

THE EFFECT OF THE INTERNET ON WOMEN IN SCIENCE AND ENGINEERING

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Abstract *¾ This paper proposes that the Internet has had a positive effect on women, minorities, and disabled people in the fields of science and engineering. Distance learning courses have “leveled the playing field” for nontraditional students and faculty. In this author’s experience, gender issues are minimal in an electronic environment. In addition, the age, physical condition, and nationality of students and instructors are irrelevant on the Internet. Multiculturalism and diversity are easily incorporated into distance learning courses, for which information typically is gathered from all over the world. This environment is also appropriate for students who tend to be quiet in class. In a forum where they are required to post weekly discussions, it is easier for them to “speak out.” Thus, women seem to have a slight advantage in Internet courses. Their typically fine communication skills are an advantage in “virtual” forums, as compared to oral discussion in which loudness and confidence appear to be benefits.*

Index Terms *¾ The Internet, distance learning, on-line.*

INTRODUCTION

The ACM Code of Ethics and Professional Conduct states that all computer science professionals should “be fair and take action not to discriminate based on race, sex, religion, age, disability, national origin, etc.” [1] This code implies that we, as computer science professionals, must be alert not only concerning our own behavior, but also towards any discrimination within our sphere of influence. In general, actions that address the imbalance of women studying or employed in the computer science field can be effective for other populations. During periods of a weakened economy, such proactive behavior is particularly critical.

Women have traditionally been underrepresented in the fields of computer science and computer engineering. The 1988-89 Taulbee Survey [3] found that, in 1989, women were awarded 17.5% of CS doctorates, and constituted 6.5% of the CS faculty, with 9% of assistant professorships, 8% of associate professorships and 2.7% of full professorships. Between 1983-1986, about 36% of CS bachelor’s degrees and about 29% of CS master’s degrees were awarded to women [10]. The 1999-2000 Taulbee Survey [13] lists women as having been awarded 15% of PhD degrees in CS (and 14% in Computer Engineering), 26% of the Master’s Degrees in CS (20% in Computer Engineering) and 20% of the undergraduate degrees in CS (12% in Computer Engineering). Women constituted 26% of newly hired CS

teaching faculty – already a low number - yet only 12% of the tenure-track positions. (We do recognize that 17% of the newly hired faculty consisted of nonresident aliens, who tend to be male.) In this time frame, women constituted 14% of assistant CS professors, 13% of associate CS professors, and 8% of full CS professors. The 2000-2001 Taulbee Survey [14] found that women were awarded 16% of PhD degrees, 27% of Master’s degrees, and 20% of Bachelor’s degrees. In addition, women constituted 22% of newly hired CS teaching faculty, yet only 15% of the newly hired tenure-track faculty positions. According to the survey, 14% of assistant professors, 14% of associate professors, and 8% of full professors in CS were women [see Table 1].

TABLE I
TAULBEE SURVEY OF WOMEN IN COMPUTER SCIENCE

	1988-1989	1999-2000	2000-2001
Doctorates Earned	17.5%	15%	16%
Assistant Professors	9%	14%	14%
Associates Professors	8%	13%	14%
Full Professors	2.7%	8%	8%

Is this low percentage of women due to combined factors of lack of encouragement and cultural attitudes, different communication styles, family responsibilities, and/or discrimination in school and in the workplace, or can it be due to genetic factors? When given the opportunity, women and minorities perform at a level comparative to white males. The increased competence of women and minorities in sports and the medical and law professions and the success of women in recent Intel Science Talent Searches prove that long-held stereotypes of minorities’ innate limitations are simply prejudice. It is the responsibility of the scientific community in general, and of the membership of WEPAN in particular, to explore and encourage factors that provide opportunity and encouragement for women and minority groups.

This paper first discusses factors involved in the low representation of women in computer science. These are well known to WEPAN members and are well documented in the existing literature. For this survey we mainly review sources that have been influential on the current work in the

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area, although some encouraging recent trends are cited. We then revisit these factors in terms of how distance-learning courses can and do provide a better and more encouraging environment for women, and indeed for other minority groups. We review the experiences that we have had with distance learning courses and some of the methods that we have used to enhance classroom-based courses with Internet tools. We focus on those factors that we feel are encouraging to women, as well as for other groups that typically have not chosen computer science for their education. We then suggest areas for future research.

FACTORS INVOLVED IN THE UNDERREPRESENTATION OF WOMEN IN COMPUTER SCIENCE

Many different factors have been suggested as causing the unbalanced representation of women in engineering and computer science. These include discouragement, disparagement, disproportionate responsibilities, and discrimination.

Lack of Encouragement

Lack of encouragement has been recognized as a factor in the disproportionate representation of women in the computer science field. [11] Many cultures, including several represented in the United States, are biased against girls in mathematics and computer science education. Expectation of parents, peers, and lower grade teachers have made clear that hard sciences, in general, are not for girls. Yet, in the last ten years there has been considerable progress in the early school years; girls are taking as many AP mathematics courses as boys and receiving comparable grades in mathematics. However, the same is not true for computer science courses. Since material taught in early grades is prerequisite for a continued education in science, girls may be discouraged from pursuing computer science at higher levels. Can the Internet be used to assist high school teachers in encouraging female students?

Different kinds of toys are chosen for boys than for girls. Video games are commonly given to boys, while dolls are favorite gifts for girls. [3] This practice can prevent girls from achieving familiarity with computers at some level and thus discourage them from continuing study in the field. Recent surveys, however, indicate that there are computers in 60% of American households. More important perhaps, women, who constituted less than 5% of Internet users in 1995, have increased their numbers to more than 50% in 1999 [12]. Studies indicated that boys consider computers as extensions of themselves and take them apart as toys, while girls tend to use them as tools [4], to assist in achieving other goals. Even if these findings are currently accurate, women still have a wide range of computer science jobs available to them, since there are many areas in which computers are used mainly as tools. Computers are an integral part of many disciplines and computer science courses can include a

wide range of applications at an early point in the educational process. Since tenured professors tend to teach what they know, can existing courses be enhanced via the Internet? The work of Margolis and Fisher [7] directly addresses the issue of revising curriculums in support of women's interests.

All people must receive encouragement in order to obtain sufficient self-esteem to persist in their goals. When women enroll in advanced studies or begin their working careers, how are they treated? An environment that channels negative feedback (some failure is good for all of us – it is possibly the best way to learn), while encouraging positive feedback is essential. However, certain behavior is deadly. A study at Harvard University found that 32% of tenured female professors, 49% of non-tenured female professors, and 34% of female undergraduate reported being sexually harassed by a person who had authority over them [11] – a particularly humiliating experience. A study at MIT also reported cases of “TA’s hitting on women in their classes.” [7] Less threatening, but also harmful, women may be left out of top study groups or computer clubs or golfing expeditions. Can the Internet be used to form virtual communities, giving women the support that they badly need?

One advantage of affirmative action is that it gives women and minorities the opportunity to prove that they can do the job – there is no better boost to one's self esteem than being successful at a chosen task. Women and minorities, however, may feel patronized by affirmative action. There is an implication that the recipient is in some way inferior, that she is given brownie points that are not deserved. On the other hand, selective hiring and promoting practices that favor white men are common and somehow are accepted as merited. In addition, men who are considered good candidates for the old boys' network are evaluated differently than those who deviate from the standard. (Would the suspicious behavior of Ames and Hanssen have been ignored if they were Black or Spanish or women or Muslim or Jewish?) These problems will be alleviated in the computer science field once more women and minorities achieve high level positions.

Female role models are important to a woman's self esteem. One of my former students, who has been successfully employed in industry for many years, told me that she was encouraged by my treatment of the starred problems in the back of the text chapters and by my having a woman teaching high level courses. A former black CS student, who received her PhD degree this year, e-mailed me about how important the encouragement of female professors was to her progress. The gender and rank of computer science professors sends an unconscious message. It is discouraging to women that female teachers are hired disproportionately for non-tenure track positions. CS programs can and should be enhanced by quality “virtual” faculty.

Different Communication Styles

Women have less aggressive communication styles than men. One study found that 57% of men against 30% of women had confidence speaking up in class. In addition, 9% of women against 33% of men feared speaking up in class, lest they be embarrassed by incorrect answers. Women are interrupted more frequently when they speak, or ignored altogether, and they tend to be less confident and assertive [10]. Women don't flame [5], although they are frequently targets of flaming [6]. They have different styles of communication - they are hesitant to speak out in class and their speech tends to be differential. Yet, differential speech (e.g., Ada Lovelace's letters to George Babbage) is used against them when men find it convenient to do so. On the other hand, firm and forceful speech in women is frequently taken in a negative way.

When I was in graduate school, my quiz paper was graded incorrectly by a graduate assistant. When I tried to explain the answers to him, he did not understand. When I repeatedly tried to speak to the professor after class, he kept brushing me off. I finally reached him outside the classroom, actually by accident, and, in a few minutes, was able to explain my answer. He said he would raise the grade. A few days later, a fellow graduate student with whom I was friendly, and who sometimes went out for beers with the professors, reproached me for making a fuss about the mark. He said that the professor had told the rest of the faculty that I was an "aggressive female."

Although on-line courses per se will not make women less differential, they do guarantee access to the attention of the professor and of the class. If run properly, all students get equal "turns."

Balancing Career and Educational Responsibilities with Time and Safety Restrictions

The years in which tenure is awarded are typically the primary years of child bearing, and women still bear the major burden of child care. [11] The six-year publish or perish rule was designed for males without major family responsibilities. [3] Women are the traditional care-givers in our society, for parents and in-laws, for sick children and husbands. Besides the pressure in academia, some jobs in industry are notorious time hogs. It is not unusual for programmers and systems administrators to work through the night completing a project or cleaning a system that was attacked by a virus. Such work hours are inconsistent with many women's home responsibilities.

When women must work late, safety issues may also be of concern. Even if companies secure their buildings and parking lots, traveling on a subway or arriving home late in the evening has proven to be disastrous for some women. Safety may also be a factor for male workers, but women generally have more to fear. In addition, women may forgo work or educational opportunities because of their concern over safety.

Education can take note of the many women and men who work out of their homes, using their computers to access information or colleagues as needed. Not only can they balance their schedules according to their other responsibilities, but they save a significant amount of traveling time.

Discrimination in School and in the Workplace

Discrimination has been placed in a separate heading; yet, this factor should be considered as the superset for the previously discussed items. It doesn't matter if women have different communication styles or are geographically challenged or have onerous home responsibilities, as long as they are provided an environment with maximum support for their progress in education and employment.

But obviously this is not the case. Consider the situation at MIT: "In contrast to junior women, many tenured women faculty feel marginalized and excluded from a significant role in their departments. Marginalization increases as women progress through their careers at MIT. Examination of data revealed that marginalization was often accompanied by differences in salary, space, awards, resources, and response to outside offers between men and women faculty with women receiving less despite professional accomplishments equal to those of their male colleagues. An important finding was that this pattern repeats itself in successive generations of women faculty. The Committee found that, as of 1994, the percentage of women faculty in the School of Science (8%) had not changed significantly for at least 10 and probably 20 years." [8]

In my University, I know of only three cases where assistant professors were granted tenure while their requests for promotion to associate professors were denied in that year; all three of these were women. The basis for two of these rejections was insufficient committee service. Yet these two women had service records equivalent or better than males who were promoted in other years, and all of the women have stronger publishing records than the majority of our male associate professors. It would appear that the administration at FDU holds a different standard for women than for men.

MY EXPERIENCES WITH THE INTERNET

I have been incorporating the Internet into my computer science courses for at least 10 years. The Internet is a valuable resource, not only for on-line courses, but also for the enhancement of traditional classroom instruction. Internet-enhanced as well as Internet-based education is beneficial to women.

I assign e-mail accounts to students who do not already have them at the beginning of each semester, and use e-mail to answer questions. These are forwarded on a group mail to the entire class. Women and shy men find this

communication style helpful. Frequently, they are embarrassed to ask a question in class, but not by e-mail. I tell them that I will not forward the answer if so requested, and, in any case, if the question is really bad and my reply might embarrass the student, I answer it privately by e-mail. I belong to several mailing lists, such as the ACM TechNews. When I find an item that is relevant to a class, I forward it via the class mailing list.

I have assigned material to be obtained from the Internet, first from anonymous ftp sites, using Archie and Gopher, and later using search engines on Mosaic and then Netscape and Explorer. I used to assign written term papers. Then some of my students started to hand in papers that were obviously downloaded. Now I assign web pages, and ask students to summarize information that they find on web sites and reference it by links to the web sites. Not only are they learning to construct web pages, but, hopefully, to organize and digest the material they find. For team projects, students routinely use e-mail for communication. Note the advantages for women in using the Internet for research and for team contacts, particularly if they have family responsibilities or safety concerns.

My class notes on power point slides, sample midterms and finals, with answers, syllabus, etc. are posted on my web pages. This teaching tool is particularly effective for students who miss classes. (I have no reason to believe that women have poorer attendance records than men, although, during some semesters, students have missed classes because they had a baby or had to tend a sick child).

I was a panel member at an Internet "Show-N-Tell" Conference at Rutgers University on June 23, 1994. When I described to the conference how I used Internet tools, I received many inquiries about how to encourage other professors to add Internet-enhancement to their courses. (That situation has changed rapidly, but this section is partially written for those teachers that have not realized the many benefits of enhancing traditional courses with Internet tools.) Obviously, I came to on-line courses with a very positive attitude.

I have taught on-line courses for almost ten years. According to the numbers that I have collected, and as best as I can determine by the names given, grades for women are, on average, first rate. Although there have not been as many women as men students enrolled, I have found that the average grades for women students have been consistently higher than that for men. I have taught approximately 15 sections, mainly of Computer Networks and Introduction to Computer Science. The departmental courses have numbered approximately 35, mainly of Database Systems, Management Information Systems, and Computer Architecture. The class enrolment has varied from 5 up to 20, but this variance have not affected the statistical results.

The first such course that I taught was through a text based blackboard system, chosen by the Academic Computing Center. The tool was poor, requiring different control codes for entering and retrieving material and for

going to other parts of the system and was difficult for students; I dropped the tool. I ran the entire course through e-mail, although I was unhappy with this method. All the later tools that we have used for distance learning have had hyperlinks and GUI interfaces. Although I do post power-point slides and other reference material using these tools, my primary teaching tool has been a forum (implemented with a hyperlink graphical blackboard) on which all students are required to post weekly material. Assigned material may be problems or case studies from the textbook, or perhaps looking up material on cutting edge technology that is found on the Internet but not in textbooks. My favorite web course is a graduate course in Computer Networks. The textbook that I use has numerous web references, and there is an abundance of material on the web for this course. I do not use a chat room.

The following statistics are for the 10 most recent of my web courses. The number of students totaled 20 females and 52 males. The average female grade was 3.2. The average male grade was 3.04. A student assistant obtained for me grade rosters for recent web courses that our department ran and also determined the sex of each student from the school database. I received 14 web-course rosters, which contained 42 female student grades with an average value of 3.6 and 95 male student grades with an average value of 3.33 [see Table 2].

TABLE 2
STATISTICS FOR STUDENTS ENROLLED IN 14 CS DISTANCE LEARNING
COURSES AT FAIRLEIGH DICKINSON UNIVERSITY

Grade	Weight	# of women	# of men	Weighted grades for women	Weighted grades for men
A	4	22	39	88	156
A-	3.65	6	12	21.9	43.8
B+	3.33	4	16	13.32	53.28
B	3	6	7	18	21
B-	2.67	3	7	8.01	18.69
C+	2.33	1	5	2.33	11.65
C	2	0	6	0	12
F	0	0	3	0	0
Totals		42	95	151.56	316.42
Average				3.60	3.33

I consider these numbers as valid for a randomly chosen sample. Although I have not recently compiled statistics for in-class courses, my department chair did compile such statistics for my classes some years ago. He found that I awarded average female grades that were less than .1% above that for males, which is less than the averages for my distance learning courses. These results are meant only to show a pattern. [See Table 2]

Fairleigh Dickinson University has become the first traditional University in the United States to require all undergraduate students to enroll in one on-line course each year. The first required on-line course for freshmen (and freshmen) was introduced in September 2001. This course is hybrid - that is, material is presented both in class

and on-line. The University has hired fifteen international adjunct faculty members who will participate in presenting portions of courses from other countries.

THE INTERNET AND DISCRIMINATION

I am not necessarily championing distance learning courses. Rather, I claim that I have found that this media helps to overcome some of the hurdles that women face in their quest for education. Consider the categories mentioned in the second section of this paper: lack of encouragement and cultural attitudes, different communication styles, balancing family with educational and work requirements, and discrimination in school and in the workplace.

The Internet is already being used for dissemination of opportunities in the computer science profession [2]. We can create more web sites that contain success stories of women and minorities in computer science, and information on the different fields that provide opportunities for computer science graduates. As we have stated, women are now the majority of Internet users, and these sites should be recommended for parents and teachers as well.

We can encourage women who enroll in on-line courses by having courses, or sections of courses, taught by women. Of most importance is that female professors cover difficult areas of study. Although a class-based course could also have visiting professors, the Internet makes this much easier. Even the obvious shortage of authoritative female faculty can be alleviated by the elimination of geographic barriers (see MentorNet, below). Alternatively, we can avoid gender identification of professors and students altogether.

Women can form virtual groups, such as MentorNet [9], which pairs women in industry with students. Because women are sorely underrepresented in the engineering fields, there may be insufficient role models to assist female perspective engineers and computer scientists at some locations. The Internet is used to form an electronically connected community, providing needed encouragement.

By requiring "class participation" to be posted as part of the class grade, women must enter into the "conversation." Since interaction is written and off-line, rather than oral, men cannot easily dominate the discussion, and display of self-confidence and assertiveness is limited. I have found that women have better written communication skills, on average, and this balances the fact that some of the men have superior technical backgrounds.

Consider the advantages of an on-line course for any student that finds traveling to school a problem, perhaps in terms of commuting, care-giving, or of safety. In fact, consider an employee who has a disability or does not live within traveling distance of a University, or has difficulty understanding spoken English and needs more time to ponder the presented material. Even a blind person (and certainly a deaf one) can learn much easier through a web course, where she can study the material at her own pace. The Internet has been a boon for many nontraditional

students and employees. It is particularly so for women who have care-giving responsibilities or safety considerations.

How do on-line courses benefit a female faculty member? As part of my teaching responsibilities, I conduct classes on two evenings a week, from 8 P.M. to 10:45 P.M. I have been assigned courses off campus as well, including traveling an hour and a half each way in the evening. I was and still am not comfortable traveling by myself at night. I much prefer to teach through the Internet. I have found that on line courses also have advantages for women teachers in the method of presentation. Student and peer evaluations may be biased towards factors that favor males. There are many male professors who are considered great teachers because they sound very confident as they tell their "war stories." I have sat in on a few of their classes, and afterwards I asked myself, what did I learn? You cannot run a distance learning class with war stories. It is also possible that students, particularly some of our male international students, treat in-class teachers differently based on gender.

I have never heard of a complaint of sexual intimidation from distance learning students. As long as photographs are not provided, I doubt that a professor would pursue a student on-line. I have heard of male professors who made some off-color jokes or comments in traditional classrooms; would they have been willing to write these on a web page for all to see? Would a professor risk sending these by e-mail?

Clearly, the Internet provides close to a neutral environment concerning gender and physical disability for both teachers and students. Although research on gender issues in computer-mediated communication shows that male aggression can still affect women adversely, perhaps causing women to drop out of on-line groups or post less frequently [4], careful oversight by professors can limit such behavior in virtual classrooms. These issues should be considered carefully when running a distance-learning course, particularly if chat rooms are used.

MULTICULTURALISM

We might define multiculturalism as the support of the social, intellectual, and artistic activity of people from all parts of the world. Thus multiculturalism must ensure that all people can take pride in their individual identities. Disabilities, gender, age, and other distinguishing characteristics are part of our identities, and education and employment are the center of our social and intellectual activity. The ACM Code of Ethics is thus integral to multiculturalism.

The Internet does not know geographic or cultural barriers. Of course, some web pages are in other languages, and you can decipher their location from their web addresses, but so what? It takes approximately the same amount of time to access information from anywhere in the world. The Internet allows groups of geographically and culturally dispersed people to create a supportive close-knit community based solely on shared interests.

A course is such a community. An on-line course can be taught by a group of professors from all over the world, each providing her culture's approach to a topic. Such an approach is relevant to the material covered in computer science courses. For example, a network class might include a case study for the design of a local area network. Expertise would probably vary: European professors might be more expert at signaling codes, Japanese professors could be more up-to-date on always-on wireless networks, U.S. professors would probably be more concerned about security. Professors and students from differing countries would take different approaches to wiring or wireless installations, mixed gender or separate gender laboratories, the amount of funds available, the cost and thus the number of laboratory assistants to hire, etc. Case studies, in general, would have to factor in different conditions in different countries. In a global economy, companies and employees from all over the world are in competition and in cooperation and this is mirrored in each Internet community.

Jane Margolis and Allan Fisher [7] have found that women prefer an interdisciplinary approach to computer science. As stated previously, women look at computers as a tool rather than as a primary goal. Indeed, Fisher and Margolis have found that the Internet is useful in developing such courses, which perhaps some tenured faculty are not entirely equipped to handle. Although their research has currently been focused on women, Fisher and Margolis' methods can easily be applied to other populations.

CONCLUSION

The patterns of enrolment of female students in advanced computer science degree programs and of employment of females in high level professorship positions is dismal, and has generally not improved over the last ten years. We view the Internet as an important tool for addressing this situation.

Women professors have found that teaching courses on the Internet, when taken as part of their normal course load, eliminates some of the negative factors of their employment. Female students may find encouragement in the method of instruction. Web instructors can moderate courses to ensure that female students are not discouraged by male participation. Courses can be customized to meet the needs of diverse populations.

Studies are needed on how best to leverage the Internet in order to further the education of diverse student populations. Should teachers and students be anonymous, so that their gender and nationality are not recognizable from their names? Are men still "hogging" the discussion groups; is their apparent confidence intimidating to others? If so, how can we boost the confidence of women (and of less assertive or experienced men)? What types of assignments and curriculums are more appropriate for women? Statistics of Internet-based courses need to be collected and contrasted with classroom-based courses. Professors and students should be surveyed for their opinions and for suggestions for

improvements. There are many insights that an international outlook will add to students and material. Teaching objectives and methods for promoting multiculturalism through a learning environment can be enhanced to assist women's education as well. Statistics should be kept and carefully evaluated to certify and adapt the capabilities of the Internet for promoting female representation in computer science education, both as students and as teachers. Much work lies ahead, but I am very positive based on my preliminary findings.

I want to thank the men and women who have preceded me in their work towards encouraging women to pursue careers in mathematics and computer science. Without this help, I know that I would not have been able to complete my education and continue my work.

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