

# Roli Varma

## DECODING THE FEMALE EXODUS FROM COMPUTING EDUCATION

*This study uses primary empirical data to better understand women's reasons for leaving undergraduate computer science and computer engineering education programs. It draws on social control theory to integrate student perspectives with structural considerations, demonstrating how secondhand knowledge of comparatively infrequent negative experiences achieves substantial immediacy and veracity among women students en masse, thereby contributing to increased attrition.*

**Keywords** Attrition; computer science education; minority-serving institution; social control theory; retention

### Introduction

Women are seriously underrepresented in computing education programs at the undergraduate level in the United States. The number of undergraduate degrees awarded to women in computer science (CS) between 1966 and 2003 shows that many of the gains women achieved by the mid-1980s were lost in subsequent years. For example, women earned 15 per cent of CS undergraduate degrees in 1966; that number had risen to 37 per cent by 1984 but then declined to 28 per cent in 2003 (Cohoon & Aspray 2006; National Science Board 2006). Between 1994 and 2000, women comprised only 24 per cent of undergraduate enrollment in CS programs nationwide, but 32 per cent of those eventually switched to a different major (Cohoon 2006).

It is therefore no surprise that in recent years scholars have turned their attention to the specific discipline of CS to explain this phenomenon. They have identified a range of factors that contribute to the relative paucity of women in CS, which may be divided into three areas. First, *objective conditions* including the small proportion of women among CS faculty and student populations, gendered recruitment techniques and pedagogy, the harassment of female students by their male peers, and economic impediments that limit

access to home computers or competent preparatory education, which disproportionately impacts on women (e.g. Frenkel 1990; Spertus 1991; Seymour 1995; National Telecommunications and Information Administration 2000; Varma 2002; Katz *et al.* 2003). Second, *women's subjective evaluations of their self-efficacy* may lead to depression, alienation and a pervasive sense of not belonging, all of which may render CS study unappealing or even intolerable (e.g. Seymour & Hewitt 1997; Margolis & Fisher 2002; Varma *et al.* 2006). Third, *gendered socialization and possible sex-based differences* may affect women's affinity or aptitude for CS study (e.g. Alper 1993; Lundeberg *et al.* 1994; Sax 1995; Cassell & Jenkins 1998; Stepulevage & Plumeridge 1998; Cohoon & Aspray 2006).

While a handful of studies have moved student perspectives toward the center of their analyses, they have seldom included women from diverse ethnic/racial groups 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 paper integrates perspectives of students from different ethnic/racial groups attending Minority-Serving Institutions with previously unexamined structural factors that influence women's decisions to abandon their computing educations.

## Methodology

An empirical study was conducted with women and men who had decided to major in computer science and computer engineering (CS/CE) fields in the United States. The study was carried out in seven institutions that granted undergraduate degrees in one or more CS and/or CE programs and were designated as Minority-Serving Institutions – 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 enrollment at a college or university must be at least 25 per cent of the total student enrollment. There are about 200 Hispanic-Serving Institutions. Historically Black Colleges and Universities were established prior to 1964 with the principal mission of educating Blacks, and are accredited by a nationally recognized accrediting agency or association. There are about 105 Historically Black Colleges and Universities. Tribal colleges and universities are those institutions that have an American Indian/Alaska Native student enrollment of 50 per cent of the total student enrollment. There are more than 30 tribal colleges and universities, most of them located on reservations (geographical areas with boundaries established by treaty, statute and/or executive or court order).

Primary data were gathered solely by the author for consistency through in-depth interviews in 2004–05. These sessions used interview guides that asked open-ended questions, and followed up with additional relevant questions or probes. The technique of in-depth interviews was considered useful primarily because there is little information on the barriers women in different ethnic/racial groups face in pursuing CS/CE education in Minority-Serving Institutions. In addition, orienting responses along issue-related axes and emphasizing text-embedded data revealed gender-based differences under certain types of external pressure.

Interviews were conducted with 150 students, divided into groups of 30 (15 female and 15 male) who belonged to one of the following five major ethnic/racial groups as designated by the US Census: White, Black, Hispanic, Asian, and American Indian. Random sampling was used to select subjects on sites with sufficient numbers of women and men; however, purposive sampling was used at sites lacking sufficient numbers of some groups (e.g. American Indians) majoring in CS/CE disciplines. All interviews were recorded with the permission of the interviewees and subsequently transcribed for analysis. Two independent coders coded the data for reliability. Nvivo software was utilized in analyzing the data.

### Inside the exodus

The problem of women's high attrition rates in the sciences, mathematics and engineering (SME) disciplines was brought to the forefront by Elaine Seymour and Nancy Hewitt in their book, *Talking about Leaving: Why Undergraduates Leave the Sciences* (1997). According to them, understanding women's exodus from SME education requires pondering the relative weight and interaction of various contributing factors. The primary causes of women abandoning SME majors are: reasons for choice of SME major proved inappropriate; poor teaching by faculty; inadequate advising coupled with academic problems; the perception that non-SME majors offered more interesting educational opportunities; loss of interest in SME; rejection of the lifestyle associated with SME; inadequate high school preparation in basic subjects; career options in SME not worth the effort required for the degree; curriculum overload; and loss of confidence due to low grades in the early years.

Jane Margolis and Allan Fisher in their pioneering work, *Unlocking the Clubhouse: Women in Computing* (2002), observed the outcome of similar factors converging in Carnegie Mellon University's CS program, most often during the sophomore year. They show that the most important factor for students to succeed as CS majors was enjoyment of computing (slightly higher for males as compared with females but still more than 60 per cent for both). At issue, then, was why women who decided to major in a CS

field because of their interest in computing ended up leaving CS education in disproportionate numbers. The key for Margolis and Fisher (2002) was that women tend to assess their own legitimacy as future computer scientists based on a distorted sense of their male peers' expert computing skills. Gendered socialization makes even well-qualified women extremely susceptible to the impediments represented by a daunting classroom climate, unsuccessful pedagogy, poor academic advising, and insufficient support of students. As a result, many woman undergraduates in CS programs experience a steep loss of confidence that leads to alienation and even depression. These students begin to lose interest and question their decision to study CS, which in turn makes them more likely to switch majors.

Margolis and Fisher (2002) argue that differential socialization and problems with curricula and teaching methodology converge to make women feel like outsiders, resulting in women being negatively affected by small slights far more than their male counterparts. They concur, in essence, with Seymour and Hewitt (1997), who posit that women's extrinsically oriented sense of self-worth renders them less able to tolerate the tests of endurance and tenacity that characterize the weeding-out process common to undergraduate SME programs, and which mirror the kinds of socialization familiar to boys. Women's perceptions of the inordinate difficulty of SME and CS degree programs may therefore be less a reflection of aptitude than a product of early socialization, which, for girls, typically does not emphasize competition as a meaningful way to receive feedback on their level of understanding.

Women-gendered dispositions flow from differential socialization – a kind of portable, reactive sensibility amassed from particular experience that Pierre Bourdieu (1977) has termed an individual's *habitus*. To the extent that women's socialization reflects a common gendered experience, their *habitus* causes them to attach greater significance to certain behaviors. In the context of a CS program, this amounts to the *subjective decoding* of convergent and mutually reinforcing objective conditions, such as women's obvious under-representation in the ranks of CS faculty and students, and the indifference, dismissive attitudes and hostility exhibited by male students and faculty. The dual outcome of this subjective decoding is, first, that women's presence is perceived as anomalous in relation to the existing practices and beliefs of the dominant group – that is, male students and faculty; and second, that this anomaly needs to be explained and made sense of by women (Varma *et al.* 2006).

An important question, however, is whether students from diverse backgrounds would cite the same reasons for considering a change from their CS major as their White counterparts. Seymour and Hewitt (1997) do investigate gender and ethnicity/race issues, but their concern is largely at the broader level of undergraduate students in SME, and not specifically as it applies to CS.

Margolis and Fisher's (2002) study is specific to CS; however, it was conducted at a single institution, Carnegie Mellon University, an elite institution ranking overall among the top 10 universities in the United States, with a CS department regularly ranked among the top five in the country. Both Carnegie Mellon University and its CS program have low representations of Black, Hispanic and American Indian students.

### Social control theory

In forwarding his theory of social control, sociologist John Braithwaite (1989) explains how culturally specific modalities of shaming may constitute a compelling control mechanism. According to Braithwaite (1989), one of the most effective modalities of shaming in the context of highly interdependent communities is indirect in nature: gossip – or more precisely, an individual's awareness or reasonable speculation that others are gossiping about him or her – which can have a profound effect on his or her propensity for engaging with others and embracing social norms.

The gendered, insular and competitive atmosphere prevailing in most CS programs comprises a social context that parallels Braithwaite's (1989) highly interdependent communities in important ways; in such a context, informal interactive mechanisms like student gossip can exert considerable force on individual perceptions and self-assessments; and this contextual-interactive similarity helps explain how comparatively few, often experientially remote phenomena can nevertheless exert a compelling influence on female students. The mechanism of gossip – both among men about women, and among women about how they are perceived by men – can make less common experiences appear ubiquitous, providing support for generalized perceptions of how men receive women's presence in CS programs *independent of or even contrary to* individual women's firsthand experiences.

In Braithwaite's (1989) communitarian theory of social control, human relations comprise a shifting skein of densely enmeshed interdependencies that, while not necessarily bilateral between any two given individuals, nevertheless underwrite a relatively stable expectation of general reciprocity and a resultant sense of belonging among community members. Some minimum frequency and quality of interaction with one's peers and with faculty constitutes the functional equivalent of Braithwaite's (1989) densely enmeshed interdependencies, and CS programs are therefore contextually analogous to Braithwaite's communitarian social settings (if only in this limited but important regard). Because women are keenly attuned to the frequency and quality of such interactions, their development of the general sense of reciprocity required to achieve a feeling of membership in the community of CS undergraduates is disproportionately contingent and precarious.

Due to the differential socialization of women and men, women are likely to decode certain behaviors or remarks as biased more often than do their male peers. The implication is that secondhand knowledge of some women's comparatively infrequent, negative experiences, and of men's negative impressions of women, somehow attains substantial immediacy and veracity among CS female students en masse. Precisely how this occurs, as well as how more general impressions based on such knowledge are reproduced over time, needs fuller explanation.

### **Contextual-interactive dynamics and women's perceived self-efficacy**

In response to the question of whether they have considered changing their majors from CS/CE to a different course of study, more than 50 per cent of the students responded positively, with 44 per cent saying they seriously considered leaving and the remaining 6 per cent saying they thought about it sometimes. More women (59 per cent) than men (44 per cent) seriously considered changing their CS/CE major. This sample does not include first-year students, therefore these students were thinking of changing their majors on the basis of their experience in CS/CE programs.

The difficulty of CS/CE curricula was the single most common reason cited by women and men who had seriously considered leaving. However, within that group, women were one-third more likely than men to find CS/CE study excessively difficult. Comparing different ethnic/racial categories, Black, Hispanic and American Indian women were much more likely to cite difficulty as a reason to leave CS/CE study than were their White counterparts, with Asian women complaining about difficulty least often. One White female student gave voice to this common perception: '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.' While complaining about the tedious nature of CS classes, an Asian woman said: 'Sometimes it is just too much, and it is getting to me.' An American Indian woman showed her frustration: 'Lately, I have been thinking of nursing. I am getting frustrated because computer science is hard. I feel like I am getting stuck.' A White woman recalled, 'When I kept failing the same classes, or at least struggling so hard, and feeling pushed out of this department, I thought about it'. Similarly, a Black woman said, 'There were times when I thought I will never get through programming classes, I will never learn programming, it is too hard and time consuming'. A Hispanic woman found herself 'burnt out' in the CS program. Clearly, the perception that CS/CE study is difficult was at the forefront of women's concerns.

One possible reason for this pattern is the interplay of gender and the socioeconomic status of minorities. Minority students (with the exception of Asians) are much more likely to have gone to disadvantaged elementary, middle and high schools. About 48 per cent of the students interviewed believed that their high schools did not prepare them 'at all' for CS/CE education at the undergraduate level, and another 37 per cent talked about being prepared 'moderately'. Among these students, women in every ethnic/racial category except Asian complained about the lack of preparation in high school. Furthermore, large numbers of non-Asian minority students reported gaining access to computers for the very first time in their junior or senior year of high school. In fact, students from every non-Asian minority category had less early exposure to computers than their White and Asian peers. Nevertheless, males among all ethnic/racial groups reported having had simple access to a home computer or their own computer while growing up, and said they enjoyed a greater level of access more often than did females.

In light of the fact that non-Asian minorities were, as an aggregate category, less likely to have had early exposure to computers, and because women within each ethnic/racial category were less likely to enjoy such exposure, and since women were invariably more likely to complain about the lack of preparation in mathematics in high school, gender and minority status would seem to constitute overlapping and reinforcing factors influencing expressions of inordinate difficulty – and, by extension, heightened vulnerability to leaving CS/CE programs.

Another prominent factor in women's decisions to consider leaving CS/CE study was the antagonism sometimes directed at women by their male peers and faculty. Hidden or overt animosity, or merely the refusal of male students and faculty members to take female students seriously, caused women to consider leaving CS/CE degree programs. Indeed, many aspects of this process are visible across ethnic/racial lines. This Black female student voiced a relatively common complaint about her male peers: 'Most of them feel you don't have anything to offer. I sat in a lab with a guy who has a program he has assembled and I am sitting there and I can help him, but he asks everyone else but me.' An Asian female talked about her male fellow students' arrogance: 'They are very smart. They know it and we know it. This makes them very arrogant. They show off their intelligence even when one is not looking for their help.' A White woman remarked about her male instructors, 'Some of my teachers make me feel like that I can never match their expectations. They definitely have attitude that I am stupid, we all are stupid.' Another Hispanic female complained about her male instructors, 'We are very stressed and defensive a lot of times. We are overworked, but professors are telling us we couldn't do it. And we are put in a position of feeling stupid. In other departments, you never get that.' An American Indian female believed that her instructors 'think I am

here because of [an American Indian initiative]. I don't really belong in the computer science program.' Such factors directly impact on the quality of the student experience.

Yet, in stepping back to look for suggestive patterns in the data, 63 per cent of women and 53 per cent of men reported no incidents specifically related to gender, with a much smaller number of women (11 per cent) and men (7 per cent) reporting that they possessed personal knowledge of prejudice against women. Reacting to a more specific question about equal treatment, 56 per cent of women and 60 per cent of men said that male students treat females as peers, while 20 per cent of women and 13 per cent of men remarked that male students are chauvinistic. In response to a more general, open-ended question about gender bias, a similar, if less divergent pattern emerged, with a large plurality (35 per cent of men and women combined) suggesting that women do not encounter any special problems, and just 17 per cent of students asserting that women do indeed encounter bias in the form of stereotypes or doubts about their abilities on the basis of gender. The question that is raised by this pattern in view of the ongoing situation is how comparatively infrequent negative experiences could have such an out-sized influence on so many women that they consider leaving CS/CE study.

All too often, women make sense of their anomalous presence and different ways of approaching CS/CE study by concluding that they do not belong. For example, a White female student said that, rather than pursuing a degree in CS/CE, 'a lot of women seem to go towards nursing and stuff that they grew up to know, taking care of people'. An American Indian woman remarked that CS/CE study required students to be, 'very logical, very non-communicative. I know a lot of girls who just have to talk to somebody.' A Hispanic woman responded that, 'perhaps women don't like it sitting in front of a monitor all day or perhaps they don't feel secure they are going to do well in that field'. The idea that women do not belong in CS/CE is frequently reinforced by the attitudes of their male peers as evidenced by the remarks of this White male: 'Most women go into a liberal arts major or sociology, or the life sciences majors. I don't think women and technical stuff go together.' His viewpoint is echoed in the remarks of an Asian male: 'Whenever you see a woman saying I am majoring in computer science or engineering, obviously there are some eyebrows raised. Some people are shocked'. A Black male student suggested, 'I think men tend to get into more logical fields, while women tend to get into more emotional fields'.

Indeed, the more sensitive male students recognized that women are socialized to believe that their academic and career options are limited by their gender: 'I think sometime in high school they get someone who tells them they can't do it, and they believe them.' A Black male suggested that, 'From elementary school and on, men are more encouraged than



women to do math and those science-type problems or classes'. This Hispanic male pointed to the influence of the family: 'I think a lot of times when you have a father who is an engineer, he would want his son to be an engineer and he will take all the necessary steps to help him along. But, he might not necessarily push his daughter.'

But the role of gendered socialization in rendering women less willing or able to abide the masculinized and often inhospitable atmosphere permeating an already rigorous program of study is only part of the equation. Another consideration is whether there exists an *entirely different category* of factors: namely, sexually generic social processes that serve to multiply the effects of comparatively infrequent and often experientially remote behavior or remarks *before* they are subsequently decoded through the prism of gendered socialization.

For example, it may seem unremarkable that males were eleven times more likely than females to believe that sexist attitudes can actually favor women, yet it is notable that when women's responses did reflect this belief, they offered little or no convincing evidence to support it. This White female student's response is particularly revealing in this regard: 'I don't feel any discrimination because I am a girl. But sometimes I wonder, you always wonder a little bit, "Oh, because I am a girl, is [my professor] making it easy on me?"' Similarly, another White woman spoke with an air of conviction about what she accepted as the perceived wisdom, despite the fact that her own experience constituted directly contradictory evidence: 'It just so happens that men have more logical minds. Women are good at English, men are more good at math. That has, like, always been the kind of norm. But, for some odd reason, I am better at math.' Similar, generalized impressions concerning women in CS/CE surfaced in the responses of even the most confident students, such as this otherwise self-assured Black woman: 'Some people just really think that you are not as competent as a man. I mean our abilities are questioned like a whole lot more than guys, even if we have the exact same training and stuff.' A fiercely determined Asian woman remarked, 'I think [female students] get scared away when there are no other girls, and then you find out guys are taking bets on how long you are going to be there. Initially, I was, like, "maybe I should leave". But I showed them.'

The regular appearance of these kinds of responses at all seven institutions across ethnic/racial lines, and among even the most confident students, reveals precisely the sort of generalized impressions that are likely to feed nagging doubts and have a devastating effect on women's self-confidence and sense of belonging, and demonstrates that these perceptions are shared by women students en masse. Moreover, when one considers two facts together – that such doubts surfaced regularly in the responses of the majority of women who maintained that they personally *had not* experienced any overt,

sex-based discrimination in their respective CS/CE programs, and that over 80 per cent of men and women said they knew someone who had left CS/CE well enough to volunteer a probable reason – it seems clear that what might easily be dismissed as idle gossip, or discredited as hearsay, plays a crucial role in the dissemination and validation of impressions that have been shown to influence women's decisions to leave CS/CE study. In short, the widely held assumption that women do not belong in CS/CE education forms an experiential common denominator for individual calculations of women's prospects for success; this regularly happens in the absence of firsthand experience of discrimination; and the process appears to be facilitated by secondhand knowledge acquired through the broadcasting mechanism of gossip.

Yet, it is not sufficient to demonstrate that women's awareness of how they are perceived transcends firsthand experience; one must get at the underlying process. What remains to be seen, in other words, is how group members who lack intimate relationships with each other nevertheless share connections that can powerfully influence their individual perceptions. Women tend to place much greater emphasis than do their male counterparts on the quality and quantity of interpersonal contact with peers and professors when evaluating their sense of belonging in CS/CE programs. The trepidation regularly expressed by students such as this American Indian woman about the prospect of interaction with her male peers thus takes on special significance: 'Sometimes, like, I am scared to speak or ask questions because of what guys might think because I am a woman.' Similarly, the common complaint that female students may be devalued *independent of* objective evidence of their performance becomes even more meaningful: 'Like, if I get an interview or whatever, they say it is because I am pretty and that is not true. It is because I have got a good GPA and I have a nice resume.' The preceding White student's remarks are echoed in the response of this highly motivated Black woman: 'Oh, absolutely I think that if women are given a challenging assignment, they need to be twice as good as a male counterpart, especially at the lab, where I think there are more male technically oriented people than female.' These relatively common impressions reinforce the proposition that the consequences of men's refusal to acknowledge women's aptitude, accomplishments or even the legitimacy of their presence extends beyond triggering a perceptual-emotional chain reaction front-loaded by differential socialization.

It is worth pointing out that since everyone in a community benefits from the reassuring presumption of membership to some degree, *any* individual could conceivably become vulnerable to potentially debilitating doubt below a certain threshold of anticipated frequency and quality of interaction. However, because women are socialized to rely more heavily than men on peer and professorial affirmation to remain fully engaged with CS/CE as a major field of study, that threshold is lower for women. They are, in other

words, more sensitive to and dependent on the contextual-interactive dynamics undergirding and reproducing a social context that does not recognize them as legitimate contributors.

An example of how this differential sensitivity is exacerbated by contextual-interactive dynamics such as departmental gossip involves the perceived difficulty of CS/CE study. Women who have been made to feel that they do not belong confront nagging doubts about their aptitude that are then reinforced by the widely circulated impression that women *as a group* find the requisite mathematics and programming classes more difficult. That generalized impression, in turn, compounds the pressure experienced by individual students such as this American Indian woman: 'You get this mentality, like, "Am I able to do this? Is this only for males? Am I doing the right thing"?' This Black woman gave voice to a resultant, underlying sense of futility detectable in the responses of many women: 'For some reason the guys are more prepared. I just don't know why.' Even through their defiant assertions of intellectual parity with men, some of the most confident women, such as this Asian student, tacitly acknowledged that what ultimately mattered was being able to approximate men's ability: 'I don't know what the words are to say, but, in some ways I feel that I get equal with the guys, yeah.' In short, contextual-interactive dynamics such as student gossip not only serve to supplant individual-level, objective indications of relative mastery with truisms about women in general; they also render such generalized impressions experientially immediate, infusing them with special veracity for individual women *regardless* of personal experience.

A final consideration is how a masculinized academic program particularly inhospitable to women could be reproduced within a surrounding society that espouses liberal-egalitarian ideals that are generally unsupportive of men's social dominance. The persistence of such an environment within academe is all the more vexing when one considers that the possession of such progressive ideals is strongly correlated with increasing levels of education and other indicators of higher socioeconomic status.

One answer to this evident paradox is that, due to the masculinization of CS/CE study and even of computing and computers themselves, CS/CE programs constitute relatively isolated sub-cultural contexts within whose boundaries some forms of gender inequity continue to thrive even as they have subsided in academe and in the surrounding society. Informal, contextual-interactive mechanisms facilitate the dissemination and validation of negative impressions regarding women in CS/CE education, which in turn exert a powerful influence on women's decisions to leave their degree programs. Moreover, this process converts the phenomenon of women's under-representation and disproportionate attrition into a self-fulfilling prophecy, reinforcing CS/CE programs as a social context uniquely suited to the continued tolerance and reproduction of such impressions.

## Conclusion

When students talk about leaving CS/CE, the reasons they cite are pragmatic, such as the time-consuming nature of CS/CE programs or difficulties they faced in the program, and not a loss of interest or lack of affinity as highlighted in the literature. Women who reported *no* firsthand experience with gender bias regularly expressed certain doubts about being a woman in CS/CE that were strikingly similar to those expressed by women who *had* experienced incidents of bias. Furthermore, there are important differences in the experiences of minority students, which complicates the proposition that gender figures more prominently than minority status in minority women's decisions to consider leaving CS/CE.

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