

# From Difference to Diversity: Including Women in *The Changing Face of Computing*

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## ABSTRACT

In this paper we argue that gender difference thinking, with regards to attitudes towards computing, can work against diversity in the field of computing. Indeed, gender difference approaches to the participation of women in computing have not provided adequate explanations for women's declining interest in computer science (CS) and related technical fields. As yet "The Changing Face of Computing" has not led to significant changes in the levels of women's participation. Indeed, the number of computer science degrees awarded to women has steadily declined since 1984. Our objective in this paper is to present a critique on why gender difference approaches may be problematic and propose that a cultural approach offers a more effective framework for investigating and increasing women's participation in CS. We support our findings and recommendations from the most recent research in a series of studies carried out at Carnegie Mellon University (CMU) over the past 10 years. In brief, we found the Women-CS fit at CMU continues to present a positive and encouraging story. Our findings demonstrate that under certain conditions women, alongside their male peers, can fit successfully into a CS environment and help shape that environment and computing culture, for the benefit of everyone, *without accommodating presumed gender differences* or any compromises to academic integrity.

## Categories and Subject Descriptors

K.3.2 Computers and Information Science Education

## General Terms

Management, Human Factors

## Keywords

Computer science education, women, culture, gender similarities, gender differences, diversity, retention, Women-CS fit

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## 1. INTRODUCTION

In this paper we argue that gender difference thinking, with regards to attitudes towards computing, can work against diversity. Indeed, gender difference approaches to the participation of women in computing have not provided adequate explanations for women's declining interest in computer science and related technical fields [1, 6, 7, 15, 16, 25]. We raise the question: is a focus on gender differences within the culture of the USA reaffirming essentialist thinking (i.e. the belief that innate differences between men and women suit them to different fields) thus contributing to the low participation of women in CS?

The 2012 Taulbee survey<sup>1</sup> reports that enrollments in undergraduate computer science programs rose for the fourth straight year. The number of bachelor's degrees in computer science awarded also increased. While this is welcome news and certainly contributes to *the changing face of computing*, the situation for women has not improved. The 2012 Taulbee survey also shows discouraging data on the national graduation rates for women in CS, rates which now stand at 11.7% down from last year's 13.8%. Indeed, the number of computer science degrees awarded to women has steadily declined since 1984 [29]; "a stark reminder that women's progress cannot be taken for granted" [18].

At the same time we face a critical situation in the history of computing in the USA when jobs in computing outnumber graduates with the necessary skills to fill them [8]. Clearly, it is in the interest of women, of the nation, and the field of computing to attract and train talent from a diverse pool of potential participants. The question that begs is why are we failing to do this?

In CMU's School of Computer Science (SCS) a shift towards a more balanced environment, and ensuing changes in the micro-culture, have contributed to a successful undergraduate experience for most students—women and men—but the changes have been particularly dramatic and positive for women. While cultural attitudes within the USA may often work against women's inclusion in male dominated fields our studies have shown that localized cultural changes can influence student experiences and attitudes and help buck any trend towards a gender divide.

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<sup>1</sup> The 2012 Taulbee Survey provides data from Ph.D. granting schools for the 2010-2011 school year.

This paper has two primary goals a) to present our thoughts on why gender difference approaches may be problematic and why a cultural approach is necessary, and b) to support our ideas with findings and recommendations from studies at CMU.

## 2. BACKGROUND

CMU has not been immune to national trends. However, even in the face of a nationwide decline in the number of new female CS majors, SCS has sustained a critical mass of female students within the entire CS undergraduate student body (currently around 25% female). For the past few years, the percentage of women enrolling in the CS major at CMU has held steady or increased at well above national averages. Indeed, since 2002 the percentage of bachelor's degrees granted to women in the CS major at CMU has exceeded and stayed well above the national average. We believe this success is due in large part to the school's commitment to building and sustaining a culture and environment which works for *both men and women*.

A full account of actions leading to changes in the CS culture at CMU has been well documented [5, 7, 14, 20]. In brief, prior to 1999 CMU maintained a very traditional male dominated CS culture, a culture that tended to support the personalities of stereotypical computer science students. By the time our research began in 2002 CMU had a more diverse student body in CS including increased numbers of women but also more men with wide ranging characteristics, all selected and admitted for their "community" and leadership potential along with high SATs. We began to observe what we believed to be the evolution of a new culture of computing as the environment shifted from an *unbalanced* to a more *balanced environment*. By balance we refer to three specific areas: balance in terms of gender, in terms of breadth of student personalities, and in terms of the development of a professional and social organization, *Women@SCS*<sup>2</sup> which provides crucial educational and professional experiences often taken for granted by the majority in the community e.g. the networking and mentoring that often goes on quite naturally among the majority male population [14]. In this more balanced environment women began to participate, contribute, and be successful, in the CS major, *without accommodating presumed gender differences* or any compromises to academic integrity.

For the past ten years, we have been paying close attention to the culture of computing and monitoring the Women-CS fit. Our research findings (2002, 2004, 2009-2010, 2011-2012) 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 the gender divide observed prior to 1999. It is also important to note that while the SCS at CMU clearly allows for diversity and a more balanced environment, *the academic curriculum was not adapted to become "female-friendly"*. In fact it has continued to be an extremely rigorous and highly competitive program receiving, for example, over 4000 applications in 2012 for the 130 places offered the same year.

## 3. CULTURE

It seems reasonable to assume that a multitude of factors are involved in women's participation in CS—biological, educational,

psychological, cognitive, social, etc.—factors which this paper cannot hope to untangle. This concept was nicely illustrated by Barnett and Rivers [2] when they explained, "We are all a product of many interacting forces, including our genes, our personalities, our environment, and chance". Their book promotes the view, and provides evidence to show, that factors relating to culture and environment which encompass so many of these "interacting forces", play critical roles in determining women's participation in CS [2, 16].

So what do we mean by culture and employing a cultural approach? Williams [28] suggests that culture belongs to everyone being part of our everyday experiences and being "*made and remade*" by us on both the personal and the societal levels. This definition allows us to see culture as a *synergistic* process for change. We are shaped by the cultures we occupy while also being active contributors to those cultures. Hence, we use the term culture as previously defined [7, 15, 16] to refer to the complex and broad set of relationships, values, attitudes and behaviors that bind a specific community *consciously and unconsciously*. This community can be localized as in the micro-culture of a department or extensive as in the culture of a nation. In all cases this definition posits that culture is bound by context and history and that we are born into specific cultures with prevailing values and structures of opportunity.

A cultural perspective can both *broaden* and *focus* our thinking. It can broaden our thinking as we think outside of our own cultures and it can focus our thinking as we recognize specific factors affecting specific situations. Taking a cultural perspective on women's participation in CS is an approach which allows us to look at *factors outside of gender* as leading contributors to different levels of participation. As gender is often constructed differently in different cultures taking a cultural approach allows us to see quite clearly and *convincingly* that many characteristics ascribed as natural to men and to women are actually produced in specific cultures. Indeed, several researchers have brought this fact to our attention describing examples of countries and cultures where women are well represented in computing [1, 10, 22, 26].

## 4. IS THE RHETORIC OF ESSENTIALISM CONTRIBUTING TO THE GENDER GAP IN COMPUTING?

Essentialism is the belief that people have properties that are essential to their composition. In this sense, all members of a particular demographic group (e.g. gender, race, sexual orientation) share common and finite characteristics. Gender essentialism is epitomized and popularized in such best sellers as John Gray's *Men are from Mars, Women are from Venus* (1992), which has sold more than 7 million copies and was the "highest ranked work of nonfiction" of the 1990s. "The book and its central metaphor have become a part of popular culture".<sup>3</sup> According to research examined in the 2010 AAUW report gender difference thinking is still prevalent in attitudes towards STEM fields in the USA: "Most people associate science and math fields with "male" and humanities and arts fields with "female" [18].

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<sup>2</sup> For details of *Women@SCS* please see <http://women.cs.cmu.edu/>

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<sup>3</sup> See Wikipedia:  
[http://en.wikipedia.org/wiki/Men\\_Are\\_from\\_Mars,\\_Women\\_Are\\_from\\_Venus](http://en.wikipedia.org/wiki/Men_Are_from_Mars,_Women_Are_from_Venus)

At the core of essentialism is the belief that men and women are inherently different in their physical bodies, and hence they are also different in the ways in which they act, behave and think. Marini [21] adds that this frequently leads to the assumption that biological features can be used to explain other observed differences between men and women. Further, DeCecco and Elia [9] explain that biological characteristics constitute the primary influencing factor influencing human behavior, thereby minimizing the effects of culture or social shaping.

Researchers argue that essentialism uses biological differences between the sexes to explain differences in male and female decisions to study CS [24, 26, 27]. Consequently, essentialism studies generally conclude that men relate to technology in differing and opposing ways from those of women. For instance, Pinker [23] suggests that the lack of women in technical careers could be due to biological differences in average temperaments and talents. Furthermore, Baron-Cohen [3] argues, “the female brain is predominantly hard-wired for empathy. The male brain is predominantly hard-wired for understanding and building systems”.

Essentialist rhetoric has become more noticeable in relation to CS and technology, and more broadly to some areas of science in general, as we have struggled to address the low participation of women. Signs of essentialist thinking are not only evidenced in the remarks of Larry Summers, when he was president of Harvard and should have known better, but also in the way we are constantly searching for ways to make science *appeal to girls and women*, as if tapping into something inherent in girls and women, or re-shaping science to suit women’s interests, will provide the answers. Such approaches, though well intentioned, may ultimately play into essentialist thinking and serve to reinforce a gender divide. By identifying gender differences and *subsequently accommodating those differences* we can be our own worst enemies playing a harmful role in *perpetuating stereotypes and differences*.

These differences, which are often only *perceived* differences that can change according to situation, can serve to *deny diversity* and the cross-gender spectrum of characteristics, interests and identities that can emerge. Gender difference approaches can result in setting up men and women as separate categories when research has shown that there are more differences within each gender than between them [16, 19, 26]. This is not an easy message to broadcast to children and parents when difference approaches seem to be the mainstay of marketing in our culture. Recent discussions on LEGO, for example, showed that sales went from only 9% purchased specifically for girls at the end of 2011 to 27% after the introduction of the LEGO Friends playsets designed especially for girls.<sup>4</sup> LEGO is famous for its creative, building and construction challenges. “Lego play develops spatial, mathematical, and fine motor skills, and lets kids build almost anything they can imagine”.<sup>5</sup> These skills are valuable to all children but critics of the new LEGO Friends, suggest that such skill building has been downplayed and replaced by “shapely female figures and playsets like the Butterfly Beauty Shop (which) reinforced the idea that women should focus on their

looks”. While this may seem a far cry from computer science it is an example of how accommodating perceived gender differences and perpetuating a gender divide within our culture can mean that sections of the population easily miss out on valuable experiences, experiences which could serve them well later in life.

Without an awareness of cultural contexts gender difference approaches can serve a) to reinforce the belief that men and women are two distinct and fundamentally different categories, which in turn can support an essentialist position, and b) to exclude significant cultural factors that are impacting participation in CS. We propose that taking a cultural approach can offer more prudent insights and open up new possibilities for thinking about participation in computing without contributing to a gender divide.

## 5. NEW RESEARCH AND INGREDIENTS FOR SUCCESS

There is a growing body of research that challenges the historical notions of essentialism. Epstein [12] argues that men and women are overwhelmingly similar and that any differences between them are socially constructed. For instance, Fine [13] argues that sloppy science is frequently used to justify gender stereotypes, which she labels “neurosexism”. She critiques the use of fMRIs and high-tech scanners to explain how sex hormones shape the brain, which then shapes behavior and intellectual ability, from mathematics to nurturance. It is not that she is opposed to neuroscience or brain imaging; quite the opposite, she strongly argues against making authoritative interpretations of ambiguous data. Supporting her argument is research emerging from the fields of psychology and neuroscience, which suggests that men and women may not be so different after all. For example, Halpern [17] recognizes that the female brain is slightly smaller than the male brain, but studies show this to have no significant effect on a woman’s intellectual performance. Further, through empirical analysis, Barnett and Rivers [2] show that the idea of a “math gene” or the hardwiring of a male or female brain is a fallacy.

Scientists are showing that more and more behaviors once thought to be hard wired can be seen to change when behavior is changed. For example, Eliot [11] uses the notion of the brain’s plasticity to explain how human brains are works in progress. She argues that brains change based on experience, especially in early childhood. Consequently, a child’s environment can dramatically influence how he or she develops in terms of skills and interests. Eliot also argues that the brain-based differences that seem so immovable in childhood can lessen with age.

For our purposes we are reminded that at one time different math abilities in men and women, with women having poorer ability, were attributed to “different brains” [4]. Such “scientific” explanations have been used to explain women’s weaker performance in math and to uphold and justify a culture entrenched in beliefs that men and women are fundamentally very different in their intellectual abilities. By paying attention to girls and math, by increasing their levels of encouragement, of experience and practice, girls have caught up with their male peers and indeed women now earn almost half of bachelors in the field of mathematics [18].

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<sup>4</sup> See <http://abcnews.go.com/blogs/business/2012/09/lego-friends-triples-sales-to-girls-despite-feminist-critique/>

<sup>5</sup><http://www.businessweek.com/magazine/lego-is-for-girls-12142011.html>

We believe there are several important ingredients outside of gender which contribute to any student's participation and success in the STEM fields at all levels of academic and personal growth. Factors such as opportunities, experience, and exposure to computing are outside of gender and not intrinsic to one gender or the other. Thus, we can be very pragmatic in recommending that we pay close attention to a small but effective set of best practices such as hands-on experience to gain important skills and exposure to role models to inspire and allow students to see themselves as next generation scientists. Students should be encouraged to see ability in computer science (or any STEM field) as an educational process of learning concepts and practicing skills, not as "gifts" more prevalent among one gender or another [18]. We particularly welcome the efforts of the Association for Computing Machinery (ACM), the National Science Foundation (NSF), the College Board, the CS Teachers Association (CSTA), the National Center for Women in Information Technology and others working to include a solid program of CS studies in the US national K-12 curriculum. We see K-12 curricular changes in CS as *essential ingredients in ensuring that ALL students are exposed to computer science*.

## 6. THE 2011-2012 CASE STUDY AT CMU

As with our initial study in 2002, our latest study, 2011-2012, was prompted by a newly revised curriculum in 2010, providing greater emphasis on computational thinking. We monitored how these changes impacted the academic and social fit of the CS students at CMU.

### 6.1 Methodology

In this study, as with previous studies, we sought to understand how a cohort of CMU CS students perceived their relationship to CS. The primary data collection tools included interviews (for depth) and surveys (for breadth). Interview and survey questionnaires covered a wide range of topics ranging from background in computing, reasons for choosing the CS major, favorite classes, attitudes to programming, and many more.

CS sophomores (first to experience the new curriculum as freshmen) were invited by email to participate in interviews. We identified and interviewed a cohort of 20 men and 20 women. We also interviewed 4 students who had switched out of CS. Interviews, which lasted approximately 30-60 minutes, were audio taped, transcribed and analyzed. Surveys targeting the entire undergraduate student body were conducted in spring 2012. We collected 200 survey responses (52 women and 148 men) from freshmen through seniors. We used traditional qualitative (selective and open coding) and quantitative processes (descriptive statistics) for the analyses and evaluation of the data.

### 6.2 Findings

Our survey findings showed little to no difference to findings from surveys carried out 2009-2010 and reported in detail [16]. Both our 2011-2012 interview and survey findings were in agreement with previous findings that men and women relate to CS through a spectrum of attitudes including many gender similarities. *In brief, we found no evidence of a strong gender divide*. For the purposes of this paper we focus on findings

relating to culture and environment, atmosphere of gender inclusion and perceptions of fit.

#### 6.2.1 Culture and Environment

The students were asked to describe the atmosphere or the environment in the computer science department. This interview question provoked a range of responses with several gender similarities. Both men and women commented on the hard working atmosphere (7 women, 9 men). Several students felt the atmosphere was friendly and comfortable (9 women, 7 men). Only 4 men and 4 women felt the atmosphere was stressful or too competitive. Otherwise one of the most interesting findings was the collaborative nature of the environment as noted by the women. Even when they commented on competition they suggested it was a healthy kind of competition "*It's not cut-throat tech like other schools ... Here, we're all just in it for the love of it*". One woman noted "*It's competitive in that you want to do well, but, it's a collaborative environment*". Men also noted the collaborative nature of the environment "*collaborative and helpful*". Four women and five men used very positive descriptions in response to this question using words like *love, enjoy, fun, great, cool, and amazing*.

Students were also asked if they found their computer science advisors and professors to be approachable. We saw this as another indication of whether or not we were sustaining a good environment. The interview responses were overwhelmingly positive with 14/20 women and 15/20 men saying yes. One man said "*Everybody is approachable... You can send the professor an email or go talk to him after class, and it's awesome*". One woman compared CS faculty to non-CS faculty "*I actually think the computer science professors are a lot more approachable than other professors*". Responses to this question on the survey were similar to interview responses and amazingly gender balanced with just over 50% men and women *disagreeing* with the statement "Professors at CMU are not approachable". In the interviews, six women and five men gave mixed or unsure responses. One woman felt "*some of the professors are a little scary but (my advisor) is very approachable*". Some students pointed to their own reluctance or need to approach faculty who they knew are busy. Likewise, approximately 35% of the men and 35% of the women who completed the survey were unsure. No students gave completely negative replies in the interviews. And only 15% of the women and 17% of the survey respondents felt their professors were not approachable. Overall the responses were more positive than negative about the approachability of professors. We also found very strong gender similarities in the responses to this question. We were very pleased to see how well faculty were contributing to an atmosphere in which both men and women could find help when needed and work towards success.

#### 6.2.2 Atmosphere of Gender Inclusion

We asked several questions relating specifically to gender giving them the opportunity to raise any gender related issues. We asked the female interviewees "what has it been like being a woman in CS overall?" Responses to this question were very positive from the women with 12 women noting they didn't feel or experience anything they thought was different to the men. One woman said "*Most people don't really seem to care about my gender. They care about whether or not I can solve problems*". Some commented on how great it was to have female friends, for others there were still too few women. Several women noted advantages

e.g. more attention from recruiters, feeling admired by non-CS majors, special events for women only provided by Women@SCS. We asked the men to speculate on what they thought it was like for women in the program. Responses proved particularly interesting with men often pointing to the difficulties women must face because of being outnumbered. One student said that some of the CS clusters look like *“someone’s idea of a frat house. I think that it’s gotta be tough”*. At the same time when asked if they had any advantages being men none of the men thought they did although 2 men (including one minority) did allude to the gender imbalance and the possibility of women having fewer friends. This was phrased as a negative for women rather than an advantage for the men.

### 6.2.3 Attitudes to Programming

During the interviews, students were asked if they liked or disliked programming and why. We asked this in part because earlier research at CMU had found a strong gender divide in student attitudes towards programming [20]. In contrast, we have asked the question throughout our studies and always found that women like programming as much if not more than the men and they held similar reasons for doing so. From among our cohort 16 women and 13 men expressed they either love or like programming. Responses ranged from expressing the sense of accomplishment that programming can provide to the creative side of programming. A male student noted *“It’s amazing how much you can do with just writing code”* while a female student said *“You can create so many things with it”*. Twice as many men as women had mixed attitudes (6 men, 3 women). Mixed attitudes usually referred to students who like programming at times but did not see themselves as programming for long periods of time, an attitude exemplified by one man who said although he liked programming *“When I think about doing it 40 hours a week, I feel I would get bored. I don’t want to do that the rest of my life”*. Only one man and one woman indicated they did not like programming at all. Clearly, our cohort does not suggest a gender divide in terms of attitudes to programming.

### 6.2.4 Perceptions of Fit

Two important interview and survey questions were intended to give us an overall sense of how students perceived themselves as fitting into CS academically and socially.

We asked students in the interviews and surveys if, overall, they felt they fit into CS academically. The interview responses produced striking gender similarities and were highly positive. 17 women and 17 men answered with very direct and simple comments like “yes”, “I think I fit okay”, “Yeah, I think so”, “I think now more so yes”. While the surveys were less gender balanced, most women, 52%, felt they had a positive academic fit (strongly agreed or agreed) and 78% of men felt they had a positive academic fit (strongly agreed or agreed). We saw gender similarities in the way students expressed their sense of academic struggle. For instance, one male said he was *“...wondering if I’m up to par with everybody else. But I think that’s something that most everyone here also has”*. A female explained, *“You’re always feeling that you’re trying to fit in struggling with all the academic concepts and things. Overall I think everyone is doing the same thing”*. In the surveys 33% women and 14% men were unsure about their sense of academic fit and expressed ambiguity in their responses. In the interviews 2 women expressed sentiments of uncertainty; one said *“I think to some extent, I do.*

*... I’m honestly not sure”*. One male interviewee also expressed uncertainty saying it was a hard question for him to answer and he couldn’t say yes or no. In the surveys only 15% of the women and 7% of the men disagreed that they fit in academically. In the interviews, only one woman was definite about not feeling she fit saying *“Not really, just because I’m not doing so well academically here”*. Two men felt they did not fit academically one saying “not really” and another saying *“academically, no. I am not going to do well as a computer science student”*. We were pleased to see so many women express a sense of positive academic fit.

We asked students in the interviews and surveys if, overall, they felt they fit into CS socially. Once again the responses were highly positive and produced striking gender similarities even to the point of the language they used: e.g. one woman said, *“Yeah, I’m definitely a CS major at heart”*, while one man responded *“Yes. I am a CS major at heart”*. With regard to the survey, most women, 71%, felt they had a positive social fit (strongly agreed or agreed) and 69% of men felt they had a positive social fit (strongly agreed or agreed). The comments of one woman in her interview clearly challenged the stereotype that computer scientists are not social: *“You make friends easily with people here. They’re actually really social people”*. Another woman also said *“Yeah, yeah. We nerd out and have fun.”* A number of the surveyed students, 17% women and 14% men, were unsure about their sense of social fit and expressed ambiguity in their responses. Only 12% of the surveyed women and 18% of the men disagreed that they fit in socially. One female interviewee said, *“I think sometimes I feel like I’m not nerdy or geeky enough”*. The 3 men who responded negatively in the interviews did so saying most of their friends were “outside of CS”.

## 7. CONCLUSION

The *changing face of computing* has brought many exciting and promising advancements to the field. Unfortunately, a key concern remains—the persistent under representation of women in post-secondary computing educational programs. We know it is in the interest of women, of the nation, and the field of computing to attract and train talent from a diverse pool of potential participants. *Yet, sadly, years of attention and funding applied to women in computing issues have not paid off.*

We believe reframing the problem lens is a critical step to attracting and retaining more women in the discipline. By moving beyond old frameworks and essentialism rhetoric that situate the problem as a male-female dichotomy, we are able to employ more sophisticated and robust tools for analysis and interventions. Findings from our most recent study suggest many gender similarities and a spectrum of attitudes towards CS exist rather than a divide between the genders. We suggest that researchers and practitioners be hesitant to assume the factors that attract and retain men to the field are opposite and at times in conflict to those of women.

Further, our research demonstrates that in order to promote the participation of women in computing, attention should be focused on cultural change and conditions in the environment, not on gender and gender differences. Indeed, we suggest caution in searching for ways to make science *appeal to girls and women*, since we know the Women-CS fit is already evident in certain cultures and micro-cultures. Findings in this paper demonstrate

that student attitudes to factors of faculty approachability, environment, social fit, academic fit, are more similar than different between the genders. Our findings also demonstrate that these factors are important indicators in building and maintaining an inclusive atmosphere. These factors are built on attention to diversity—not gender differences—and are positively related to a Women-CS fit. Conditions that foster diversity, not gender divides, are essential for changing the face of computing to include and reflect the face of the population it serves.

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