As the Culture of Computing Evolves, Similarity can be the Difference[1]

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Most studies of gender and computer science have (of necessity) been conducted in gender imbalanced environments. The findings often point to significant gender differences, leading the researchers to recommend strategies to meet these differences. One such recommendation is to adopt a "contextual approach" to the curriculum (Margolis and Fisher 2002, *Inroads* 2002: 81).

In contrast, based on our recent and ongoing studies of undergraduate computer science (CS) students at Carnegie Mellon University, we hypothesize that, in a *more balanced* environment, gender differences tend to dissolve. That is to say, the *spectrum* of interests and personality types of men and of women becomes more alike than different.

By *more balanced* we mean: more balanced in terms of gender, more balanced in terms of the mix of students and breadth of their interests, and more balanced in terms of professional experiences afforded all students. This leads us to be considerably more pragmatic in our recommendations for effective and positive change. *Indeed, we believe that recommendations for curricular changes based on presumed gender differences can be misguided and indeed may help reinforce, even perpetuate, stereotypes.*

Here we describe some of the changes in the culture of computing at Carnegie Mellon as the undergraduate CS environment has become more balanced in the three domains articulated above. We begin with a brief background to indicate how these "increased balances" have come about. More details and suggestions are presented at the end of this article.

Brief Background

In 1995, just 7% (7 out of 96) of the entering freshmen CS majors were women. Since 1999, about a third of the entering CS class (on average, 45 out of 132) each year has

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been women. These increases challenge trends across the country. Widely cited statistics from the articles, "The Incredible Shrinking Pipeline" (Camp 1997, 103-110) and "The Incredible Shrinking Pipeline Unlikely to Reverse" (Camp 2000), indicate that the percentage of women entering CS programs and careers in the US declined precipitously during the past decade and suggest change unlikely. According to the *New York Times*, 22 May 2003, the national average for women students in undergraduate programs in CS in the US in 2003 was 15%.

The factors that contributed to the dramatic increases at Carnegie Mellon have been well documented (Margolis and Fisher 2002, Blum 2001, 2,6,9). Particularly important were the changes in the Carnegie Mellon CS admissions policy and the outreach program for high school CS teachers that combined technical training with discussions of gender gap issues.

Since 1999, admissions criteria for all CS students at Carnegie Mellon has broadened to emphasize diverse interests (along with high academic achievement) and to downplay prior programming experience. This was a direct result of studies undertaken by Allan Fisher and Jane Margolis (Margolis and Fisher 2002) that showed that prior programming was not a predictor for success in the CS major at Carnegie Mellon and from a vision for computer science at Carnegie Mellon, articulated by Raj Reddy, to develop admissions criteria that would help select future leaders and visionaries for the field. Thus, in addition to opening doors to talented women students who may not have had prior computing experience, the new admissions criteria opened doors to a broader range of students, men and women.

When the number of women entering the CS program increased to "near critical mass", the challenge was to ensure an environment in which these women could flourish and be successful in the program. In 1999, the student organization, Women@SCS (http://women.cs.cmu.edu) was created to meet this challenge. Women@SCS explicitly provides for our students *crucial* educational and professional experiences generally taken for granted by the majority in the community, but typically not available for the

minority participants. 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.[2] An organization like Women@SCS also gives voice to the community of women so that "critical mass" becomes more a question of visibility and effectiveness than one of numbers.

Voices of a Class in Transition

We describe the ensuing changes in culture, including the diminishing of gender differences, through the voices of the CS class that graduated in the spring of 2002. This class, having entered the program in 1998, was a unique *class in transition*. They were the last to have entered before there was anything close to a critical mass of women. The number of women in their class, as well as in previous classes, was on a par with the low number of women entering CS programs across the nation.[3] By their senior year, all three classes following them had significant numbers of women students. Their unique positioning alone was enough to warrant some recording of the views before they disappeared into the world beyond Carnegie Mellon. And, if these seniors had noticed any changes, we were curious to see if they had been affected by them.

Our curiosity and expectations were tempered primarily by our understanding that students tend to work, socialize, and share the experience of student life alongside the class in which they enrolled, and by the fact that these students had been admitted under guidelines *that were designed (consciously or not) to produce cutting edge programmers*

[2] Indeed, a recent British think-tank publication broadly supports our emphasis on building of professional community arguing, as we do, that "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).

[3] While the percentage of women entering in 1998 (the "2002 graduating class") had risen to 19%, the significant jump to "near critical mass" occurred the following year.

for the technology workforce. Clearly, these guidelines would tend to both favor "geek"[4] personality types and support the well documented geek culture of computing that had been so prevalent here in years past (Sproull et al., 1984, 31-48, Margolis and Fisher 2002).

Surprisingly, what we found, in interviews with these seniors, appears to show a closer connection to an evolving culture than we had expected. We found many students who did not fit traditional CS gender stereotypes, men and women whose perspectives were often more alike than different, students who were well-rounded (or at least aspiring to be so), 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, and women who were enthusiastic and positive about their experiences as CS majors. Some of the most interesting signs of transitional culture emerged from those women in our group who seemed to be constructing a new identity that was both "geeky" and feminine, while at the same time both men and women in our cohort were reevaluating and redefining what it means to be a computer scientist. *In short, we found the spectrum of interests, motivation, personality types and personal evolution amongst both genders more alike than different.*

The interviews provide us with a snapshot of the culture of computer science at Carnegie Mellon;[5] to a limited degree we can see these findings as a brief follow up to the intensive longitudinal studies of CS students at Carnegie Mellon carried out by Fisher and Margolis during the period 1995-1999. Their studies, funded by the Sloan Foundation, were undertaken to help understand differences in male and female students' engagement (attachment, persistence, and detachment) with computer science, with a special focus on the gender imbalance in the field (Margolis and Fisher 2002). A major

[4] 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 .

[5] Interviews have also been conducted with a sample of the 2004 graduating class; we plan to continue these senior interviews and analyses on a regular basis.

goal was to devise and effect changes in recruitment, curriculum, pedagogy and culture in order to encourage the broadest possible participation in the computing enterprise.

Our 2002 glimpse of Carnegie Mellon's computing culture show several similarities[6] to the findings of Fisher and Margolis along with some *marked changes*. It is these *changes* that interest us most; they form the focus of this chapter in our studies of the evolving culture and help shape our recommendations. We have chosen to categorize these changes under themes that were either prominent in the questionnaire, or which emerged subsequently, and seemed to command our attention --*Stereotypes*, *Programming and Applications, The Expanding View of the Field, Diversity,* and *Women@SCS and the Evolving Culture of Computing*. We hope our findings will help inform others who work to increase gender equity in the computer sciences and provide some guidance as to what to expect from an environment and culture in transition.

The Impetus for Interviewing

During the two years preceding the seniors' interview project, as more women were entering the CS program, and Women@SCS was growing as an organization, several of us began to notice some changes that were hard to define or quantify. Some faculty members, for example, commented that the student body was becoming "more interesting";[7] we noticed a (surprising) number of male students attending Women@SCS organized activities; Women@SCS Council members were keen to arrange events, not just for women, but for the entire student body. We began to see male students who were quite comfortable attending "women's" events and wearing Women@SCS T-shirts, in fact it seemed that Women@SCS had become the "cool" computer science student organization. We saw women students challenging the traditional computer science student stereotype by their very presence, while at the same time many of them were

[6] Since the students in our cohort were members of the last class to enter with relatively few women (indeed two had been interviewed in the early studies), it is not surprising that some of their perspectives and experiences would also echo earlier findings. The most prominent of these relate to male dominated classrooms, especially upper division CS courses in which many male engineering students enroll as well.

[7] In particular, this has been the view of Peter Lee, Associate Dean for Undergraduate Computer Science Education, as expressed in his annual State of the Undergraduate Program addresses.

following conventional roles of helping and nurturing by organizing and providing activities for the general student body. In contrast to the findings about the adverse affects of the culture of computing on women students at Carnegie Mellon,[8] women students now seemed to be flourishing as an integral part of the community.

We knew that an increased number of women in a male dominated field was an interesting change in itself but the situation appeared to be much more complex and interesting than we had anticipated. Blum speculated that the change in admissions, which had contributed to the increase in the numbers of women, had also contributed to a more diverse body of male students. Evidence of such diversity was beginning to show up in student behavior, in conversations with students and in the classroom.

When we conducted the interviews in the spring of 2002 we found clear signs that these students had been shaped by the changing culture in which they found themselves.

The Interviews

Throughout the spring semester 2002, Frieze conducted a set of interviews with 33 CS seniors, 17 women and 16 men.[9] The interviews were conducted in an office on campus and the questions were adapted as appropriate from the Margolis/Fisher questionnaire. (See Appendix.) The questions were very open ended and meant to solicit perceptions and comments more than direct quantifiable information. As in the earlier studies (Margolis and Fisher 2002), the interviews were transcribed and imported into NUD*IST qualitative analysis software to examine salient variables addressing issues of change. Researchers Elizabeth Larsen and Peggy Stubbs coded and analyzed the data using this tool; their results are in presented in a companion paper (Larsen and Stubbs 2003).[10]

[8] See Chapter 5, "Living among the Programming Gods: The Nexus of Confidence and Interest", in *Unlocking the Clubhouse, Women in Computing* (Margolis and Fisher 2002).

[9] All 24 women seniors were invited and a random selection of 24 men from among the 129 male seniors.

[10] The preliminary phase of the Larsen/Stubbs analysis investigates, as we do here, how this *class in transition* observed and interpreted the various changes in the School of Computer Science --and in themselves. Their secondary analysis looks further into the 'of two minds' theme "to see how students deal with apparent cultural contradictions during a period of transition" (Larsen and Stubbs 2003).

In the next sections, we include our interpretation and commentary on students' perceptions in an attempt to add another dimension to our understanding of how men and women relate to computer science, particularly as the environment becomes more balanced.[11]

Stereotypes

Although no interview question category specifically addressed the issue of stereotypes, all eleven categories had questions that elicited responses related to gender stereotypes. We were struck by how frequently the seniors' responses did not fit into traditional computer science gender stereotypes.

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."*

Another woman's single mindedness and passion for computing was clearly evident, "*When you get engrossed with a program you don't think about anything else and kind of have a one-track mind. In the middle of another class you'll realize the problem with your program and you'll write it on the corner of your notes. Your friends look at you strangely, because they don't know where that came from, and then 2 hours later you find that it works*." Her enthusiasm had begun in childhood when she taught herself to program. For her, coming into computer science "*wasn't a decision; it was just what I was going to do*".

One woman made some interesting observations on women and stereotypes pointing to some *intra-gender* differences, *"I feel like there [are] different types, even of the CS*

[11] This research represents a qualitative, interview-based case study with a small number of respondents. Thus while numerical data may be used to illuminate the relative importance of various themes in the interviews, this information should not be interpreted as formal, statistical findings. We note however, that with open ended questions and a small number of participants, the presence of as few as two or three similar responses takes on magnified significance. (Larsen and Stubbs 2003).

girls. … Like there [are] some that I feel like… they're girls, but they're gonna hang out with the guys. They're all about computers and they're really excited about it. There's a girl that I have a class with and I feel like that's the kind of girl she is, like she'd just fit in with the guys completely in any case. … And then I feel like there's sort of a type who seems to know what they're doing and yet manage to be able to join sororities and stuff so they don't fit the stereotype at all. And then I felt like there were some who were like me who were just kind of in CS and maybe not sure what we're doing… but not really either type."

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 and came back later to finish the interview while sewing a ripped hem on his jeans. 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. Later, at Carnegie Mellon she explained that she had *"been in the cluster*[12] *for nights on end"* but added, *"usually I go home and shower because I don't like to smell"*. 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*".

Contrary to the findings of the earlier studies, our snapshot of students' perceptions revealed that the confidence of most women in our cohort *had increased* by their senior year and had not been "extinguished".[13] One woman made this very clear, *"I see myself as one of the best of the best now"*.

The irony in this situation is that just as some women appear to be appropriating and molding a geek image for themselves, this image (which of course has never been a

[12] The *clusters* are rooms filled with computer terminals that students can use at any time, day or night. They often have served as the 'home away from home' for CS students, and are associated with the genesis and protector of computing lore and culture.

[13] This contrasts with earlier findings that for the most part, "women who were enthusiastic about computing find their confidence and interest extinguished in the college years" (Margolis and Fisher 2002, 5).

flattering one) is being marginalized by our cohort of male seniors. Our student group showed the same distancing yet awareness of a computer science stereotype that the Margolis/Fisher students showed. But the image of "dreaming in code"[14] as the dominant characteristic of male computer science students is being challenged. *"[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"*.

We found that both men and women appeared to be moving towards a new identity based on a more well rounded image. Students describe themselves as *"individual and creative, just interesting all around people", "very intelligent, ..., very grounded, not the traditional geek…", "... much more well rounded than people five or six years ago*".

This is not to say that programming isn't still an important part of their world, it certainly is …and has to be. Nor is it saying that students who enjoy coding don't exist, but this interest seems to be placed within a broader context, with respect both to the field of study as well as participants. 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."* We found men and women who enjoyed programming and the "geekier" aspects of computer science, and we found men and women who didn't.

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 and how they were now seeing each other. 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

[14] " 'Dreaming in code' has become one of our working metaphors, emblematic of a male standard of behavior in this computer-oriented world" (Margolis and Fisher 2002, 5).

"newer", more diverse aspects of the student body, while retaining some of the traditional aspects. This was truly a group in transition, even though, as stated before they were admitted under the older guidelines that favored hard-core programmers.

Programming versus Applications

While one might assume a gender difference in which male students focus more on programming and women more on applications of computers, and indeed which was noted in the earlier Margolis/Fisher study, 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 computers 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*". Two women specifically stated that they do not want to code in a cubicle for the rest of their lives. Two men responded similarly, with one commenting, "*My focus was always on doing something new*".

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 was just interested in computer science for its own sake and now it's just another tool I have, another way that I can make things that I want to make."* 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".*

Another man articulated his evolving interest in this way, *"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. It's gone from, wow I can do all these little cute things to…I can actually do something useful with it. Now what are the useful things that I can accomplish, that I can't do with any other tools? I still don't think it's been fully explored, so I find it interesting."*

The Expanding View of the Field

Many students, men and women, commented that when they came into the program they thought of computer science as programming and now saw its broader meaning. From freshmen who saw computer science "*as writing programs, programs, and programs*", we saw a shift to seniors who saw it as "*a whole lot of stuff* "! They often struggled to define computer science in a way that encompassed their new understanding, *"It's hard for me to define because there are many academic areas within computer science and I'm trying to . . . find a definition to encompass all of them."* Another student commented on *" . . the excitement surrounding it over the past few years and knowing that it's something very important…".* While another voices a common theme, *"I was pleased to find out it was more than programming."*

Another example of how the view of the field crossed gender lines emerged when students were asked to define computer science. The most common theme to emerge – explicitly in the responses of five women and five men -- was that computer science meant "*problem solving*".

Many of the students, men and women, expressed a genuine appreciation for the education they had received and a sense of well-roundedness that is not typically associated with majoring in CS. Men and women were just as likely to stress the need for more social life outside of computer science.

Diversity

Our program, Women@SCS, and our current study, focus primarily on increasing *gender diversity* in computer science, as did the earlier Fisher/Margolis work at Carnegie Mellon. Although increasing diversity of underrepresented groups is a major initiative of our university, we have not yet seen significant advances beyond gender in our computer science community.[15] We believe that features of our program can be effectively adapted

[15] For example, there were only three African American students in the 2002 graduating class, all male; all were invited to be interviewed, one participated.

to increase the diversity of other underrepresented groups and we plan to implement these as we go forward. Indeed, one of the most successful programs we know to increase diversity in computer science ---run by Richard Tapia at Rice University--- incorporates philosophy and methodology similar to ours. (Tapia and Lanius 2000).

Students in our class in transition were clearly grappling with issues raised by changes in our undergraduate student body. Both men and women in our cohort had heard (usually only hearsay) that women were getting into the program simply because of gender and this made everyone uncomfortable. For some men this conflicted with their sense of fairness, women were somehow taking the places of better qualified guys. For these men, bringing in women meant lowering standards and having to make the program easier.[16] Other men often observed this wasn't true. "*Almost all the women I'm friends with are extraordinarily intelligent. I mean the junior year I was talking about earlier* [i.e. the first CS class that entered under the new admissions criteria, and with the large increase of women students]
kicks my butt in just about everything."

Many women had developed strategies for working in a male dominated situation and overall seemed ready to deal with any, and all, challenges. "*At times it was frustrating and challenging. I felt like I had a lot of attention on me …. When I asked a question in class, people noticed because I was a woman".* This same woman pointed out the positives of such a situation, "…*Well the attention can always be a good thing. If you want a partner on a project every guy will want to be your partner*". Another woman explained how the unequal numbers had become part of CS humor, *"Yeah! there's more guys ...good for us"* and other women would joke, *"Yeah, the odds are good but the goods are odd".*

[16] These responses indicate the major "backlash" we had to address in the first years of the *transition* period. They also indicate the need to educate the community on why and what is being done in early stages of any educational reform. In our case, this was the focus of our January 2000 CS faculty meeting. Here Blum presented background for the changes in the undergraduate program and Associate Dean Lee explicitly pointed to the challenges and opportunities afforded by our newly diversified student body. Importantly, he outlined suggestions for faculty involvement that could assist in positive outcomes. While we have not continued to formally discuss these and related issues (rather, they have been addressed in an "as needed" basis), we believe ongoing departmental forums would be even more beneficial.

Many students, men and women, thought that women could add another dimension to the field and that their input was valuable. *"It's a one sided view if it's only men. Women could add to the field from the women's perspective*". *"If half of society is discouraged from being a part of it then we're missing out on a lot of great ideas"*. One guy suggested, *"I think that having more women would improve the quality for everyone*". Women, it seemed, were not only reducing the "*testosterone*" level "*in the computer science lounge*" but also helping the guys to expand their interests, "*Women want more of a life I guess*".

Some men showed a very sophisticated approach to having more women in computing: *"Computing is going to be affecting our whole society and it probably makes a difference on who is giving input into this, but that's just from the societal point. As far as being fair, that should just be dependant on whether they are interested or not. I would hope that it could be that just traditionally the field hasn't attracted women because it hasn't exposed, hasn't properly recruited them, so let's give it a shot."*

Another had a plan to encourage more diversity at the admissions level, *"[Students] should have a lot of other interests. That's how computer science should be. ... You wouldn't talk about computer science as just programming experience, just the usual stuff, and you try to look at what other things the students can do and try to take people who excel in different sciences and mathematics or even people who have things totally unrelated to computer science but show interest."*

Women@SCS and the Evolving Culture of Computing

Since its inception in 1999, Women@SCS has played a major part in balancing the professional experiences afforded our students (Frieze and Blum 2002, 74-78). The organization has flourished, and its members have been featured on national TV, and in local and national newspapers. On campus, meanwhile, Women@SCS has become the largest and most active student organization in the School of Computer Science.

The interviews indicated that both men and women could see the benefits of an organization like Women@SCS even when they had not personally been involved in the activities. *"They're pretty well organized and touch on other relevant issues that concern young female students at Carnegie Mellon. They organize a lot of activities and their website is very informative."* One guy said, "*It seems to be quite a moving force*", while another guy commented, *"I'm pretty impressed with it, actually it seems like they're doing a lot. They're very active and up to date and it seems like a very solid organization although I don't know a lot about it."* Many women pointed to the advantages of having more women friends and colleagues. One stated, *"I find that we think more alike and it's probably easier to work with female students"* while another mentioned, *"There is also a greater sense of community than before"*.

Background and Features Essential for Change

We first note that in its structure, the Carnegie Mellon School of Computer Science (SCS) reflects and embodies the philosophy that computer science thrives on the interaction of diverse perspectives and expertise. Faculty within SCS's six interdisciplinary departments[17] represent a growing range of areas including: computer science, software engineering, robotics, artificial intelligence, human computer interaction, entertainment technology, linguistics, psychology, computational biology, operations research, business, rhetoric, public policy, security and privacy.

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. This point is crucial: *while the need and methodology for change might be motivated by the interests and needs of an underrepresented group, it is our view that,*

[17] 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.

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[18].

The salient features for the changes in the student body are a direct result of a combination of actions --aspects of which we believe are adaptable to other venues. The actions that we view most essential are:

1. ***Outreach*** *in the form of summer workshops for high school computer science teachers* from feeder schools. During the course of three summers (1997-1999), 240 Advanced Placement (AP) CS high school teachers (approximately 16% of such teachers in the US) participated in six two-week workshops on the Carnegie Mellon campus. The workshops, funded by a grant from the National Science Foundation, had the dual aim of teaching new technical skills required for the advanced placement tests and addressing gender gap issues. Both directly and indirectly, these workshops played a significant role in the increased numbers of high school women considering majors in computer science, in particular at Carnegie Mellon. Anecdotal evidence from interviews with students supports this claim. Moreover, the percentage of women from the participating schools entering our undergraduate CS program in 1999, and again in 2000, was 18%, compared to 0% in 1995. We believe that similar positive outcomes would accrue nationally from programs sponsored by colleges and universities on their campuses that provide technical training along with discussions of gender for teachers, counselors, administrators and students from their feeder schools ---and for their own freshmen.[19]

At our own institution, the gender component of these workshops was discontinued after

[18] An example of such synergy is the institution of the double major in Human Computer Interaction and the minor in Robotics for undergraduates in the School of Computer Science.

[19] High school students –and teachers-- tend to equate computer science with programming. Thus outreach programs clearly provide an opportunity to also include materials and start discussions illuminating the broad range of areas and new directions that comprise, and emanate from, computer science. Women@SCS students have designed Outreach Roadshows for a variety of audiences with these goals in mind (see, for example: http://women.cs.cmu.edu/What/Outreach/Roadshow/). This is just one more example of how programs designed to increase the participation of an underrepresented group can serve to enhance the field more generally. Indeed, with a general downturn of student interest in computer science nationally, it behooves us in the CS community to adapt some of these ideas to educate the public about exciting directions and possibilities in the field.

the original three summers.[20] We believe this was a mistake and plan to resurrect aspects of this program together with Mark Stehlik, SCS Assistant Dean for Undergraduate CS Education.

2. ***Changes in the admissions criteria*** *that more closely reflect both SCS goals as well as more rational prerequisites for success in the major* (thus downplaying prior programming experience and placing high value on indicators of future visionaries and leaders in computer science). High academic standards (grades and test scores) remain unchanged.[21]

At Carnegie Mellon, students enter the CS undergraduate program directly from high school. This provides certain advantages in achieving gender equity over computer science departments in schools where students choose their major during their sophomore year or later. These departments have to compete with all the other attractive programs on campus, and so they must be particularly appealing. To meet this challenge, such departments might examine unnecessary obstacles that may impede entry into their CS program, take a broader view of the field, and pro-actively promote the field and their program with exciting and informative campus events.

3. ***Providing effective access into the computer science curriculum*** *in the form of multiple entry routes into the entry level programming sequence* in order to accommodate varying levels of prior programming experience of our students. In addition, all entering computer science majors attend a weekly Freshman Immigration Course during their first semester. During this time, students hear from different members of the SCS community who discuss their research and future trends in their area. The idea is to expand the

[20] One apparent reason for discontinuing focused gender discussions in the workshops was that an early evaluation deemed them unsuccessful with respect to the *only* variable measured: Did the teachers attract more females to their classes after participating in the workshop? (Campbell et al., 2000).

[21] This is imperative to ensure that accepted students meet the challenges of a rigorous undergraduate program. We note that recent data shows that gender parity has been obtained in high school mathematics. Indeed, the number of girls taking AP calculus now exceeds the number of boys (Clewell and Campbell 2002, 255-284). Thus, if one removes prior programming as a criterion for entering a college CS program, the potential pool of female students increases dramatically. This highlights the *critical* importance of effective outreach activities.

students' concepts of what is available to them as students within the School of Computer Science.[22] Aside from regular updating of courses and the curriculum, these entry-level changes have been the *only major curricular changes* in the Carnegie Mellon undergraduate computer science program.

4. **Creating a professional organization/community for students with faculty and professional guidance and support** that provides colleagueship, role models, mentors and leadership opportunities. The student organization Women@SCS and its Advisory 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 SCS. As Women@SCS has become a respected part of the SCS 'institution', the atmosphere for all students in SCS has greatly improved.

While some might describe Women@SCS as a "support group", this label suggests a limited and faulty understanding of its function. Indeed, its function, structure and activities are very deliberate ---and labor intensive. Members of the Advisory Council plan a myriad of events, ranging from faculty/student dinners, to course advising sessions, to a Distinguished Speakers Lecture Series, to producing Outreach Roadshows.

Initially geared towards women, Women@SCS events are now welcomed by the whole student body. Nowadays it is not unusual to have men and women show up in fairly equal numbers at events, and two young men are currently active members of the Advisory Council. The Women@SCS website (http://women.cs.cmu.edu) has become a highly accessed resource serving the wider community.

As additional evidence of the impact of Women@SCS on the entire SCS community, we have witnessed the establishment of two major community wide endeavors initiated by student members of the Women@SCS advisory council: SCS Day[23], an annual event that

[22] See http://www.andrew.cmu.edu/course/15-128/. Mark Stehlik, Assistant Dean for Undergraduate Education and academic advisor for undergrads in CS, and Jim Roberts, Computer Science Freshman Advisor, have been primarily responsible for these innovations in our entry level program.
[23] For SCS Day, see http://www.cs.cmu.edu/~scsday/ .

celebrates the diversity of skills and interests among our faculty, staff and students ---and the re-introduction of the Pittsburgh chapter of Computer Professionals for Social Responsibility,[24] a national public-interest alliance of computer scientists and others concerned about the impact of computer technology on society.

We strongly believe building an energetic, action-oriented student organization *with faculty and professional leadership and support* is *key* to building a successful community of women in the computer sciences and a successful outcome for our students.[25] A tool kit of examples and suggestions is provided in "Building an Effective Computer Science Student Organization: The Carnegie Mellon Women@SCS Action Plan" (Frieze and Blum 2002, 74-78).

The first three key actions outlined above were initiated as a direct result of the Fisher/Margolis studies (Margolis and Fisher 2002) and a vision for the School of Computer Science articulated by Dean Raj Reddy. The fourth key action, initiated by Blum in 1999, was not in the original recommendations, but we believe is essential for any such program to succeed. Importantly, these and subsequent developments have been undertaken with *essential support from top administrators,* including the President of the University.[26]

In Conclusion

In these interviews with our class in transition we identified several *significant changes* to the findings of Margolis and Fisher, changes which lead us to question some of the accepted differences in how men and women relate to computer science.

A principal finding of the Margolis/Fisher study (of computer science students at

[24] For, CPSR, see http://www.cs.cmu.edu/~cpsr/.

[25] Of the first large class of 49 women (of a class of 130) who entered the program in 1999, 43 graduated from Carnegie Mellon (35 in CS, 2 in Information Sciences, 4 from the Business School, 1 in Biology and 1 with a self-defined major), 4 are on leave (of which 3 are expected to graduate in CS) and 2 withdrew.

[26] In particular, primary funding for creating Women@SCS, our student organization, has come from Carnegie Mellon President Cohon, Provost Kamlet and former School of Computer Science Dean Morris. J. McGrath Cohoon stresses the importance of institutional support for effective change (Cohoon 2000).

Carnegie Mellon during the period 1995-1999) was that men tended to view the computer as an object of study, while women tended to view the computer as a tool. This led Fisher and Margolis to hypothesize, and recommend, that to increase the participation of women in computer science, curricular changes to emphasize real world applications were necessary.

Our conclusion is that the observed gender differences from the 1995-1999 study tell more about the *biases in our former admissions criteria* (and a limited view of the undergraduate major)[27] rather than significant or intrinsic gender differences in potential computer scientists. With changes in the admissions criteria and subsequent changes in the student body (amongst men as well as women) the manifest dichotomy observed by Margolis/Fisher is considerably less apparent, and becoming less so. Indeed the spectrum of motivation and interests (from hacking to applications) for men and for women is more alike than different.[28] These similarities emerge even in our 2002 class in transition.

We also do not agree with the consequent recommendation to revamp, (in particular to contextualize) the curriculum in order to facilitate gender equity. For example, it may or may not be a good idea to incorporate applications to a particular course. That would depend on whether it makes sense for the subject matter, for the intellectual skills[29] to be developed, or for pedagogical purposes. We believe, to do so as means to promote gender equity helps reinforce, even perpetuate, stereotypes. It also puts the onus on the

[27] At Carnegie Mellon, computer science started as a PhD program. The undergraduate major came much later and was not, in the beginning, a primary focus for the research faculty. During the years of the Margolis/Fisher study, the undergraduate major fed primarily into the booming high tech industry. With an admit rate of one for every 10 applicants, the admissions criteria was set to select people who would become hot shot programmers for the high tech industry. It stands to reason that the high school computer "geek" would have an admissions advantage. Women, and men, with potential to become computer science leaders, but without demonstrated programming experience or commitment, would have had little chance. The very few women who managed to get in had exceptional academic records.

[28] Indeed, students individually embody a spectrum of motivation and interests, and these evolve with time, experience and circumstance.

[29] Contextualizing a course designed to promote abstract and analytical thinking would have to be done with considerable caution not to undermine the kind of skills such a course intends to develop. On the other hand, adding applications to a course may make perfect sense from the perspective of the field irrespective of gender. We note that Blum is co-director of the ALADDIN Center which promotes synergy between algorithm theory and practice. The genesis of this Center came from Professor Guy Blelloch's graduate course, "Algorithms in the Real World", designed for theoreticians to see how their work is being used in practice.

underrepresented group and can promote marginalization. Pragmatically, the process of revamping the curriculum is daunting; consensus to do so for the perceived needs of a particular group near impossible.[30] Furthermore, as we observe within our changing student body and its evolving motivations and interests, some of these recommendations may even be misguided.

Our findings suggest that once a near critical mass of women students is established and supported, many assumed gender differences become less apparent, men and women appear to demonstrate many gender similarities, and above all they share a love of the field. In fact differences often show up more strikingly as intra-gender differences. Diversity of the student body and the increasing breadth of the field appear to be evolving simultaneously and reshaping the culture of computing at Carnegie Mellon for the benefit of all.

[30] We are in no way implying that the undergraduate CS curriculum as it currently stands does not need revision. To the contrary, effectiveness and relevancy, with regard both to the curriculum and how the field is portrayed, are critical if computer science is to attract the creative minds that are so important for its future health and vibrancy. We are arguing that to do so for the perceived needs of a particular group, rather than within a broader context, is fraught with problems.

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Appendix

The Interview Protocol

2002 Spring Semester; Computer Science Seniors (Individual) Interviews

Date—

STUDENT #

Were you interviewed as a freshman as part of the Margolis/Fisher study of computer science at Carnegie Mellon? ___ Yes ___ No

Standard Questions:

1. General Background:
   Family and Computing:
   - Did you grow up with a computer in the house? (more than one computer?)
   - Where was it? What was it used for? Who used it most?
   - Who was the computer 'expert' in your house? (siblings?)
   - Did you have your own computer? (Tell me about that, e.g., when did you get it?)

2. When and how did you get interested in computers and computing?
   Listen for and ask about:
   - When did you become interested?
   - What interested you?
   - Who introduced you to computers?
   - Where did you become interested?
   - Schooling experiences (elementary, middle, high, summer program, work)
   - Affective experience (love, one interest among many, mixed, slow to warm).

3. Tell me about your decision to major in Computer Science. (Listen for and ask about):
   - Experiences that were particularly influential
   - The experience most responsible for the decision to major
   - Mentors
   - Peers
   - Parents
   - Teachers
   - Interests
   - Aspirations
   - Other

4. Carnegie Mellon and the CS dept.:
   - Why did you decide on Carnegie Mellon?
   - Why do you think Carnegie Mellon selected you?
   - Was coming to Carnegie Mellon as you expected?
   - What did you expect the Computer Science department to be like? Can you remember if it met your expectations?
   - How would you describe the atmosphere in the CS Department now?
   - Has it changed since you first came here?
   - Can you describe for me the characteristics of computer science students?
   - Is this you? Do you fit in? Not fit in? Why is that?
   - Can you remember your first impressions of computer science students? (Have your impressions changed?)

5. Your interest in Computer Science:
    - What interests you most about Computer Science?
    - Why do you think that is?
    - What interests you least about Computer Science?
    - Why do you think that is?
    - What projects are you drawn to?
    - Do you like/dislike programming? Why?
    - What skills do you need for good programming?
    - Do you have them?
    - Has your interest in Computer Science changed over the years?
    - Why do you think that is? (Program? Personal maturity?)
    - What do you regard as your academic strengths?
    - Are these the same as your academic likes or interests?
    - What helps you to learn best? :
        - Listen for and ask about: class sizes, teachers, types of teaching, trial and error, team work, other)
    - Do you feel you've been successful in this program?
    - What skills do you think are necessary to be successful in Computer Science at Carnegie Mellon?
    - Do you think your grades reflect the skills you mentioned?
    - What have your grades been like? (overall GPA?)
    - Do you feel that your confidence in your ability to do well in CS has increased or decreased? (what has most significantly influenced you sense of confidence?)

6. Let's talk more about your thoughts on the Computer Science major:
    - What was the best thing about doing this major?
    - What was the worst thing?
    - What has been your favorite class? Why?
    - Least favorite? Why?
    - What would you change about the CS major if you could?
    - What do you see as the program's strengths?
    - What do you see as the program's weaknesses?
    - Have you ever thought about switching out?
    - What has kept you going?
    - Were there any particularly difficult semesters? Or years?
    - Have you ever felt discouraged?
    - Where do you go when you feel discouraged? :
        - Listen for and ask about: –Roommates, Peers—male or female?
        - Any difference in the kind of support? Faculty, Mentors, Teachers, Parents?
    - Have you felt any problems with mixing CS and the rest of your life?

7. Women@SCS :
    - Do you know about the student organization—Women@SCS?
        - What's your impression of Women@SCS?
        - Have you had any contact or experiences with the organization?
        - Has it had any effect on your experiences at Carnegie Mellon?
        - Do you have a faculty mentor?
        - Has it/would it have helped?
        - If no faculty mentor do you feel you have a mentor? (for CS or 'Life' in general?)

8. Gender:
    - What do you think is the men-to-women overall ratio now in Computer Science at Carnegie Mellon?
    - Have you noticed there are more women now than when you first came here?
    - Is it different having more women in the program than when you first started?
    - Do you think Carnegie Mellon should make any further efforts to attract and retain more women in computer science?
    - Are you aware that there are very few women in Computer Science generally?
    - Why do you think that is?
    - Does it matter?
    - What was it like for women when you first came here? (ask men to speculate)
    - What has it been like being a woman in CS overall? (ask men to speculate)
    - Have you experienced any problems in the program because you are a woman? (or a man?)
    - Have you experienced any advantages because you are a woman? (or a man?)
    - Have you noticed any changes that might affect women? (For better or worse?)
    - Have you noticed any changes that might affect men? (For better or worse?)
    - What do you think the situation is like for other minorities—African American, Hispanic, for example?

9. Now that you are a senior:
    - How would you define Computer Science?
    - Is this what you thought as a freshman? Has your conception of computer science changed since you were a freshman?
    - Looking back what have you enjoyed most about your years here?
    - What have you disliked most about your years here?
    - What advice would you give to new students?
    - Would your advice be different, depending on whether the new student was male or female?
    - What would you say to a high school senior boy or girl thinking about CS, about Carnegie Mellon?

10. Changes:
    - Can you identify for me what changes, if any, you've noticed over the years between now and when you were a freshman? (Listen for and ask about: climate, work ethic, leisure, faculty, support.)
    - Why do you think that is?
    - What would you say is/are the biggest change/s you've noticed? (Listen for and ask about: faculty, curriculum, gender, the major, and types of students.)
    - What's stayed the same?
    - Why do you think that is?
    - Have you changed?
    - In what ways? (personal growth, knowledge)

11. The Future:
    - How do you see your future? (job, private life, computer science, grad school)
    - Would you say this is how you saw your future when you came here?
    - What have been your experiences in the job market, recruiters, etc.
    - What is your vision of how computers can shape the future?
    - What role do you see for yourself in that vision?

*Is there anything we haven't discussed that you would like to add? Anything about life in CS that we should know about?