Gender in IT Undergraduate Education:
Institutional Choices

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INTRODUCTION

While the issue of attracting women to information technology professions has been studied extensively since the 1970's, the gender gap in IT continues to be a significant social and economic problem (Thom, 2001). Numerous research studies have been conducted to understand the underlying reasons for the gender gap in IT (Gurer and Camp, 2002). Universities and colleges have developed a variety of programmatic efforts to apply the results of the gender gap research to implement strategies that increase female undergraduate enrollment in computer science programs (Wardle and Burton, 2002). Yet, individual successes have not translated into any significant change in the overall percentages of women choosing IT. An analysis of current choices of women in their selection of four year undergraduate institutions reveals yet another alarming trend – young women are not choosing to study IT at the traditional academic four year institutions that would best prepare them for the IT professional careers of the future.

To complicate matters, the information technology job market is changing rapidly. For example, some well-documented IT trends that are causing shifts in the fundamental nature of IT work are outsourcing, the commoditization of IT, the effect of the dot com bust on the job market, and most importantly, the integration of IT into the fundamental economic, social and cultural fabric of our society. IT now permeates every aspect of professional work, even the traditional female-oriented occupations such as nursing and teaching. This integration of IT into the professions must guide the development of a new set of strategies to insure that women have equal opportunities and access to the benefits of an education that prepares them for professional careers. It is in the best interest of the IT profession and our society in general to help young women make the right choices about the study and pursuit of information technology at an early age.

BACKGROUND

The underrepresentation of women in IT is a critical issue of equity and access for women due to the pervasiveness of computing in our society, the many economic opportunities afforded those who have technology skills and knowledge, and value of diversity for this profession (Cohoon, 2003). Although job opportunities in technology companies and technology-oriented industries have recently declined, the need for advanced technology skills in mainstream professional and business careers and entrepreneurship remains critical (Thibodeau, 2004). Nearly 75 percent of future jobs will require the use of technology, 8 of the 10 fastest growing occupations between 2000 and 2010 will be computer-related, and the annual mean salary for computer and technology occupations remains significantly above average compared to all occupations (U.S. Department of Labor, 2004). Thus, the IT gender gap translates into salary and employment inequities.

Table 1 shows that in 1996, women were 41% of the IT workforce compared to 34.9% in 2002, yet they accounted for 46% and 46.6% of the overall workforce in 1996 and 2002, respectively. Note that, in 1996 and 2002, the higher percentage of females was due largely to greater numbers of women in Data Entry and Computer Operator positions, jobs that required less formal education and experience, and provide lower pay. In fact, in both years, women account for over 81% of the data entry positions. The current lack of women in the IT workforce is in part, a consequence of women not choosing IT undergraduate degree programs or dropping out of these majors.

One traditional path into the IT profession is the completion of an undergraduate degree in Information Technology. However, the percentage of undergraduate degrees awarded to women in Computer Science and Information Technology as reported by the National Center for Education Statistics has declined since 1986 (See Table 2). It is well-known that one approach to moving women into IT is through the educational pipeline, that is, motivating young women to explore these career paths early in life and to choose IT degree programs.

Table 1: Women in the IT Workforce versus Overall Workforce (1996 and 2002)

2002 Total	2002	2002		1996	
Employed (thousands)	Total	% Men	% Women	% Men	% Women
Electrical and electronic engineers	677	89.7	10.3	92	8
Computer systems analysts and scientists	1,742	72.2	27.8	72	28
Operation and systems researchers and analysts	238	51.3	48.7	57	43
Computer programmers	605	74.4	25.6	69	31
Computer operators	301	53.2	46.8	40	60
Data entry keyers	595	18.3	81.8	15	85
Total IT occupations	4,158	65.1	34.9	59	41
All Occupations	136,485	53.4	46.6	54	46

Source: Bureau of Labor Statistics

Table 2: Computer/ information science bachelor's degrees awarded

Year		Degrees awarded			
		Total	Men	Women	% Women
1986		42,195	27,069	15,126	35.8
1987		39,927	26,038	13,889	34.8
1988		34,896	23,543	11,353	32.5
1989		30,963	21,418	9,545	30.8
1990		27,695	19,321	8,374	30.2
1991		25,410	17,896	7,514	29.6
1992		24,958	17,748	7,210	28.9
1993		24,580	17,629	6,951	28.3
1994		24,553	17,533	7,020	28.6
1995		24,769	17,706	7,063	28.5
1996		24,545	17,773	6,772	27.6
1997		25,393	18,490	6,903	27.2
1998		27,674	20,235	7,439	26.9
2000		37,388	26,914	10,474	28.0
NOTE:		Data not available for 1999			

Source: National Center for Education Statistics

Despite the benefits of professional technology careers and the advancements of women in many other fields, little progress has been made in moving women through the educational pipeline in computer science (Camp, 1997). In fact, less than 33 percent of participants in computer courses and related activities in high schools are girls (AAUW, 2000).

The extensive literature on this topic (Baum, 1990, Beyer, Rynes, and Haller, 2004, Gurer and Camp, 2002, Klawe and Leveson, 1995) provides us with many reasons why IT is not attractive to young women. Potential causes of the gender gap includes: unsupportive academic environment, the perception of computing as a male-oriented profession, gender differences in how students assess their own performance, lack of role models and insufficient critical mass of female students and faculty to build community.

Colleges and universities face additional challenges in recruiting women. Because of the pipeline issue, women are often less experienced in computing when they enter college, computer science department cultures and software are typically male-oriented and don't appeal to women, there is a lack of visibility regarding the social value of computing that would appeal to women. Furthermore, while some institutions have been successful in recruiting females to undergraduate computer science programs (Fisher and Margolis, 2002, Roberts, Kassianidou, and Irani, 2002), the percentage of women in these disciplines for most institutions continues to decline (ITAA, 2002). Cohoon (2001) argues that, based on her investigation of the University of Virginia's CS department, the characteristics and practices of computer science departments affect female retention at the undergraduate level and inherent female characteristics are an insufficient explanation of women's underrepresentation in computer science. In fact, women themselves tell us why they are not choosing IT, often indicating they find IT uninteresting or perceive that it is more difficult academically than other professions such as surgery and law (Weinberger, 2004). Individual characteristics and environmental influences are explored to provide a perspective on women in IT in Trauth (2002) in order to better understand women's lack of involvement in IT.

Numerous recommendations to assist educational institutions and academic departments in attracting women to undergraduate degree programs in IT appear in the extensive body of research on gender and IT (Baum, 1990, Cohoon, 2003, Cuny and Aspry, 2000, Wardle and Burton, 2002). Colleges and universities and academic departments that have been successful in increasing the number of women in technology have shared their strategies for recruiting and retaining female undergraduate students (e.g., Baum, 1990, Margolis and Fisher, 2002). They encourage institutions to establish and fund university programs and policies to expand the recruitment pool, provide a supportive climate with appropriate student services, broaden (not weaken) admission requirements, offer bridge programs, educate parents and teachers on gender issues, expand undergraduate research opportunities, and build supportive communities of learning through role models and mentoring.

Nevertheless, these successes are not widespread and the question of why women are not choosing computing as a major is a question that may benefit from institutional research. Exploring the characteristics of institutions that have been successful in attracting women may help us to better understand the choices that women are making when they do choose to pursue an undergraduate degree in IT.

USING DATA MINING TO DISCOVER WOMEN'S EDUCATIONAL CHOICES

Data mining refers to a set of techniques used to search large amounts of data for patterns. Rather than specifying a hypothesis, selecting a sample, and performing a test of the hypothesis, data mining instead searches the data for patterns that occur within it. Thus, it is a set of data driven techniques. The knowledge contained within the data set gives shape to the model that is created. Three of the most used data mining techniques are cluster analysis, association analysis, and decision trees. In this analysis, we only used descriptive analysis as a first step in analyzing our data. Descriptive analysis was used to search a large data set for patterns and associations related to educational choices of women.

When a young woman leaves high school for college, she is making a career decision that can influence the path she takes for the rest of her life. Not only the choice of major, but also the choice of the institution itself can have long-lasting effects on the possibilities available to her thereafter. The following preliminary research study compares institutions where women, in large numbers and in very small numbers, have chosen to concentrate in some IT-related major.

This study uses IPEDS (Institutional Post-Secondary Educational Statistics) data for 2000-2001. The purpose of this project is to discover the factors associated with the type of institutions that have demonstrated success in attracting women to IT programs, using data mining techniques. The comprehensive IPEDS data set contains variables related to characteristics of the institution, including enrollment numbers by academic discipline using a variable called the CIPCODE (Classification of Instructional Program Code) reported by institutions of higher ed.

Table 3 shows the factors from the IPEDS data that we chose to examine for this study, based on previous studies. Four-year institutions that offered an undergraduate degree in Information Technology in 2000-01 composed the data set to be analyzed. The number of female students across the IS/IT CIP codes in Table 4 was calculated to give a total for each institution. This sum was divided by the total number of students at the institution, then multiplied by 100, to generate our target variable: Percent of women in IT/IS at the institution. This yielded a total of 985 institutions for our analysis. Institutions that had missing values on the variables considered, including both Not Reported and Not Applicable, were deleted

All institutions were sorted by the value of the target variable. The group with the greatest percentage of women majoring in IT/IS areas is hereafter called the top group. Those institutions with the smallest number of women majoring in IT/IS areas is called the bottom group. In the top group of schools, the proportion of females is 0.78% or higher and there are 121 schools in this category. The bottom group is the set of schools with the lowest female representation, that is, under .06% and it contains 119 colleges and universities. Though the sizes of these two groups are about the same, they have very different sets of values on the IPEDS category variables as can be seen in Table 5. In our analysis, we will only focus on those which either provided new insights or great contrast between the two groups.

What are the characteristics of institutions that have the greatest percentage of women IT majors in their overall undergraduate population? The variables which show the greatest differences between the groups are: size, affiliation, highest degree offered, accreditation, placement services offered, dorms, athletic association, and entrance requirements. From the data, we observe that 22.3% of the top group are non-accredited while only 11.8% of the bottom group are non-accredited. Of the schools with the lowest female representation, 49.6% are public institutions, 0% are for profit, 21% are private, non-profit, nonreligious and 29.4% are private, nonprofit, religious institutions. For those with the most females in IT, these numbers are 30.6% public, 31.4% for profit, 24% private, nonprofit, nonreligious and 14% private, nonprofit, religious. Thus, for the group with the best female representation, they break out into fewer publics (14% vs. 49.6%) and more private nonreligious institutions (31.4% vs. 21%). For the bottom group, 97% of the schools belong to an athletic association, but for the top group, this drops to 64.5%. We also note that 97.5% of the bottom group offer dormitories, while only 66% of the top group are schools are residential. The data also shows that 22.3% of the schools with high representation of women do not offer placement services as compared to 3.4% for schools with lower numbers of females in IT. Finally, 33% of the schools that have higher concentrations of women in IT offer nothing higher than a bachelors' degree, while 88.2% in the group not chosen by women offer masters' and doctoral programs.

Looking at this data in total, we see that the top group institutions tend to be smaller in size, private, and do not offer doctoral degrees. They are less likely to have any athletic association, to require an admissions test or secondary school GPA, or to provide dormitories.

Table 3: Factors Explored As Influencing Women's Choices of Postsecondary Institution for IT undergraduate degree programs

ACCRD1
Institution is accredited (yes or no)

ADCON1
Secondary school GPA

ADCON7
Admission test scores

AFFIL
Affiliation of Institution (public, private and for profit, private and nonprofit and nonreligious, private and nonprofit and religious)

ATHASSOC
Athletic association (yes or no)

BOARD
Provides a meal plan (yes or no)

CALSYS
Calendar system

HDEGOFFR
Highest degree offered (bachelors, masters. Doctoral)

HOSPITAL
University has a hospital (yes or no)

LOCALE
Degree of urbanization

OBEREG
Region code

ROOM
Provides on-campus housing (yes or no)

SECTOR
Sector of the institution

STUSRV3
Offers on-campus jobs to students

STUSRV4
Offers placement services to degree completers

TUITVARY
Tuition varies for out-of-state students

Table 4: Cipcodes used in study of IPEDS data, 2000-2001

COMPUTER AND INFORMATION SCIENCES, GENERAL
COMPUTER PROGRAMMING
DATA PROCESSING TECHNOLOGY/TECHNICIAN
INFORMATION SCIENCES AND SYSTEMS
COMPUTER SYSTEMS ANALYSIS
COMPUTER SCIENCE
COMPUTER AND INFORMATION SCIENCES, OTHER
COMPUTER TEACHER EDUCATION
COMPUTER ENGINEERING TECHNOLOGY/TECHNICI
COMPUTER MAINTENANCE TECHNOLOGY/TECHNICI
MATHEMATICS AND COMPUTER SCIENCE
INFORMATION PROCESSING/DATA ENTRY TECHNOLOGY
MANAGEMENT INFORMATION SYSTEMS AND BUSINESS DATA
BUSINESS COMPUTER PROGRAMMING/PROGRAMM
BUSINESS SYSTEMS ANALYSIS AND DESIGN
BUSINESS SYSTEMS NETWORKING AND TELECOMM
BUSINESS COMPUTER FACILITIES OPERATOR
BUSINESS INFORMATION AND DATA PROCESSING

Table 5: Characteristics of the Top and Bottom Institutions with Respect to Female Representation in IT Programs

Group		**Bottom**	**Top**
Percent Women in IT		.0599 or less	.7817 or more
Total in Group		119	121
Avg Total Students		7947	4134

Category		**Percentages in Category**	
		%	%
Affiliation	Private, for profit	0.0	30.6
	Private, NFP, not religious	21.0	31.4
	Private, NFP, religious	29.4	24.0
	Public	49.6	14.0
Highest Degree Offered	Bachelors	11.8	33.1
	Masters	49.6	37.2
	Doctorate	38.7	29.8
Accredited	No	11.8	22.3
	Yes	88.2	77.7
Placement Services	No	3.4	22.3
	Yes	96.6	77.7
Dorms	No	2.5	33.9
	Yes	97.5	66.1
GPA Required for Admission	Neither	5.9	25.6
	Recommend	18.5	14.9
	Required	75.6	59.5
Test Required for Admission	Neither	0.0	10.7
	Recommend	2.5	17.4
	Required	97.5	71.9
Athletic Association Member	No	3.4	35.5
	Yes	96.6	64.5

FUTURE TRENDS

As many of the previous studies examining the gender gap indicate, this is a complex problem and one that requires a comprehensive, yet focused, institutional and departmental strategy in order to bring about significant change. One critical component that will impact the agenda to increase IT enrollments is the changing face of the IT profession over the next decade. The traditional approaches employed must be supplemented with new strategies, addressing future IT trends such as outsourcing, the commoditization of IT, the effect of the dot com bust on the job market, the integration of IT into the fundamental economic, social and cultural fabric of our society, and the cycles of interest in academic areas of the current and future generations of undergraduate students.

There are multiple challenges – understanding why girls and women make the educational choices they do, attempting to change the culture to help them make choices that will prepare them for technology careers, and predict how the IT profession will change in the short run and the long run. In the short run, we see that the global economy and new impetus on IT to deliver business value are changing jobs from those that require traditional programming and software development skills to jobs such as project management and application integration that require teamwork and organizational skills (Thibodeau, 2004). In the long run, we need to design new ways to educate girls and women on the opportunities of using IT in many non-IT professions and engage them early on in interesting, challenging and meaningful work requiring technology skills. For example, areas such as nursing, teaching, marketing, social work and human resource management that have a large female professional staff are becoming increasingly IT-oriented. Specific examples are medical informatics in healthcare, customer relationship management in marketing, and meeting the needs of K-12 tech-saavy students.

CONCLUSIONS

Based on the research conducted to-date and the analysis presented here, there are several conclusions and consequent recommendations for reducing the gender gap in IT. First and foremost, we need to educate girls and young women while they are in elementary and high school to help them make better choices regarding their future and view of their lives beyond college. The pipeline begins at a very young age and stereotypes and barriers are established early in life. If they are getting their degrees at unaccredited, non-Ph.D. granting schools, we will not see them at research universities in the future, adding to further decline in the pipeline. Specific recommendations are shown in table 6, incorporating what we have learned about the gender issue.

First and foremost, we must provide interventions early in girls' lives through programs that reach them and their teachers, parents, and counselors. If young girls are choosing to attend nontraditional and two year programs, then we must connect with them at the community college level and align ourselves with these institutions. Aggressive recruiting and then providing "gap education", i.e., classes, workshops or seminars to bridge the gap between their educational background and those of the students who follow a more traditional path is the next recommendation. Finally, the ultimate challenge will come for all IT students as we better align our undergraduate curricula with the skills and knowledge needed to succeed in the next generation of computing.

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Table 6: Recommendations for Attracting Female Students to Undergraduate IT Programs

- Offer pre-college experiences such as summer technology camps
- Educate local high school counselors and teachers about women and IT careers
- Align 4 year programs with community college programs
- Provide “gap” educational programs to prepare students coming from institutions with different academic standards
- Develop baccalaureate programs that provide the skills needed for today’s IT workforce
- Offer an array of ways to major in technology – CS, MIS, IS
- Hire faculty and staff who can provide insights into the variety of IT-related careers

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Terms and Definitions

Accredited institution: Institution that is accredited by national institutional or specialized accrediting agency that establishes operating standards for educational or professional institutions and programs, determine the extent to which the standards are met and publicly announce their findings.

Computer science: Study of data, computation and information processing, including methodologies, processes, hardware, software, and applications.

Data mining: Search of large-scale databases for patterns and trends using a variety of techniques implemented by computer software, sometimes referred to as KDD, knowledge discovery in databases.

Gender roles: Professional or social roles associated with males or females that are socially acceptable and considered to be the norm.

Gender studies: Theoretical and empirical work that focuses on gender in society and language.

Information Technology: The technology associated with information processing, including computer hardware and software used to store, process and transmit data and information.

IPEDS: The Integrated Postsecondary Education Data System (IPEDS), established as the core postsecondary education data collection program for the National Center for Education Statistics, is a system of system of surveys designed to collect data from all primary providers of postsecondary education.

pipeline: Channel or set of connecting links that move an object from start to finish; used metaphorically to represent the number of qualified individuals who move from one stage in the educational process to another.

Private, for-profit institution: A private institution in which the individual or agency in control receives compensation other than wages, rent, or other expenses for the assumption of risk.

Private, nonprofit institution: A private institution in which the individual or agency in control receives no compensation other than wages, rent, or other expenses for the assumption of risk. These include both independent and those affiliated with a religious organization.

Public institution: An educational institution whose programs and activities are operated by publicly elected or appointed school officials and supported primarily by public funds.