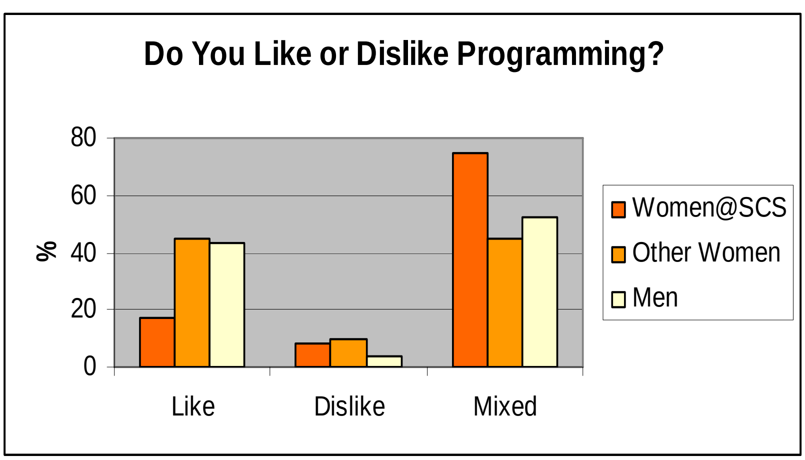


Chart 2. Student Responses to Q. 19. Do you have these (good programming) skills?

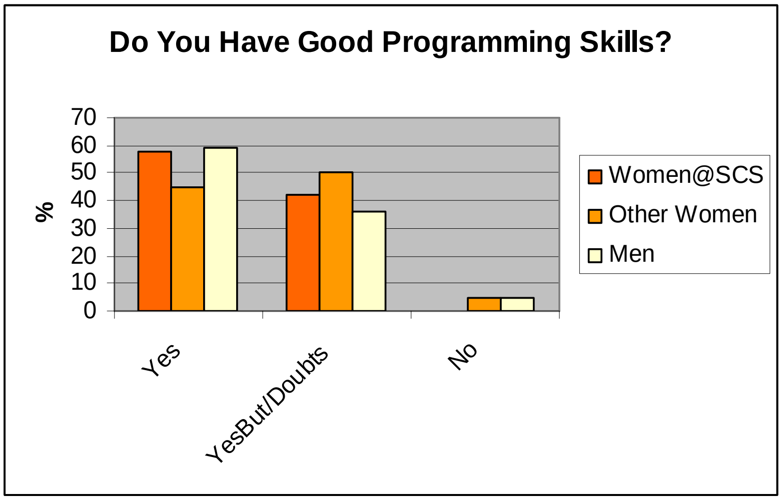


Chart 3. Student Responses to Q. 28. Do you feel that your confidence in your ability to do well in CS has increased or decreased?

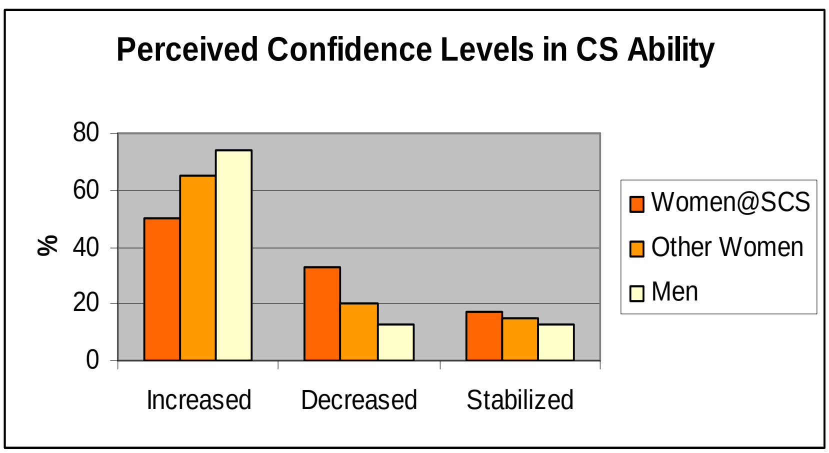


Chart 4. Student Responses to Q. 11. Where do you fit into this picture? (or not fit in?)

(Student were previously asked to describe the characteristics of CS students at CMU.)

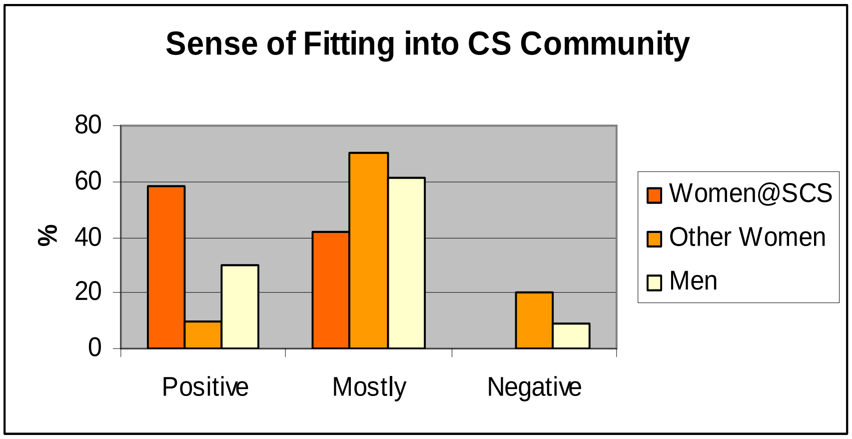


Chart 5. Student Responses to Q. 40. Have you felt any problems with mixing CS and the rest of your life?

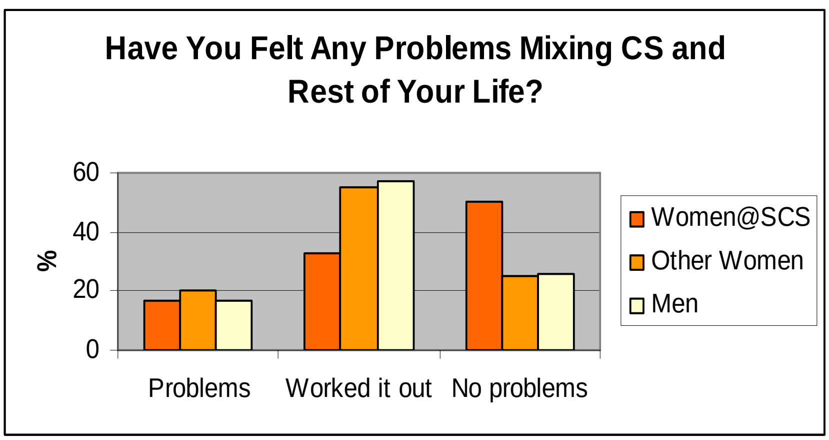


Chart 6. Student Responses to Q. 35. Have you ever thought about switching out?

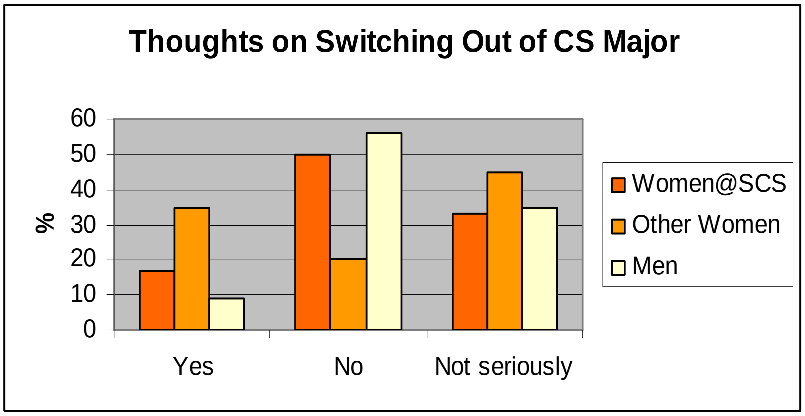


Chart 7. Student Responses to Q. 14 What interests you most about Computer Science?

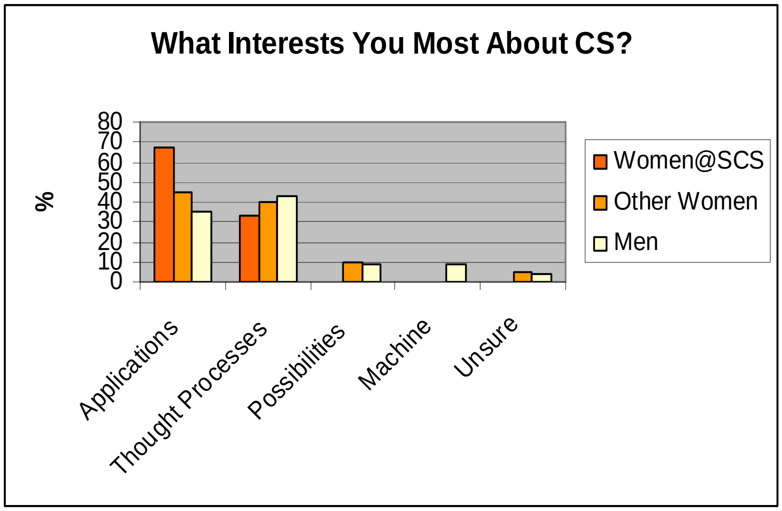


Chart 8. Student Responses to Q. 25. Do you feel you've been successful in this program?

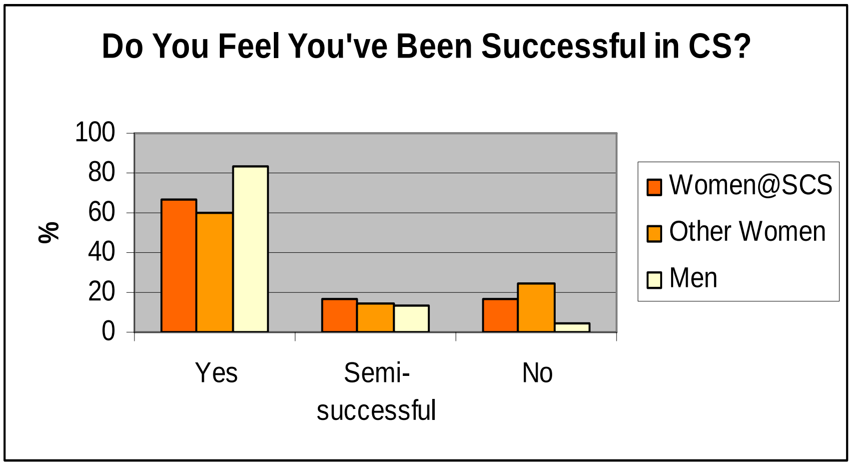
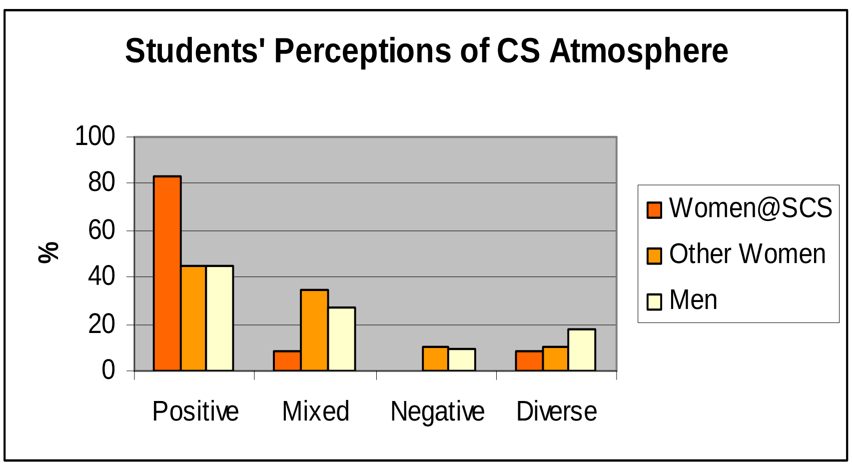


Chart 9. Student Responses to Q. 9. How would you describe the atmosphere in the CS Department now?



The 2004 Student Interview Questionnaire

The following questions were modified from the original Margolis and Fisher questionnaire. Their questionnaire was year-appropriate as theirs was a longitudinal study. We produced a much longer questionnaire incorporating most of the questions they had used. We added questions relating to stereotypes and to *Women@SCS*.

Time permitting most students were asked the following questions:

Date: Student: senior #, female/male

General Background

1. Did you grow up with a computer in the house?
2. Who used it most?
3. Did you have your own computer? (Tell me about that, e.g., when did you get it?)
4. When and how did you first get interested in computers and computing?
5. Why did you decide to major in Computer Science (CS)?
6. Who was most influential in your decision to major in CS?

CMU

7. Why did you decide on CMU?
8. Was coming here as you expected?
9. How would you describe the atmosphere in the CS Department now? and has it changed since you first came here?

CS Students

10. Can you describe for me the characteristics of computer science students here at CMU?
11. Where do you fit into this picture? (or not fit in?)
12. Can you remember your first impressions of computer science students? (Have your impressions changed since you were a freshman?)
13. Can you say a few words about computer science stereotypes?

Your interest in Computer Science

14. What interests you most about Computer Science? Why?
15. What interests you least about Computer Science? Why?
16. What projects are you drawn to?
17. Do you like/dislike programming? Why?
18. What skills do you need for good programming?
19. Do you have these skills?
20. Has your interest in Computer Science changed over the years?
21. Why do you think that is?
22. What do you regard as your academic strengths?
23. Are these the same as your academic likes or interests?
24. What helps you to learn best?
25. Do you feel you've been successful in this program?
26. What skills do you think are necessary to be successful in Computer Science at CMU?
27. Do you think your grades reflect the skills you mentioned? And what have your grades been like? What is your overall GPA?
28. Do you feel that your confidence in your ability to do well in CS has increased or decreased? (what has most significantly influenced your sense of confidence?)

More about your thoughts on the Computer Science major

29. What was the best thing about doing this major?
30. What was the worst thing?
31. What has been your favorite class? Why?
32. Least favorite? Why?
33. What would you change about the CS major if you could?
35. Have you ever thought about switching out?
36. What has kept you going?
37. Were there any particularly difficult semesters? Or years?
38. Have you ever felt discouraged?

39. Where do you go, how do you handle it, when you feel discouraged?

40. Have you felt any problems with mixing CS and the rest of your life?

Women@SCS

41. Do you know about the student organization—Women@SCS?

42. What's your impression of Women@SCS?

43. Have you had any contact, been to any events run by the organization? and if not why not?

44. Has it had any affect on your experiences at CMU?

45. Do you have any suggestions for how Women@SCS can reach out to more students—men and women?

Gender and CS

46. What do you think is the men to women overall ratio now in Computer Science at CMU?

47. Do you think CMU should make any further efforts to attract and retain more women in computer science?

48. Are you aware that there are very few women in Computer Science generally?

49. Why do you think that is?

50. Does it matter that there are so few women in the field?

51. What has it been like being a woman in CS overall? (men are asked to speculate)

52. Have you experienced any problems in the program because you are a woman? (or man?)

53. Have you experienced any advantages because you are a woman? (or man?)

54. Have you noticed any changes that might affect women? (For better or worse?)

55. Have you noticed any changes that might affect men? (For better or worse?)

56. What do you think the situation is like here in CS for other under-represented groups?—African American, Hispanic, for example?

Now that you are a Senior

57. How would you define Computer Science?

58. Is this what you thought as a Freshman? Has your conception of computer science changed since you were a freshman?

59. Looking back what have you enjoyed most about your years here?

60. What have you disliked most about your years here?

61. What advice would you give to new students?

62. Would your advice be different, depending on whether the new student was male or female?

63. What would you say to a high school senior boy or girl thinking about coming into CS at CMU?

Changes

64. Can you identify what changes, if any, you've noticed over the years between now and when you were a freshman?

65. Have you changed? (In what ways?)

The Future

66. So where are you going from here? and how do you see your future?

67. Would you say this is how you saw your future when you first came here?

68. What have been your experiences in the job market been like, with recruiters, etc.?

69. What is your vision of how computers can shape the future?

70. What role do you see for yourself in that vision?

Finally

*Is there anything we haven't discussed that you would like to add? Anything about life in CS that we should know about?