Caring About Connections: Gender and Computing

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Introduction

Do women approach the study of computer science differently from men? And does that difference work against their involvement in the field as it currently exists? Although substantially more women than men attend college, only 15-20% of undergraduate computer science majors at leading U.S. departments [Kozen & Zweben, 1998] and only 17% of high school computer science Advanced Placement test takers [College Board, 1998] are female. This is a matter of concern not only for women who may be forgoing opportunities for economic success and personal satisfaction, but also for an industry in the grip of a shortage of skilled workers, and a society deprived of a broader set of perspectives in the design of its increasingly critical information systems.

For nearly four years, we have been interviewing female and male computer science students about their experiences studying computer science at Carnegie Mellon University, in one of the top computer science departments in the country. This paper

explores the differences in orientations to computing that we hear in men's and women's interviews when they arrive at the university, and traces the effects of these differences on women's sense of belonging and comfort in the program, and on their decisions to stay or leave. While most of the male students describe an early and persistent magnetic attraction between themselves and computers, women much more frequently link their computer science interest to a larger societal framework. Nearly half of the women we've interviewed attach their interest in computer science to other arenas, such as medicine, education, space exploration and the arts. For many of these women, while interest in computing is strong, they are concerned that their study of computer science *not* require a myopic focus on the machine, or detach them from people and other concerns.

We also discuss how computer science curriculum and culture frequently mirror and bestow prestige on an orientation toward computing commonly identified with men, while devaluing and pushing to the margins the orientations associated with women. Certainly there are women and men whose approaches and perspectives are more alike than different; some women love gizmos, gadgets, and "technology for technology's sake," and not all men subscribe to the "geek" ethos. Yet the identification of computing as a male domain is so pervasive that men suffer far less from a mismatch with the dominant culture than do women. In this context, we discuss the importance of "re-visioning" computer science, so that the answer to the question "what is computer science?" incorporates and values women's perspectives as well as men's.

The study of which this paper is a part is longitudinal, following students' experiences for two to four years. The heart of our data is transcripts of semi-structured, open-ended interviews with students which occur once per semester. Additional data are gathered through surveys, classroom observations, interviews with faculty, a small journal writing project, and monitoring of electronic discussion forums. Our sample consists of the majority of female CS majors at Carnegie Mellon, and a comparable sample of male majors. To date we have conducted interviews with 51 female and 46 male computer science majors.

Caring About Connections

Almost all of the women students who are admitted to the Carnegie Mellon School of Computer Science enter with high enthusiasm and interest. We have interviewed the former president of her high school's computer club and another student who took great pride in being the computer "genius" in her family. These students major in computer science because they feel competent in and enjoy computing and programming. As one woman told us: "I have always been a problem-solving person and it just really gives me a rush when you are working and working on a problem and finally it just works!" Women talk about the pleasure in "systematic thinking," as well as the creative aspects of programming -- having a program express their individuality. Almost every woman in our sample came to computer science as a "math and science person," enjoying problem-solving, puzzles, and logical thinking tasks.

While these students are enthusiastic about computers and programming, and talk about the "rush in having my program run," the *context* and *connections* of computing to other arenas makes the study of computer science meaningful for them. Forty-four percent of the women we interviewed, as compared to 9% of the men students, link their interest in computers to other arenas. These women emphasize the importance of having computing and their programs "do something." Some students have specific projects in mind, such as this woman who wants to use computers in biology :

> *I think with all this newest technology there is so much we can do with it*
>
> *to connect it with the science field, and that's kind of what I want to do*
>
> *(study diseases)...Like use all this technology and use it to solve the*
>
> *problems of science we have, the mysteries.*

Another is interested in the links between computing and education:

> *What I would really like to do is teach...would like to minor in education,*
>
> *how computers affect education and what is the most efficient way to use*
>
> *them in education.*

Several of the women we interviewed didn't have a specific field in mind, but stressed how important it is that their computer work do something useful for society. A first-year student told us how much she enjoyed science fiction when she was young. She remembered reading about a robot that was "more like a tool; it wasn't something that

would take over a place, but it was a machine that would help out." She said she wants to help design this type of intelligent machine. She was inspired by a recent Carnegie Mellon lecture about a robot car, in which the lecturer explained the utility of the car by describing the number of accidents and deaths caused by human error. This use of computers resonated with this student's desire to connect computer science to real world problems:

The idea is that you can save lives, and that's not detaching yourself from society. That's actually being a part of it. That's actually helping. Because I have this thing in me that wants to help. I felt the only problem I had in computer science was that I would be detaching myself from society a lot, that I wouldn't be helping; that there would be people in third world countries that I couldn't do anything about...I would like to find a way that I could help. That's where I would like to go with computer science.

Answering the interview question "What interests you most about computer science?", a female student told us she wanted:

...to be able to write a program that would actually help; not programming for the sake of programming, which is what I am doing right now. But programming for the sake of solving a specific problem, or for

the sake of developing a program that would solve something very

specific.

Another woman student who has always done well in math and science, who finds these subjects to be fun, relates her interest in computer science to her concern for her grandmother's medical condition:

> *I don't think science--just for making video games--is worth the energy*
> *and talent that it takes, but I think it's important if it makes a contribution,*
> *so...Um, part of that would be a contribution in medicine, like, my*
> *Grandma had a pacemaker, a renal dialysis machine, it's like...I've seen*
> *the contribution in my family in my life, so that's something. Medicine has*
> *always fascinated me, so I just always wanted to apply my sciences there.*
> *And I see the opportunities now, with the computer technology to apply*
> *there and that's what I want to do.*

These quotes are examples of how women students' passion for computer science, their excitement about the field, is often presented and articulated in terms of the *context* of larger, often people-oriented issues. This is not to say that these women do not enjoy the purely technical aspects of computing, because many do. But a distinction is often made. For instance, a woman student described a difference between herself and most of the male students. She says they want to focus on "building bigger and bigger computers." "That's fine," she says, "and I'd like to be involved with that, too, but in the long run I

want to use computers for what they are now, and just use them to help people." These narratives echo the theories of developmental psychologists [Gilligan, 1982; Miller, 1976; Pipher, 1994] who study the lives of girls and women. Miller [1976], in her landmark study of women's psychology, states:

> *It is true that women, like everyone, are motivated out of the well-springs of their own being. In that sense, we all, at bottom, act on what is moving us individually. It is also true, however, that women feel compelled to find a way to translate their own motivations into a means of serving others and work at this all their lives. It they can keep finding ways to do this, they are often comfortable and satisfied--and they do thereby serve others. This translation of motivation accomplishes an integration that is significantly different from the integration that society encourages in men. In fact, our society specifically discourages men from even attempting anything like this. (p.63)*

Male Fascination with the Machine

In our interviews with male students, learning all about the computer is described as a pleasurable end in itself. Concerns with context are rarely articulated in most men's interviews. In response to our opening interview question, "Can you tell me the story of you and computers?" many male students describe falling in love with the computer the minute they put their fingers on the keyboard--often at a very early age--and the screen responds. For most of the male students in our study, love of computing comes early, and

becomes part of their identity and the stories they tell about themselves. They describe a magnetic attraction between themselves and the computer, with the computer becoming an object of fascination and allure. From then on their activities, conversations, waking hours center around the computer. The computer is the ultimate toy. "Intensely fascinated," "play" and "fun" are words they use when they describe their first experiences with computers. One of the male students we talked to says, "My mother bought me a computer back in Alabama when I was four years old and I guess ever since it has been me playing video games, thinking 'WOW, how did they do that?'" Another student tells us:

> *Well, I think it was sometime in middle school, sixth grade, about then, my*
> *dad borrowed a computer from a friend, it was an old black and white*
> *Macintosh, just totally self contained one unit thing, and I remember just*
> *playing with that all the time and trying to figure stuff on it. And that got*
> *me really hooked...I was really getting into figuring things out on*
> *computers and I just knew that that was going to be something for me.*

This fascination with the computer often leads to self-initiated exploration and learning about various aspects of computing, including programming. When we asked a male student to describe how games were a key source of motivation to learn programming, he told us:

I would see stuff, because I played video games all the time and I really

liked the graphics and everything. And I was interested in learning how to

do that. So to learn how to do that you got to go get the books and to

understand how to do graphics you have to understand how to do the

basics so you have to learn the basics. And then just like a general

progression, if you are interested in something and you want to learn how

to do it, you have to get from point A to point B and along the way you

pick up a lot of stuff that you need and will help you out with some of the

other classes.

This description of the pull to "figure out how it works" is something prevalent in the

male interviews and almost non-existent in the female interviews. It positions the male

students in a very active relationship to the machine. As young boys, males step right

into the driver's seat, leaping from the outside to the inside. Many male students report

programming to be a source of extracurricular pleasure, having done it since they were

young (38% of the men among our sample, compared to 10% of the women). Male

interviews are often filled with lengthy accounts of their computing experiences, jobs,

and projects. Computing emerges as an integral part of their lives.

Even among the few male students who emphasize the importance of computers in the

larger societal context, their focus still tends to be more machine-oriented than the

women's. A male student who wants to make more computers useful for people says,

"Since doing so much work with them [computers], it's become more a tool to me. I

can't imagine a contractor getting excited over a hammer, but having a great respect for it." Another student tells us: "I've always had aspirations of making computers. I read science fiction, and a lot of their dreams I would hope would become reality." He goes on to say that he aspires to make:

> *. . . computers that can reason and think . . . interact with humans and carry out tasks efficiently and intelligently, and in the end become great companions for human life. That's the whole reason why we build them. And basically I guess that fits CMU's ideal, so . . . I just thought we would be a good match.*

The suggestion that men and women tend to view technology differently resonates with other research from the field [Honey, 1994; Martin, 1992; Schofield, 1995; Turkle, 1988]. Studying how males and females design technological innovation, researcher Brunner [1997] concludes:

> *The feminine take on technology looks right through the machine to its social function, while the masculine view is more likely to be focused on the machine itself. As a result, when technology is introduced as an end in itself, as in a programming class, for instance, young women are less likely to be interested than young men.*

A meta-analysis of research on gender and science concluded that a "major sex difference in interests in math and science is its perceived usefulness" [Linn and Hyde, 1989]. Schofield's [1995] ethnographic study of the introduction of computers into a high school found this difference among the male and female teachers, as well:

> *A number of male teachers also reported doing things such as building computers for fun or deciding to teach computer science out of a deep-enough fascination with the subject to lead them to switch fields, although it required a major investment of time and effort. Not a single female teacher we interviewed spoke of the kind of fascination with the computer that a number of their male peers evidenced. Rather, those who responded positively to them tended to speak about their actual or potential usefulness.* (p.161)

The mass media has popularized a similar conception, the "toy/tool" dichotomy – the idea that boys and men see computers as toys to play with, while girls and women use them as tools to do things with [Kantrowitz, 1994]. Whether these differences are fostered by parents and society or not, they are reinforced by many cultural and educational cues, all pointing to computing as a male domain. Unfortunately, they leave many women questioning whether computer science is a place for them, and wondering if their orientation will allow for comfort and success.

Gender and Computer Science Culture

Women we have interviewed often speak of struggling to maintain their own confidence and breadth of interest in the computer science environment. College computing cultures often reflect the ways of the male-dominated hacker subculture, one in which joy, play, fun, love are wrapped up in intense, singular focus on computing and the computer itself. The lifestyle is one in which hackers seem to spend nearly every waking hour at the computer, talking incessantly about computers, eating and sleeping in front of the computer [Hafner & Lyon, 1996; Kidder, 1981; Levy, 1984]. In their article "Encountering an Alien Culture," [1987] researchers Sproull, Kiesler and Zubrow describe the college computing culture as one in which skills such as speedy programming are highly valued:

> *"there is competition to write the best, fastest and biggest program...the status hierarchy is revealed through assigning people to such categories as wizards, wheels, hackers, users, and losers. True members of the culture can be found at the terminal room or computer center at all hours of the night."* (p.175)

Many women students are hesitant to join this "computer science world" in which they sense that the links to other interests in their lives will disappear. In her article "Computational Reticence," Sherry Turkle [1988] concludes that "when women are introduced to [computers] in cultural contexts where the most successful users seem to 'love the machine for itself', they define themselves as relational women in terms of what

12

the 'serious' computer users are not." (p. 44) When we asked a sophomore if there was anything she disliked about computer science, she responded:

> *Once you start working in computer science, you tend to limit your world to the world of computers, and you sit in front of the machine, and everything that is on the machine is your life. I saw that about myself. Like since I've come here, I feel like everything is with a computer, you know? And a few weeks ago I went and watched a nature movie, you know? I used to read National Geographic regularly, and now I was like, "Oh my gosh! What's happened to me? I've forgotten this part of me altogether! What's happened?" You know, it's like . . . maybe because sometimes I feel like I'm getting segregated from the rest of the world. It's like the computer science world.*

We have then witnessed women's confidence erode when they compare their attachment to computing to that of their male peers. When the world around them grants prestige to the "boy wonders," departure from this path becomes "lesser than." A female junior who was very involved in the Internet before coming to Carnegie Mellon and who has always regarded herself as a math-science person, after several semesters doesn't think that computer science is for her, because "It's not my passion like everyone else. They're all, like, really into it." In her particular case her boyfriend is "really into robotics," planning to go to graduate school and become a professor, but she sees herself as different. When

the interviewer asks her to "talk to me a little more about the reasons you are thinking that computer science isn't for you," she says:

> *When I have free time I don't spend it reading machine learning books or robotics books like these other guys here. It's like, 'Oh my gosh, this isn't for me.' It's like their hobby. They all start reading machine learning books or Robotics books or build a little robot or something and I'm just not like that at all. In my free time I prefer to read a good fiction book or learn how to do photography or something different, whereas that's their hobby, it's their work, it's their one goal. I'm just not like that at all; I don't dream in code like they do.*

Comparing herself to peers who "dream in code," read computer books on the side, and do computing as their hobby, she feels she is not meant to be in computer science. Another woman questions whether she should even be in the major:

> *Sometimes I feel they [male peers] have a motivation that's deeper than I do. It's weird, I have that kind of feeling like, "What? Do I belong in this major if they love programming that much!" and I have friends who will be like, "Well, I am going to teach myself a new language" and they'll go pull an all-nighter. I don't have that motivation, so "Am I in the right department? Am I in the right thing?"*

Such concerns appear to be heightened as women struggle with course material; some come to conclude that a narrow focus of interest is necessary to do well, and that their orientation to computers isn't "enough." For example, we interviewed a woman who ended up transferring out of Computer Science to Information and Decision Systems (a computer-related major reputed to be more people-focused). She related that she was not interested when her computer science classmates would talk about "the latest machinery on the market or how much RAM space a computer has and how they have to upgrade it and what new software they want (blah, blah, blah)." Twenty percent of the female computer science majors interviewed have questioned whether they belong in computer science, because they feel they do not share the same type of focus and intensity of interest they see in their male peers. In our last interview with a student who ended up transferring out, we asked her, "What advice would you give to a high school senior thinking about majoring in computer science?" and she replied:

> *I think they kind of have to be the people that do programming and other...*
> *that do other computer science stuff in their free time. They have to be the*
> *people that, like, know a lot about it and like really like it in order to*
> *spend a lot of time learning about stuff, and having the motivation to*
> *just...learn about random computer science stuff.*

When the interviewer asked her "What do you think it takes to be a good computer scientist?" she responds:

I think a lot of people are just born with it. You just gotta be like,

"Computers! Yeah! They're awesome! They're my life!" You know, a

lot of computer scientists, that's all they do.

Yet, this same environment can be very comfortable, almost "like home," for most (but

not all) male students. They are thrilled to find so many other companions who love

computers and computing as much as they do. As one male first-year student says:

. . . Finally there are all these people who also love computers as much as

I do, and I can actually talk about this stuff without being looked at

strangely or whatever. (laughs). . . I like that I can talk and discuss about

some interesting things that I see with computers and what we can do with

them. And . . . I mean, that's probably the difference between computer

science people and others -- that I can actually talk what I want to do. But

that's just it . . . because you're so amazed that hey, there's all these other

people all of a sudden that love these computers! And I can now talk

about this, so . . . instead of just talking about just more socially

interesting subjects.

Reforming Undergraduate Science Education for Greater Participation

We have found the notion that computers is "all they do" to be quite prevalent among

majors and non-majors alike, when discussing what it is like to be a computer science

major. While we have heard both male and female students assert that "this is not me"

[see Margolis, Fisher and Miller, 1998b], this pervasive image of the computer science student has a more deleterious affect on women students.

Curriculum helps set the tone and, unfortunately, most computer science programs in their early years are narrowly focused on programming and the more technical aspects of the field, with applications and multidisciplinary projects deferred to the very end. This gives beginning students the false message that computer science is "only programming, programming, programming," abstracted away from real world contexts. Feminist educator Sue Rosser [1990], from her investigation of gender and science education, argues that "insuring science and technology are considered in their social context…may be the most important change that can be made in science teaching for all people, both male and female" (p.72.) Computer science professor Dianne Martin [1992], in her article "In Search of Gender Free Paradigms for Computer Science Education," discusses "a premise for the gender bias in computer science: the existing educational paradigm that separates studies of science, math, and computer science from studies of the humanities, starting in the secondary schools." She speculates that an integrated approach to computer science would attract more women students, and that "greater attention [should be paid] to values, human issues, and social impact as well as to the mathematical and theoretical foundations of computer science." (p. 1)

We stress that the goal is not to devalue or derail some students' single-minded pursuit of technical virtuosity, but rather to validate a wider array of ways to think about computer science, to engage students' interest and motivation to become computer scientists. In

light of these considerations, at Carnegie Mellon we have been making some modest efforts to broaden the perceptions of the field. We are trying to establish through the curriculum, pedagogy and culture that there are multiple valid ways to "be in" computer science. Some elements of a more contextual approach include

1) an "immigration course" for new students that exposes them to a wide variety of computer science issues and applications, to counteract the "all programming" stereotype;

2) interdisciplinary courses that bring students of diverse backgrounds together to work on multifaceted problems;

3) an undergraduate concentration in human computer interaction;

4) courses that focus on a variety of advanced computing applications, and

5) a new course (entitled "Computer Science in the Community") that engages students with non-profit groups in the local community, helping members in community organizations become computer literature and learn to use and manage computer technology. One of the male students in the course said: "This has been the only class that really has talked at all about interacting with people...It's a challenging and different way to think about computer science" [Gerson, 1998].

Resisting the "Male" View of Computer Science

Until the long-range goal of gender integration and cultural/curricular change in computer science is accomplished, it appears that an important component of women's persistence in the major involves conscious resistance to the dominant culture. We have found that women who persist are those who have found a way to get the grades they are satisfied

with, and are able to reconcile a "different" relationship to computing. One female

student told us how she has refused to conform to the image of the myopically focused

"computer geek." And since she is "getting really good grades without changing myself"

she is ever more confident that she can remain in the major and be herself:

> *I: Well looking around and seeing that other students in the program are*
>
> *very focused on computers in a way that you're not, do you feel like you*
>
> *need to . . . is there any feeling of needing to conform to that, or are you*
>
> *pretty comfortable . . .*

> *S: I refuse to. (laughs)*

> *I: You refuse to, okay.*

> *S: Like, I was worried that, like . . . what if I don't . . . like, will I need to*
>
> *conform to that? Will I need to read, like, books on computers all of my*
>
> *free time or something to survive here? And I feel like so far I haven't.*
>
> *I'm getting really good grades without that . . . without changing myself.*
>
> *So I feel much more confident now that I don't have to. It's kind of nice, I*
>
> *can, like, define a . . . prove them wrong or something.*

Other students maintain a critical perspective on the "toy" orientation to computers and reaffirm their own perspective. A woman talks about her peers' response to a faculty lecture on the ways that computers can be detrimental:

> *Everyone just said how boring it was. "Who cares that computers did not benefit anyone? We like computers! We love computers! We know computers! And who cares about the rest of the world?" . . . And if you're trying to make something that's going to change the world, that's going to help the world, you have to have some sort of concern about what's your long-term goal. Not just to produce Word 8 . . . I don't know, or Excel . . . whatever. (laughs) How . . . how is this helping? Or is it helping? Like go see if that stuff is doing anything.*

Computer scientist Frances Grundy (1998) argues that "the debate about the nature of computing is an important one and not simply because of its intellectual importance but also because of the implications as far as the attraction of women into the discipline is concerned." As an example, in her article "Mathematics and Computing: A Help or Hindrance for Women?" she examines how status and politics shapes the dominant definition of a field. She argues that "pure" computing (such as analysis of algorithms and complexity theory) has historically been considered more prestigious than applied computing because male theoreticians, who are the "inner circle" of computer science, define what is "real computer science." She believes that while "in fact, everything done

20

on a computer requires some abstraction…abstraction by itself is not enough; we must be able to set the results of our task back into the real world."

Without taking a position on the math vs. computer science debate, we concur with the view that re-visioning computer science is an important project, both for engaging and educating more women to be inventors and creators of technology and for society as a whole. Will computer science continue to be staked out as male territory—as "guy stuff"—partly through a curriculum that promotes an unnecessarily (and misleadingly) narrow technical view, or can it be re-visioned as a discipline that is highly technical yet linked to other arenas, people, and the world?

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