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Women in Computing: The Role of Geek Culture

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'Geek culture' evokes a high-tech, andocentric, sub-cultural milieu often associated with computing. Many consider this culture as central to understanding the dearth of women in computer science (CS) and computer engineering (CE)[1] education (e.g. Rasmussen and Hapnes, 1991; American Association of University Women, 2000; Craig *et al.*, 2002; Margolis and Fisher, 2002; Gansmo *et al.*, 2003). Policy makers agree that geek culture has hurt the computing fields (Lipp, 1999). However, scholars have yet to critically examine the impact of geek culture on the under-representation of women in CS/CE in relation to ethnicity/race and class.

This paper examines whether the under-representation of women in undergraduate CS/CE education in the USA results from its geek culture in terms of ethnicity/race and class. Specifically, it considers the extent to which geek culture remains viable beyond the context of Jane Margolis and Allen Fisher's (2002) pioneering study of the gender gap in CS at the undergraduate level at the Carnegie Mellon University (CMU), which is an elite institution with low representation of black, Hispanic, and American Indian/Alaska Native students.[2] The paper proposes that institutional-contextual and student-demographic factors must be taken into consideration before one can discern how heavily geek culture figures in women's decisions to remain or leave CS/CE studies.

The paper is based on primary qualitative data that were gathered during the 2004–2005 academic year through in-depth interviews with 150 undergraduates from five major ethnic/racial groups; namely white, black, Hispanic, Asian, and American Indian. These students were attending seven US campuses that were designated as Minority-Serving Institutions.[3] These institutions grant a high proportion of undergraduate degrees to under-represented minority students.[4] Interviews were conducted with 15 female and 15 male students in each ethnic/racial group who were in their second and third years of CS/CE study. Random sampling was used to select subjects on sites with sufficient numbers of female and male students. However, purposive sampling was used on sites where the numbers of some groups (e.g. American Indians) in CS/CE disciplines were small. To ensure that data collection is consistent, the author conducted all

interviews. All interviews were recorded, subsequently transcribed, and inserted in the Nvivo programme for analysis. Two independent coders coded the same data to ensure reliability and validity.

Geek Culture

Geek, Hacker, and Nerd

The dictionary defines the term geek as: (1) a performer whose show consists of bizarre acts such as biting the head off a live chicken or snake; (2) a person often of an intellectual bent who is disliked; and (3) an expert especially in a technological field. However, general usage of the term geek is different from the dictionary's definition. The term 'geek' is slang for a person who has encyclopaedic knowledge of computing and is obsessively fascinated by it, but is socially inept, exhibits odd personality traits, excludes normal social and human interests, and spends free time being 'social' on a computer.

Often, the terms geek, hacker, and nerd are used interchangeably (Gansmo *et al.*, 2003). However, 'hacker' connotes extraordinary skills more strongly than geek does. A hacker is able to gain access or 'hack' into a system through high intelligence and unexpected skills not possessed by geeks. One of the earliest incidences of hacking was the 1959 infiltration of the US Defense Department's telephone communication system that Massachusetts Institute of Technology (MIT) students accomplished by systematically deciphering telephone codes (Leibowitz, 1990). Because hacking involves unauthorized computer access to other systems, it is considered illegal. Generally, a 'nerd' is portrayed with pocket protectors, taped glasses, and plaid shirts. A nerd is fascinated by theoretical scientific knowledge and learning whereas a geek is more computer specific. A nerd aspires to become a 'true scientist' whereas a geek aspires to become a 'true technology user'. Though both have poor social skills, a geek maintains more social contacts than a nerd.

Finally, the terms geek, hacker, and nerd have negative connotations though recently they have become less pejorative, mostly because they denote competence in technology. Their culture has been described as the 'third culture'; a pop culture based in technology where creation rather than creativity is the preferred mode of action (Kelly, 1998). Nonetheless, 'geekiness [remains] unacceptable in the larger culture' (Barker and Aspray, 2006, p. 39).

Mythologized Male Archetype

What exactly is geek culture? At the heart of geek culture is a set of idealized male norms such as falling in love with computers with the first exposure, being extraordinarily well-versed in the inner workings of computers, myopically being focused on them to the point of obsession, and being antisocial (Margolis and Fisher, 2002). A special community within the computing world is responsible for assembling the image of the ideal geek (Turkle, 1984). A basic profile of geeks shows that they are predominantly white male, who do well in school especially in mathematics and sciences, have high IQs, collect technical products, and are science fiction fans, but are socially inept (Kendall, 2000). Geeks possess traditional masculine characteristics such as fascination with technology, but lack traditional feminine characteristics such as social skills. These male norms circulate in everyday life projecting the male way as the only way to be and do CS/CE.

The standardization of geek culture can be understood as 'myth' defined by Roland Barthes (1972). He conceptualized myth not as a fictitious or unverified thing, but as a socially constructed reality, which is passed off as 'natural' despite having little actual connection to history. According to Barthes (1972), myths circulate in daily life, and once they become established in people's beliefs and values, myths serve the ideological agendas of the dominant classes. Through myths, erroneous thinking becomes entrenched and obvious. As an example, there is a myth that women are 'naturally' afraid to tinker with the computer, a technocratic icon of the information era, while men are 'naturally' bold enough to have a close encounter with the powerful computer. Such gendered constructions of technology portray women's 'normal' occupations to be in non-computing areas, while men's 'dominant' employment to be in high-computing areas. This way geek culture legitimizes men's exclusive claim to computing on the one hand and defuses the power relations between men and women in the high-technology sphere on the other hand.

Geek culture has deep historical and cultural roots in the vanguard CS/CE programmes established in the late 1960s and early 1970s at famous private educational institutions such as CMU, MIT, and Stanford University (Margolis and Fisher, 2002). The computer geek gained currency mostly because he is emblematic of masculine traits traditionally associated with professional achievements such as single-mindedness and competitiveness. Furthermore, the computer geek exudes rationality and empirical knowledge, two central tenets of positivist philosophy that has underwritten scientific and patriarchal Western civilization for the past 150 years. Most importantly, the computer geek is not like other mythical figures who only come to life on the pages of dusty books and whose imagined power flows at least in part from what amounts to an apotheosis as they become enshrined as cultural icons. Quite the contrary, a computer geek is worldly in the most modern sense—consider the status of Paul Allen, Sergey Brin, Larry Ellison, Bill Gates, Steven Jobs, Larry Page, or Steve Wozniak.[5]

To be a computer geek is to be the ultimate twenty-first century entrepreneur, someone who reaps the very tangible rewards of the most lucrative scientific field of the new millennium by virtue of being talented, capable, and driven. At bottom, the power and appeal of the computer geek lie in his invocation of the most efficacious individual traits recognized by Western society, most of which are associated with masculinity; in his embodiment of core cultural prescriptions such as his penchants for self-sacrifice and hard work and in his conversion of those qualities into an ability to secure the American Dream. For example, *Time Magazine* portrayed Netscape's Marc Andreessen as 'The Golden Geeks' on its cover (19 February 1996). The caption said: 'They invent. They start companies. And the stock market has made them INSTANTAIRES. Who are they? How do they live? And what do they mean for America's future?'

It Matters

Does geek culture figure in women's decisions to pursue or leave CS/CE education? Margolis and Fisher (2002) found that female students at CMU had entered the programme enthusiastic about becoming computer scientists. Perhaps they were attracted by the geek's mastery of computers, even if they did not like certain aspects of geek lifestyle. However, once in the programme, women began to question whether they belonged in CS because they did not share the same intensity in focus and interest that they saw in

their male peers. Similarly, the SIGIS study in Norway found that many female students opted out of doing CS at the university level because they were put off by the nerd image of their male peers (cited in Barker and Aspray, 2006). Another study at the Norwegian Institute of Technology found the male culture of 'the key-presser's society' made CS a difficult subject for female students to study (Rasmussen and Hapnes, 1991). A study conducted at four universities in Australia, China, the UK, and the USA found female students viewed computing careers as being less social and more isolating (Craig *et al.*, 2002).

The disincentive of geek culture may start much earlier at middle and high school levels. For instance, a survey of middle and high school female students in the US revealed that the respondents perceived a career in information technology as a waste of their intelligence, and thus they wanted to pursue those fields where they could make a difference (American Association of University Women, 2000). Similarly, a study conducted in primary school in Denmark found sex-based stereotypes do not associate females with computer competency (Elkjaer, 1992). Generally, young female students believe that a career in an information technology field means sitting behind a computer all day, talking through the keyboard, having singular focus on machines, and being isolated from other people (Barker and Aspray, 2006).

The question of importance is: how could a sub-cultural milieu centred on a mythologized male archetype, which did not have any importance when women decided to major in CS/CE, end up having a disproportionately negative effect on them? According to Margolis and Fisher (2002), geek culture reflects male domination and projects the male way as the only way to be in CS. The main role of geek culture appears to provide an archetype of the successful computer scientist or computer engineer which serves as the standard for women's self-assessments and which informs ascriptions regarding their capacity for CS/CE studies. Even though the majority of women do not identify with the geek ideals, they suffer from a perceived inability to measure up to it.

Gendered socialization makes female undergraduates in CS/CE highly vulnerable to the confluence of multiple factors including an intimidating classroom climate, ineffective pedagogy, poor academic advising, and inadequate nurturing of students. As a result, many women experience a precipitous loss of confidence that leads to alienation, a pervasive sense of not belonging, and even depression. Margolis and Fisher (2002) found that females at CMU expressed more self-doubt about their computing abilities than did their male counterparts. Furthermore, a meta-analysis of 18 computer anxiety studies conducted among university undergraduates between 1990 and 1996 concluded that females were generally more anxious (cited in Barker and Aspray, 2006).

One reason that even ambitious, well-qualified female students fall prey to this trap is that the exercise of comparing themselves to gendered archetypes is so familiar to them. Men are traditionally seen as capable, rational, and driven, whereas women are perceived to be dependent, emotional, and lacking the intensive focus necessary to succeed in demanding and highly technical professions. The idea that men are more suited for CS/CE education is thus merely the logical extension of implicit and overt messages to which both men and women have been exposed ever since they were children. Geek culture does not create a new juxtaposition of man and woman scientists-engineers so much as it rearticulates very old notions of male and female in a new context.

A related point is that men are socialized from a very early age to gain pleasure from manipulating and mastering tools, weapons, and all manner of machines (Turkle, 1984; Hacker, 1990; McIlwee and Robinson, 1992). To say that boys and men in US society

worship machines would hardly be an overstatement. Machine or gadget fetishism is practically a given among the vast majority of US men, with the automobile constituting the classic example of individual identity being bound up with machine stewardship. The geek's virtual marriage to his computer is therefore as familiar to most men as it is foreign to most women. In order to surmount these kinds of obstacles to constructing an identity as a computer scientist or computer engineer, a woman must have developed a sense of self that either rejects many of the cultural tenets which cordon off CS/CE as masculine professions, or one that otherwise resonates with socially accepted gendered prescriptions sufficiently to assure her identity as a woman.

Computing, Medicine, and Law

But what makes CS/CE so different from other lucrative, rigorous, and highly demanding fields such as law and medicine, which were dominated by men for decades, yet women have successfully penetrated them successfully in the USA? And what does geek culture have to do with this difference?

Jacquelynne Eccles (1994) found that women rate family, friends, richness of one's cultural life, and joy in living more than men do. The legal profession necessarily deals with human relations—something for which women are expected to have a natural affinity—and its everyday practice is remote from that of the so-called 'hard sciences', which are suffused with abstractions and disembodied mathematical formulae. The CS/CE curriculum emphasizes hard areas such as mathematical formalism instead of skills traditionally associated with women (Mahony and Brett, 1990). Similarly, medicine resonates strongly with women's traditional role as nurturing caregivers. It is true that doctors must perform calculating diagnoses and achieve some degree of professional detachment, but women are traditionally seen as intuitive and warm, both qualities associated with healers. CS/CE education is rarely embedded in a social context which women prefer to pursue (Kvande and Rasmussen, 1989).

In addition, the popular images of lawyers and doctors are somewhat the antithesis of the geek; they are seen as smooth, cultured, and highly socialized. In marked contrast, both the substance and daily practice of computer scientists and computer engineers are largely devoid of any redeeming sensuality or frequent need for meaningful face-to-face interaction—a situation that is powerfully evocative of the centuries-old division between emotion and reason in Western thought: 'Society accepts and defensively asserts the need for a severed connection between science and sensuality, between people who are good at dealing with things and people who are good at dealing with people' (Turkle, 1984, p. 197).

The Outcome

Women make up 51% of the US population and 47% of the civilian labour force, but comprise only 27% of computer/mathematical scientists (National Science Board, 2004). The number of women earning a bachelor's degree in CS grew significantly from 1977 to 1985, by almost 10-fold, whereas for men the increase was about five-fold. From 1985 to 1995, however, this number decreased by half for women, whereas for men, there was a 30% decrease. During the dotcom boom in the late 1990s, the number of men and women gaining CS degrees went up. However, while male enrolment

in CS surpassed its previous 1985 peak, the number of females gaining CS degrees in 2000 was still 30% less than in 1985 (see Table 1).

For ethnic/racial groups, with the exception of American Indians/Alaska Natives, there was no dip in the years between 1985 and 1995, although there were sharp decreases in the rates of degrees earned across ethnic/racial groups. From 1995 to 2000, the percentage increase in the number of American Indian/Alaska Native females was slightly higher than the percentage increase in the number of their male counterparts. The percentage increases for Asian females and males were roughly the same during the same period. For black and Hispanic females, however, the percentage increase was less than it was for males from 1995 to 2000. Finally, the percentage increase was higher for white males than white females during the same period (see Table 1).

Freshmen interest levels have been an accurate predictor of trends in the number of bachelor degrees granted four or five years later. After peaking in 1999 and 2000, interest in CS as a major among incoming freshmen in the United States has fallen 70% in the past five years. Alarmingly, the proportion of women who thought that they might major in CS has fallen to levels unseen since the early 1980s; from 4.1% in 1982 to 1.5% in 1999 and 0.3% in 2005 (Vegso, 2005).

It is therefore no surprise that women's under-representation in CS/CE education has been scrutinized from many angles over the last two decades (e.g. Frenkel, 1990; Spertus, 1991; Cassell and Jenkins, 1998; American Association of University Women, 2000; McClelland, 2001; Palma, 2001; Camp, 2002; Margolis and Fisher, 2002; Varma, 2002, 2003; Leggon, 2003; Cohoon and Aspray, 2006; Trauth, 2006). These studies

Table 1. Bachelor's degrees in computer science in the United States by gender and ethnicity/race for selected years

Gender, ethnicity/race	1977	1985	1995	2000
Total[a]	6,426	39,121	24,769	37,388
Male[a]	4,887	24,690	17,706	26,914
Female[a]	1,539	14,431	7,063	10,474
White[a]	5,508	31,321	15,601	21,719
White male[b]			11,845	16,748
White female[b]			3,756	4,971
Asian[a]	163	2,044	2,371	5,401
Asian male[b]			1,589	3,660
Asian female[b]			782	1,741
Black[a]	361	2,143	2,517	3,497
Black male[b]			1,253	1,827
Black female[b]			1,264	1,670
Hispanic[a]	114	1,045	1,314	2,155
Hispanic male[b]			880	1,460
Hispanic female[b]			434	695
American Indian/Alaska Native[a]	15	139	110	172
American Indian/Alaska Native male[b]			73	113
American Indian/Alaska Native female[b]			37	59

[a]*Source*: National Science Board, *Science and Engineering Indicators 2004* (Arlington: National Science Foundation, NSB 04-1A 2004), pp. 2–22, 2–23.
[b]*Source*: National Science Foundation, *Female, Minorities, and Persons with Disabilities in Science and Engineering 2004* (Arlington: National Science Foundation, NSF 04-317 2004), pp. 33, 44–48, 56–62.

identify a range of factors that contribute to the relative paucity of women in CS/CE education such as limited access to computers in schools and at home; the differential use of the computer technology; subtle gender bias in early school years; performance gap in mathematics and physical sciences in high schools; the small proportion of women among CS/CE faculty and student populations; gendered recruitment techniques and pedagogy; the harassment of female students by their male peers; women's subjective evaluations of their self-efficacy; and the masculine environment.

Contextual Viability of Geek Culture

Sherry Turkle (1984) argues that geek culture is continuously and self-consciously reconstructed—with the implication that its overpowering and palpably real presence with which students must contend will vary in different contexts. Robert Ibarra (2001, p. 66) maintains that context should be redefined as a

> . . . relationship rather than a single entity. For on the one hand, context connotes an identifiable, durable framework for [an] activity, with properties that transcend the experience of individuals, exist prior to them, and are entirely beyond their control. On the other hand, context is experienced differently by different individuals.

With regard to higher education specifically, he calls 'the patterns of cultural context, ethnic identity, and academic culture . . . "situational frames" [which] are found within the organizational structures of our colleges and universities' (Ibarra, 2001, p. 63). This suggests that one must understand how different situational frames generate cultural dissonance for ethnic/racial minorities and, by extension, for minority women.

   Several factors could influence how prominently geek culture figures in women's decisions to remain or leave CS/CE studies at the undergraduate level. These may be divided into two closely inter-related categories: contextual-institutional and student-demographic factors. Both kinds of factors could produce variation in the extent to which idealized norms of geek culture are accepted as a standard for self-assessments by CS/CE female students from different ethnic/racial groups.

Computing Culture

On the question of describing typical culture within their programme, almost half of the interviewees (51% female and 45% male) believed there is a stereotypical computer culture mostly consisting of geeks, nerds, and/or hackers (which are substantially overlapping). In general, more whites (60%), blacks (50%) and Hispanics (47%) than American Indians (43%) and Asians (40%) identified CS/CE as a geek culture. Among females, more whites (73%) and blacks (60%) identified computing as a geek culture than American Indians (47%), Hispanics (40%), and Asians (33%) (see Table 2).

   A large majority of interviewees believed in the prevalence of geek culture. They pointed out that all CS/CE students know of geek values even if they do not possess them. An Asian female generalized typical CS/CE students as 'Someone with glasses, a geek, whatever'. 'Usually just a bunch of weirdoes', said a white female. A Hispanic female alleged that 'They are hacking on some sort of program until like three in the morning'. An American Indian female believed they are 'nerdy-type people . . . who

Table 2. Typical computing culture (%)

Culture	White		Black		Hispanic		Asian		American Indian		Total		
	F $n=15$	M $n=15$	F $n=15$	M $n=15$	F $n=15$	M $n=15$	F $n=15$	M $n=15$	F $n=15$	M $n=15$	F $n=75$	M $n=75$	T $n=150$
Geek	73	47	60	40	40	53	33	47	47	40	51	45	48
Hard working	20	13	27	33	47	27	40	33	40	53	35	32	34
No typical	7	40	13	27	13	20	27	20	13	7	15	23	19

F = female; M = male; T = total; n = number of respondents.

Figure 1. Girl with thick glasses. *Credit*: www.fotosearch.com/stock-photo-licensing/inspirestock/

teach themselves all computer stuff'. Several interviewees added lack of social relations or interpersonal communication skills such as they 'do not have a life other than school'; 'don't party that much'; 'don't have a girlfriend they complain about'; and 'buy the cheapest clothes so they can buy more computer stuff'.

While females refuted the geek image as being applicable to themselves, some males referred to themselves as the embodiment of geek ideals, including this white male: 'We are geeky. Our lives revolve around computers. ... We love it'. An Asian male considered Asian students to be 'advance geeks in computing'. Another Asian male said

> A typical computer science student would be somebody that puts in lots of hours sitting behind the computer. It is somebody that doesn't know how to speak very well ... maybe somebody that is almost anti-social. ... I am perfect for the field because I put in lots of hours and I am anti-social.

A black male said the iconic computer geek was more than a stereotype: 'If you go to the lab, you will see a bunch of geeks. I am one of them. Our social life deals with computers'. A Hispanic male proclaimed that 'We are geeks. We play lots of video games. We watch Star Trek. It is true. We are geeks'. Another Hispanic male proudly declared that geeks are not ostracized. 'Computer scientists aren't nerds. They are geeks. There is a difference. Women will date geeks, they won't date nerds', he said. This student said that he was dating a Hispanic girl from Latin American Studies.

Over one-third of the interviewees (35% female and 32% male) talked about the changing computing culture. According to them, typical CS/CE students were mostly hard working, intelligent, smart, and dedicated, without being geek, hacker, and/or nerd. Among males, more American Indians (53%) described the computing culture as hard working than did other minority groups; whites (13%) mentioned it the least. Among females, more Hispanics (47%) identified typical CS/CE students as hard working than did other minority groups and whites (see Table 2).

A white female characterized typical CS/CE students as follows: 'They were at the top of their classes coming in out of high school. ... They are very good in math, very good in science, and accelerate in their efforts here'. A black female echoed that 'they work very hard. ... They are willing to give the effort that is needed to stick it out'. A Hispanic female described geeks as 'Meticulous. Working until it is perfect. ... They are fascinated by little details to make things work and not shy about putting in long hours'. An American Indian female characterized typical CS/CE students as 'Serious, real serious. ... They are very hard workers and somewhat tired from working so hard'. A white male agreed: 'These students are very methodical, procedural, and professional about computer science. They are not the kind of students who just float'. An American Indian male proclaimed the typical CS students to be 'smart, in general ... [and] ... not geekish or anything like that'.

Another group of interviewees (19%) also acknowledged the stereotype but said that while it was viable at one time it is no longer accurate or that it is changing due to diversity brought by different types of students making typicality diffused. More males than females believed in the lack of a dominant typical culture; a difference of eight percentage points. Among different ethnic/racial groups the discrepancy between white females and males was the largest; 40% of white males compared with 7% of white females (see Table 2).

One white female explained that

> Ten years ago, I would have described CS students as basic nerd, somebody who is antisocial, who would rather spend all their time on the computer than ever talk to a person. ... a brilliant mind, but don't know how to speak to other people. ... ten years ago, that is how it was, but I think it has branched out so much more now.

A Hispanic female said:

> I think you have two groups over in the CS department. You definitely have the stereotypical, computer nerd, where all they do is play on their computer, and that is all they want to do. There is also another group of students who seems more rounded in the sense that they enjoy computers, want to work in the field, but it is not necessarily the entire focus of their life.

A black female noted: 'There are a bunch of stereotypes about persons in computer science. ... In reality, we don't stand out. Most of us are just kids walking down the street'. A Hispanic male explained that there has been a shift in recent years. 'It is kind of a bunch of normal people, now, that don't necessarily know too much about computers when they start. And they learn more as they go along, instead of the super geek that comes in writing all kinds of code'.

Considering almost half of the interviewees identified the dominant computing culture to be geek and a number of males referred to themselves as the embodiment of geek ideals, the question of importance is: how the geek culture affects women's decision to remain or leave CS/CE undergraduate education?

Selecting a Computing Programme

An examination of interviewees' reasons for majoring in CS/CE fields in their university shows that low socioeconomic class and minority females appear to be less likely than their upper- or middle-class white counterparts to choose CS/CE on the basis of its 'intrinsic' appeal, or seek admission in the desired university because it represents a 'calling'. While minority females were exhilarated about studying CS/CE, very few of them seemed to connect either computing or where they were studying to their sense of self. When they spoke about what led to their enrolment in the study of CS/CE, white females mostly mentioned their early exposure to and intrinsic interest in computers as the main reason for choosing their major, while most minority females decided to major in CS/CE because it provided more opportunities for secure employment, high pay, and better social standing (see Table 3a).

Similarly, when interviewees spoke about why they decided to join their university, minority females made their selection primarily on the basis of lower in-state tuitions, scholarship offered, and closeness to their family; white females, on the other hand, primarily considered reputation of the university and the details of the CS/CE programmes (see Table 3b).

This, however, does not mean that minority women lack either the desire and need for intellectual fulfilment or the capacity to identify strongly with their chosen profession. Since being a member of a minority in the US corresponds strongly to lower socioeconomic status (with the exception of Asians), getting a job with a good salary and social prestige is a more pressing concern to members of these groups than choosing a career path that resonates with some deeper affinity for the content of the work. These minority women view pursuing a CS/CE education because it is a 'calling' as a luxury reserved for socially privileged white persons.

Leaving Geek Field?

Yet minority women do seriously consider changing their major and some do leave CS/CE fields after investing their time, money, and energy for a few years.[6] However, issues of persistence and departure seldom arise on the basis of the geek image associated with being a computer scientist or computer engineer, which is mostly found with their white peers. Instead, the reasons for minority women thinking of changing from a CS/CE major come down to more practical concerns resulting from their social and economic status (Varma, 2007).

Minority students (with the exception of Asians) are much more likely to have gone to disadvantaged elementary, middle, and high schools. About 48% of the interviewees believed that their high schools did not prepare them 'at all' for CS/CE education at the undergraduate level and another 37% talked about being prepared 'moderately'. Among these, Hispanic, black, and American Indian females complained the most while white and Asian females complained the least about the lack of preparation in

Table 3a. Reasons for choosing computing field

Subjects	Comments
White female	'When I was three-and-a-half, I started working on computers. . . . I simply got hooked on them just by copying codes from magazines, playing games, and stuff like that.'
Black female	'It is rather simple why I chose to major in computer science. I chose because it is a lucrative field.'
Hispanic female	'By studying computer science, I am surpassing the goal that my family had set for me to become a secretary or a clerk. . . . Most of my relatives are manual labourers.'
Asian female	'My parents were keen on me studying computer science because it is a growing field, and if you don't know computers . . . you are way behind. . . . I like math more than computer science. I like geography. But they suggested that those are some of the fields which don't have any future.'
American Indian female	'I can start my own business on the reservation with a computer science degree. I don't have to be away from my family.'

Table 3b. Reasons for selecting particular university

Subjects	Comments
White female	'I was really impressed with their computer science department. . . . They are a little more practical and a little less theoretical.'
Black female	'I have kids and I couldn't go elsewhere. . . . My mother is close by to look after my kids for free.'
Hispanic female	'It was the cheapest option and it was close to home.'
Asian female	'It was free. They gave me really good scholarship.'
American Indian female	'My mom told me that it was a lot cheaper going here, it does not cost that much, and it is close to home.'

high school. Whereas women admitted to elite universities are just as well qualified as the men, non-Asian minority women admitted to Minority-Serving Institutions may not measure up to admission qualifications of women in elite universities. These are important contextual-institutional and student-demographic differences.

CS/CE are rigorous, hard, mathematical, and demanding technical fields. The pace of a CS/CE courses is faster than their rate of absorption and the large volume of course work is combined with the expectation of mastering it at high speed. In addition, computer programming requires an extra investment of time. These fields become more demanding for those students who are non-traditional.[7] They often do not enter postsecondary education immediately after finishing high school; instead, they enter after working for a number of years to save money for their educations. They tend to be older than the 18–23 year old traditional college/university student. Also, they are likely to be married and have young children, or are single parents. Furthermore, they work full-time (minimum 35 hours a week) or part-time during the academic year to support their studies and families.

Almost 40% of interviewees were above 25 years of age; of these 41% were females and 28% were males. Over 30% of females and 24% of males were married, divorced, or

separated. Almost 27% of interviewees (25% female and 16% male) had at least one child living with them. More white, Asian, and black females were single than Hispanic and American Indian females. Most importantly, over 70% of interviewees (79% male and 63% female) held a full or part-time job during the academic year to support their studies. While most whites and Asians held a job related to their CS/CE studies, most Hispanics, blacks, and American Indians held odd jobs. Within each ethnic/racial group, more females than males held a job unrelated to their CS/CE studies.

Most interviewees acknowledged that the CS/CE programmes demand that successful students be unmarried, without boyfriends or girlfriends, no children, jobs or outside interests. They felt that students who are unable to devote long hours to their studies or who have responsibilities outside their studies face serious difficulties in CS/CE. Often, non-traditional students struggle to keep up with the rigorous CS/CE curricula requirements, look after their children, maintain social and family lives, and work full or part-time. It is not surprising that they feel overwhelmed, fall behind, and have to repeat courses.

The difficulty of CS/CE curricula and balancing that with families and jobs was the single most common reason cited by interviewees who had seriously considered changing their majors. However, within that group, women were one-third more likely than men to find CS/CE studies excessively difficult (see Table 4). Furthermore, Hispanic, black, and American Indian females were more likely to cite the difficulty of CS/CE curricula than

Table 4. Reasons for considering leaving the computing field

Subjects	Comments
White female	'[Male students] think that we aren't anywhere as good as they are. They are all extremely egotistical.'
	'I don't know if CS is what I am best at. I am seriously questioning whether or not I have an aptitude for CS.'
Black female	'It is hard. It is hard for me. I work. I have no choice but to work. Then, I have two little kids. . . . They are literally being raised by their grandmother because I can't find any time from my studies and job.'
	'Usually the women that study computer science are thought of as either bisexual or real ugly. . . . They feel you don't have anything to offer.'
Hispanic female	'In the lab when a pretty girl walks in they just assume she is an education major. And when they find she is studying computer science they are shocked.'
	'I think [male faculty] are not patient when it comes to answering questions from a female student. . . . If a female is asking for help with her programme, he gets frustrated easily when she doesn't understand certain things. And if he is helping a male student, he spends more time and he is less likely to get frustrated.'
Asian female	'There are guys. They can stay till two o'clock, three o'clock in the lab. My mother gets concerned. . . . How you are going to walk to the car? Hold on, let's send Dad over, he will pick you up.'
	'Sometimes it is just too much, and it is getting to me.'
American Indian female	'As a woman you have more responsibility once you start creating a family. I know a lot of girls on the reservation have babies already and they can't keep up with computer science because it is too time consuming.'
	'It is challenging because you have to combat a stereotype. . . . men do not see that we are just as competent and just as capable as them.'

their white peers, with Asian females complaining the least. This sample does not contain first-year students; therefore, these interviewees were thinking of shifting major on the basis of their experience in CS/CE programmes.

Another prominent factor in women's decisions to consider leaving CS/CE studies is the hostility sometimes directed at them by their male peers and by faculty (see Table 4). Latent or open hostility, or merely the refusal of male peers and faculty members to take female—particularly under-represented minority female—students seriously, ends up initiating an emotional chain reaction leading women to consider leaving CS/CE programmes. Except white males, interviewees in all ethnic/racial groups pointed out hostility to be a factor in their decision to change their CS/CE studies. Interestingly, more white females cited antagonism directed toward them than minority females in their consideration to change their major.

Yet, for minority women, the investment in time and money that CS/CE studies represent may be too great to actually change career paths midstream. A Hispanic female said that she found the coursework of CS so demanding that she had considered changing her major, 'but it was too late. I had more to lose, because if I changed it I would have lost a year of work . . . I have to struggle to do well in CS classes'.

When asked if they were to change their major from CS/CE to some other field, what it would be, an overwhelming percentage of minority females mentioned CS/CE related fields such as Information Systems, a degree offered by the Business School; most white females preferred to change to psychology, biology, or liberal arts. Minority females seldom talked about changing their majors to non-information technology fields, which shows that they want to remain in the computing arena, even if it is not in the prestigious fields of CS/CE. If minority women were desirous of leaving CS/CE altogether because of or their failure to integrate themselves into geek culture, they would be unlikely to continue in the information technology subject area.

While few of the women in this study cited a lack of identification with the geek ideal as a barrier to success in CS/CE, most felt that gendered socialization was at the heart of the phenomenon of few women pursuing an education in CS/CE and that same dynamic made their own experiences more difficult. A Hispanic female said, 'Women think different than men do and we have different approaches to problems, we have different priorities to problems than men do. So you have to think more aggressive, and more like a man in this field'. An Asian female said, 'I think that society kind of gives women an idea that the men usually engage in more technical fields. So even though I don't think girls are not as intelligent as men, we have gotten used to the idea that most women don't study computer science, computer engineering'.

Male students agreed that gendered socialization was responsible for the under-representation of women in CS/CE as reflected in this black male statement: 'I think from elementary school and on, men are encouraged to do math and those science types of problems or classes. . . . We have a societal issue where we just encourage men to do certain things and discourage women to do certain things'. An Asian male said, 'In the lower level of school, they kind of push women towards English and they push boys towards math. . . . It is believed that men-are-better-at-math, women-are-better-at-English'. A Hispanic male observed, 'Men think that women are not as smart as they, but you know it is normal'. Similarly, a white male believed, 'Women are not expected to do well in these areas. So they become assistants and generally they are expected to do poorly'.

Conclusion

This article has examined the effect of geek culture—the high-tech, androcentric, sub-cultural milieu—on women's under-representation in and attrition from the undergraduate studies of computer science (CS) and computer engineering (CE) in Minority-Serving Institutions. It has shown that due to lower social and economic status, minority women are less likely to resent being associated with geek culture. For them certain benefits accruing from a CS/CE career—such as a social prestige and a good paying job—outweigh the stigma. Even if the ascribed master status of the geek identity threatens a minority or lower socioeconomic status woman's femininity, it is still preferable to the default master status of 'working class' or 'minority' woman. Once in these academic programmes, minority women face the rigors of CS/CE fields and the lack of a financial support system that forces them to consider abandoning their study of CS/CE in favour of a less demanding programme such as management information system, which is still an information technology field. The reasons behind minority women's attrition from CS/CE are not their lack of affinity for machines or masculinity of computers; rather it boils down to the more practical considerations associated with their familial, social, and economic conditions.

This is in contrast to Margolis and Fisher's (2002) study of undergraduate women in CS at Carnegie Mellon University, which showed that geek culture undermined women's interest in computing and their confidence in being able to succeed at it. As a result, women ended up questioning whether they belonged in CS and some left the major before graduation. Perhaps the importance of conforming to the geek ideal is applicable to white women's experience in an elite university represented in their study. The diverse ethnic/racial women's experience in a standard CS/CE programme is inarguably more representative of the average woman's academic experience than white women's experience in an elite CS programme.

While a handful of studies have begun to focus on the gender construction of computers, they seldom include women from diverse ethnic/racial groups and from Minority-Serving Institutions. Generally, it is assumed that what applies to white women also applies to non-white women, and what applies to non-Minority Institutions translates to Minority-Serving Institutions. This study has shown that women are situated within the scheme of ethnicity/race and class, which should not be considered alone as it may result in incomplete or perhaps inaccurate generalizations about women.

Finally, gender and computer technology are co-constructed in the sense that ideas about computer technology generally are deeply implicated in the construction of gender. By examining the process of cultural reproduction within a major agent of socialization such as CS/CE undergraduate education, this study has improved the understanding of gendering—that is, the ways in which societies generate and embellish the social significance attached to sexually based difference. As CS/CE has become ascendant as the fount of the information era, they have lent a more precise articulation to and extended the social meaning of unconsciously held analogies redolent with traditional notions of femininity and masculinity.

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Notes

[1] In the US, computer science (CS) began to be established as a distinct academic discipline in the early 1960s with the creation of the first CS departments and degree programmes. It has been closely related to mathematics and/or electrical engineering, from which CS historically emerged (Denning, 2000). Some departments have maintained computer engineering (CE) programmes with electrical engineering while others have integrated CE with CS programmes.

[2] Carnegie Mellon University (CMU) is a private university, ranking overall among the top 10 universities in the US, with a CS department regularly ranking among the top five in the country. CMU's CS programme was officially established as a department in 1965 under the Mellon College of Science, became one of the first schools of CS in 1988, and has been a major source of seminal advances in artificial intelligence, computer design, robotics, and many other areas. Out of 5,389 undergraduates enrolled in Fall 2004, only 286 were blacks, 281 were Hispanics, and 27 were American Indians/Alaska Natives. Out of 532 undergraduates enrolled in CS in the same year, 33 were Hispanics, 21 were blacks, and two were American Indians/Alaska Natives. Overall undergraduate female enrolment was 2,120, with 136 in CS.

[3] A Minority-Serving Institution is defined as an institution that meets the requirements of Section 1046(3) of the Higher Education Act of 1965 of the US. It makes up a category of educational establishments such as Hispanic-Serving Institutions, Historically Black Colleges and Universities, and Tribal Colleges and Universities. To be considered a Hispanic-Serving Institution, the Hispanic enrolment at a college or university must be at least 25% of the total student enrolment. There are about 200 Hispanic-Serving Institutions. Historically Black Colleges and Universities were established prior to 1964, whose principal mission was, and is, the education of blacks. There are about 105 Historically Black Colleges and Universities. Tribal Colleges and Universities are those institutions that have American Indian/Alaska Native student enrolment of 50% of the total student enrolment. There are about 30 Tribal Colleges and Universities, most of them located on Indian reservations.

[4] The National Science Foundation (2004) uses the term minority for people other than whites. Accordingly, blacks, Hispanics, American Indians/Alaska Natives, and Asians are minorities though the first three groups are considered under-represented minorities and Asians are considered over-represented minorities in science and engineering education and careers.

[5] Paul Allen and Bill Gates are co-founders of Microsoft; Sergey Brin and Larry Page are co-founders of Google; Larry Ellison is the co-founder of Oracle; and Steven Jobs and Steve Wozniak are co-founders of Apple. They are in *Forbes'* list of the world's richest people.

[6] US national statistics on students' dropout rates from science and engineering are not available. Some studies have calculated persistence and dropout rates in science and engineering on the basis of enrolment profile and graduation rates (e.g. Seymour and Hewitt, 1997; Huang *et al.*, 2000). These studies show that among the students enrolled in science and engineering programmes in the first year of postsecondary education, under-represented minority students seemed to have difficulty attaining a degree in S&E fields within a five-year college calendar. Some of them had to switch to other fields. A study of 18 CS departments in 2001 and 209 in 2002 showed that on average women's attrition rate was six points higher than was men's in the same department (Cohoon, 2006, pp. 214–225).

[7] 'Traditional students' commonly refers to those students who enrol in postsecondary education immediately after graduation from high school and complete their bachelor's degrees in four or five years at a young age of 22–23. They tend to pursue postsecondary studies on a full-time basis, are financially dependent on family, do not have children, and work mostly in the summer. In 1999–2000, almost one-third of undergraduates were strongly non-traditional and another one-third were moderately non-traditional (National Center for Education Statistics, 2002).

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