Geek Mythologies: Gender and Computing

Susan Detrie

Teachers College, Columbia University

Abstract

Computing technology has had increasing global impact, but participation of women in computer science has declined in the United States and around the globe, even with significant growth of computer and information technology jobs. Social constructs, myths and culture have shaped ideas about computing, especially in relation to gender and computing, creating barriers women must cross to succeed. History shows intervention and support impacts women's participation positively, and a review of U.S. computing history from the 1940's on shows periods of increased involvement and significant contributions to the field when women's participation is encouraged. Computing history also reveals where, when and how barriers came to exist, informing a path forward to increasing participation in computer science.

Keywords: women; computing history; underrepresentation; culture; myths

Introduction

Computing technology has had a tremendous global impact over the last several decades, increasingly becoming a main source of jobs and innovation, as well as altering the daily lives of people everywhere. In light of this impact, and with the growing number of job opportunities, universities and employers might expect to see increased enrollment and participation by women in informational and computing technology programs but this has not been the case. Instead, the number of women in computing education and in computing and informational technology professions has declined. This is true, not just in the United States, but in many countries around the globe. (Cohoon, 2011)

Looking at other countries around the globe, there is a similar pattern of decline in the number of women in computer science, and many Western countries have record low points in enrollment and participation. The few countries that are exceptions to this decline in participation by women, like Malaysia, however, are significant because they hold clues to how cultures address the issue of gender and involvement in computer science. Though it is certain each country followed it's own distinctive path to women disengaging from computer science professions, it is clear that culture, it's social constructs and it's social myths are a potent element of the decline, along with other factors like educational support systems and employment of women in the computing industry.

It will true, both here in the U.S. and globally, without more comprehensive societal attention to the declines, women will use much of the technology innovation of the future, but few and fewer women will be involved in creating it. More significantly, with the projected growth of computing jobs, fewer women and their families will gain the economic benefits associated with technology participation, creation and innovation, perpetuating a potentially larger gender gap in wages. Here in the U.S., the United States Department of Commerce reports that women in STEM fields overall earn 33% more then their non-STEM counterparts (U.S. Department of Commerce, 2011), making the issue of economic advancement for women not just an issue of educational and industry barriers being removed, but an issue of creating a more enlightened cultural narrative about computer science and women.

In many respects, the mythologies that have been constructed around computing can be reshaped by looking back at computing history and understanding the peaks in women's participation in the computing industry. Going back to as early as Word War II and the creation of the first American computer, the ENAIC, women have entered computing, helped to create the field of programming (Light, 1999), been successful in computing and then left computing in several cycles over six decades. (Misa, 2010) Though culture has changed over these six decades, and the role of women in civic life and the workforce has increased,

these distinct cycles of participation and exclusion (or disinterest) are evident in the research of the history of computing technology and stands as something unique about computer science. Unlike most fields, where the numbers of women grew as women working outside the home were increasingly accepted, computer science has progressed very differently, exposing the myths and cultural bias surrounding the field.

Gender and Computing

The data: computing education in the U.S. - and around the globe.

In the United States, there has been a significant decline in the number of women majoring in computer science. Cohoon (2011) states, “Young women comprise few of the college-bound students who intend a computing major. Their representation in this group has declined for more than twenty years, and since 2005 has hovered at about 12 or 13 percent.” (p. 526) From 1985 to 2005, the proportion of computer science degrees awarded to women dropped from 37% to 22% (National Science Foundation, 2008), while science and engineering degrees earned by women overall increased from 12% in 1980 to 27% in 2007. (National Science Foundation, 2010)

Female share of S&E bachelor's degrees, by field: 1985–2005

	Physical sciences	Biological/ agricultural sciences	Mathematics	Computer sciences	Psychology	Social sciences	Engineering
1985	28.1	45.1	46.1	36.9	68.2	45.8	14.5
1986	27.7	45.5	46.5	35.8	69.0	45.6	14.5
1987	28.4	46.1	46.5	34.8	69.0	45.8	15.3
1988	30.5	47.7	46.4	32.5	70.1	45.8	15.4
1989	29.8	47.6	46.0	30.8	70.8	46.2	15.2
1990	31.4	48.2	46.4	30.2	71.5	46.3	15.4
1991	31.7	48.7	47.2	29.6	72.6	47.2	15.5
1992	32.9	49.3	46.8	28.9	73.2	47.8	15.6
1993	32.9	48.9	47.1	28.3	73.2	48.2	15.9
1994	33.8	48.9	46.3	28.6	73.1	49.0	16.5
1995	35.2	49.7	46.9	28.5	73.0	49.8	17.3
1996	36.2	50.2	45.8	27.6	73.0	50.8	17.9
1997	37.6	51.6	46.3	27.2	73.9	51.8	18.4
1998	38.8	52.7	46.8	26.9	74.4	52.5	18.6
1999							
2000	40.8	55.8	47.8	28.0	76.5	54.2	20.5
2001	41.5	57.3	48.0	27.6	77.5	54.8	20.1
2002	42.7	58.5	46.9	27.5	77.5	54.8	20.9
2003	41.7	59.7	45.6	27.0	77.7	54.6	20.3
2004	42.2	60.1	45.9	25.1	77.8	54.5	20.5
2005	42.6	60.0	44.6	22.2	77.8	54.1	20.0

Source: National Science Foundation

These figures illustrate a future where a majority of men will be creators of our computing technologies, with the commensurate salaries, and women, who have increasingly become the users driving technology adoption, according to Intel Fellow and researcher, Genevieve Bell (The Atlantic, November 28, 2012) will determine which innovations succeed in market place as consumers.

This decline in entering the computer science field and the subsequent financial benefits of technology creation is not limited to the United States, but can be seen in countries across the globe, including countries where social equality is

considered a priority. Wyatt (2008) concludes “gender inequalities persist even in countries such as Norway, and technologies remain implicated in the structure and performance of inequality” (p.121) Valenduc (2011) adds that in France “the proportion of female students in informatics was about 35 to 40% at the beginning of the 80’s, against less than 10% in 2005 (as cited in Collet, 2006). Times have radically changed.” (p. 487) In Brazil, where 60% of the college graduates in 2006 were women, only 5% of them graduated in computer science and participation in computer science has also declined. (Medeiros, 2006) In the UK women made up 16.6% of computer science undergraduates in 2010/11. (HESA, UK)

There are few exceptions to these widespread trends. One is India, where back in 2003, 55% of all computer science degrees were awarded to women. (Varma, 2010) Varma (2010) states that the “CS curriculum in many accredited institutions of higher learning in India is similar to the United States; Indian departments rely on American curricula and standards and use American textbooks.” (p. 258) and makes the point that aptitude is distributed between both genders. Varma (2010), in elaborating on the higher percentage of computer science degrees for women, says that despite certain levels of inequality for women overall in Indian culture and less access to opportunities in computer science, in India computing is a culturally acceptable occupation for women. It provides an economic autonomy for women who have fewer pathways to achieve

it than in many other cultures. Beyond India, women in computer science show up in greater numbers in the countries of Malaysia, Hong Kong, Taiwan and in Iran. (Varma, 2010)

Like the unusually high numbers to India, in Malaysia women represented 45% of undergraduates in computer science, 56% of women in computer science masters programs and 32% of women in doctoral programs in 2006. (Othman & Latih, 2006) Research on male and female computer science students in 2005/06 found that students in Malaysia do not see computer science as a 'masculine' field (Othman & Latih, 2006), unlike many of their U.S., South American and European counterparts, and that there were no significant differences between male and females grades, drop out rates and skill levels. Women stated they were looking forward to working in the field upon graduation at greater rates than men did. (Othman & Latih, 2006)

Othman and Latih (2006) also say that 'there is no gender bias with regard to how CS/IT is perceived by young Malaysians". (p.114) They noted that there are significant numbers of female CS and IT faculty both at the University of Malaya, where 61% of the lecturers are women and 73% of the Ph.D.'s are women, and at University Kebangsaan Malaysia, where 40% of Ph.D. holders are women and 66% of the lecturers in Technology and Information Science are women (p.114) Othman and Latih (2006) cite the large numbers of female role models available

to women, concluding that under the circumstances, computer science as a choice for women is ‘normal’ and ‘unremarkable’. (p.114)

Lagesen (2007) adds, “ICT has been a government priority area fueled by the rapid economic growth in Malaysia.” (p. 9) Lagesen (2007) also concluded when looking at Malaysia in contrast to many Western countries that “physical activities like working with electronics and mechanical objects were looked upon as ‘masculine’, in contrast to software engineering and programming. The latter were deemed as “theoretical” and thus fitting for women. In fact, a gendered dichotomy of the physical and the theoretical was quite prevalent. “ (p. 22) As one of the few countries without a notable gender gap in computer science, they ultimately display a unique social construct in what are considered appropriate jobs for men and women- a social construct that has existed in a similar form in the history of computing in the U.S. and will be covered later in this research.

The data: the computing workforce in the U.S. - and around the globe.

Workforce participation by women in computing and IT professions in the U.S. is also down, with only 25% holding jobs in these two areas of computing, a number that stands next to an overall workforce participation rate by women of 57% in 2011. In contrast, in 1991 women held 36% of all computing and IT jobs. (NCWIT, 2010) Though the U. S. government provides important statistical snapshots of the female computing workforce, and academic research has

substantially documented progress or a lack of progress on the educational front, surveys of businesses like the one conducted in 2012 by the Telecity Group, of 450 U.S. technology leaders and reported on by Reuters, paints a distinctive picture of the IT workforce directly from the labor market itself. Their survey found that 30% of the 450 companies surveyed had no women at all in IT management and the number of CIO's (Chief Information Officers) fell from 12% in 2010 to 11% in 2011.

Although women occupy high-level and high profile positions at companies like Xerox, Facebook and IBM, in a large number of the technology companies doing business in the U.S., there are few women to draw on to promote, even when there is a desire by a company to elevate women into a management or a senior management positions. (Zieminski, 2012) The Telecity group survey, which was reported in *The Chicago Tribune, The Huffington Post* and *Forbes,* lends further perspective to the data on women and educational attainment. With fewer women participating at the academic level in computing, the impact on the workforce has been substantial.

In another large survey of over 800 global companies by business consultants McKinsey & Company, one part of their survey focused on diversity and women in times of crisis, and was specifically designed to examine the effects of the recession in 2008 and it's effects on diversity. The consultants found in

conducting the survey that “only 28 percent of the respondents say gender diversity has been a top-ten agenda item in their companies over the past five years, and 40 percent say it is not on their companies’ agendas at all. The good news is that for the vast majority—including those where gender diversity is near the top of their agendas—the crisis hasn’t changed its priority.” (Desvaux, Devillard & Sancier-Sultan, 2009).

This data point illuminates information on the place of diversity issues in businesses overall and illustrates perhaps the kind of climate women face upon graduation. Without diversity concerns and positive environments for women, a shift in educational interests is less likely to change. Still, while the 28% figure gives the impression of relatively low level concerns about a diverse workforce, companies who run technology businesses specifically express awareness of internal diversity issues, but state they have no real tools, experience or staff to research and identify the sources of the diversity problems, nor do they have the necessary research to implement a data driven plan to alter the culture of the company. (Zieminski, 2012) With global competition, taking the long view and researching problems not core to the business model often gives way to a short-term focus on profits and stability, as well as the need to direct the vast majority of available resources to maintain competitiveness. To alter business environments and reinvent them as more diverse environments, diversity would need to be seen as integral to competitiveness.

Low participation by women in IT and computer science can be found in most countries around the globe. In the UK, women only comprise 14.6% of the ICT workforce (UK Resource Centre for Women in SET, 2013). In the EU 27 workforce, 27.8% of computer and information systems workers are women and female hardware engineers comprise 9.6% of all hardware engineers. (Gras-Velaquez, Joyce & Debry, 2009). In South Africa women make up 18% of the core IT workforce while they represent 75% of the end IT users. (James, 2006) And in South Korea women represent 18% of all IT workers. (Huyer & Hafkin, 2012)

Huyer and Hafkin (2012) found in a pilot assessment of six different countries: Brazil, India, Indonesia, the Republic of Korea, South Africa, the United States and the European Union that when they applied the Gender Equality- Knowledge Society framework to produce national assessments of ‘gender and science, technology and innovation’, that there was an underrepresentation of women across all countries. In engineering, physics and computer science, women rarely rose above 30% of all participants. And in women who were moving from educational attainment to the workforce, there was a drop off sometimes as high as 30 points in the transition from education to work in the STEM fields. (p.11) With similar problems seen around the globe for women in computing and

information technology jobs, it is clear that in many parts of the world, computing has come to be defined by one gender.

Early U.S history: the links between gender and computing

Looking at the current numbers in computer science, much of the concentration and conversation in the U.S. has focused on the significant drop in participation by women since 1985, a high point for women in computer science education. Importantly, researchers have gone back and looked at time periods prior to the eighties to mine them for women's participation in computing, document the history and catalogue women's contributions to the many histories of computing, computer science, data processing and women's place in the birth of the information society. As it often the case, looking back can shed light on contemporary problems and illuminate some of the myths culturally regarded as 'truths' in mainstream society today.

Though in earlier decades women encountered working environments where gender equality was not yet a mainstream idea, where want ads were most often separated by gender until the mid-seventies (Library of Congress, American Memory) and where workforce participation by women was perhaps only considered really desirable in cases of economic necessity, women quite successfully navigated computing in many of it's early forms and succeeded in ways that would be notable today. Looking back at some of these successes

reveals some of the cultural myths that surround computers, precisely because the status of women was so markedly different than it is today.

In light of the current state of computer science, contemporary questions to ask might be why there were significant numbers of women programmers in the 1960's, where estimates reach 30%? (Ensmenger, 2010) And how, in light of women's participation in computer science from the days of the first computer programmers, did contemporary society come to view programming as a distinctly masculine occupation? Looking at the various histories of computing, from data processing to programming and systems analysis, often reveals that what seems like real 'innate' ability and logical gender roles is not remotely innate or logical but evolved over time. Behind the increasingly gendered division of labor is a series of social constructs that shaped computer science, information technology and computing over time.

During WWII, when women joined the workforce to support the war effort, the word 'computer' usually identified the role of particular women working in the wartime economy. (Light, 1999) 'Computers' then were people, and they computed ballistics trajectories and solved complex mathematical equations for wartime research with simple tools, pencil and paper. Though the job took advanced mathematics skills, the U.S. government categorized the job as clerical labor, and women, albeit women with college mathematics degrees filled these

jobs almost exclusively (Light, 1999). It was when women doing all these laborious calculations by hand resulted in information bottlenecks; the seed of the idea for an electronic ‘computer’ came about, in hopes of speeding up the process. The idea then for the first American electronic computer was conceived and undertaken at the Moore School of Electrical Engineering at the University of Pennsylvania, in the hopes of both aiding and replacing human computers with electronic computers.

Having conceived of this first electronic computer engineers J. Presper Eckert and John W. Mauchly decided that the human ‘computers’ doing all the manual calculations would be the best and more logical choice to program this new computer, both as an extension of the clerical work they were doing and because the ENAIC computer was ultimately to replace them. Women ‘computers’ thus became ‘operators’, or what we now refer to as programmers. (Light, 1999) Though just an accident of wartime labor shortages, women were in effect given the original programming assignment, and strictly in keeping with the division of labor deemed appropriate by both the government and the engineers. As a matter of record, this was one of the original American social constructs around gender and computing. While men worked in the more important domain of hardware, dealing with the engineering challenges of building a computing machine, women created software and instructions. Eventually the manual for the ENIAC was written by Adele Goldstine, the senior programmer on the ENAIC

project and officially made the first documentation of programming procedures a product of the “ENIAC girls”, as they were known among the project’s staff. Light (1999) states, “With no precedents from either sex, the creation and gendering of ‘computer operator’ offers insight into how sexual divisions of labor gain momentum. Computing was a female job, and other female clerical workers operated business machines.” (p. 305)

With this significant achievement accomplished by primarily women, after the war, the government reversed course on women in the workforce and as a matter of policy, replaced women in government jobs with returning veterans. Still, many of the women on the original ENIAC project continued to work in the infancy of computing. Women from the ENIAC project wrote the programs for the UNIVAC (the first commercially available computer, also engineered by Eckert and Mauchly), collaborated on the computing languages COBOL and FORTRAN, and programmed the Mark I (the IBM Automatic Sequence Controlled Calculator, the first computer used at Harvard in 1944). In addition, from 1946 through 1951, the majority of the programmers at the Electronic Computer Project at Princeton’s Institute for Advanced Study were women, and closely in keeping with what was first viewed as female appropriate labor. (Light, 1999) Though it seems incongruous now, one of the very first cultural myths surrounding computing was that programming computers was women’s work.

Socially acceptable labor for women in computing continued within the clerical ranks after the war, in the early age of data processing. By 1954, General Electric became the first to use electronic computing and the UNIVAC for administrative work. Within five years they were followed by thousands of companies in a large wave of computerization. (Haigh, 2010) During this time period, large numbers of both women and men were hired into data processing jobs, as keypunch operators and machine operators respectively, again maintaining a certain division of labor, appropriate to the then social views of gender and labor. Sex discrimination, which was still legal, allowed jobs to be advertised via separate male and female help wanted ads, and it was left to the culture of a company which jobs could be occupied by men and women. Almost universally, there was a continuation of the division of labor established prior to the computerization in offices. (Haigh, 2010) Much of the keypunch work was taken over by women as an extension of their usual clerical duties before computing, and men did much of the machine operation, as an extension of blue-collar work done in factories on machines before computerization.

Still, some jobs created by computerization were new and not yet sex-typed in the corporate world. The position of programmer and systems analyst were the newest jobs in these corporate computing departments. Though the division of labor did not precisely mirror the division of labor on the ENIAC project, the division of software (clerical) and hardware (machines) functions continued as

typical gender appropriate assignments. Men designed, built and operated machines and women, in large numbers did the associated ‘soft’, keypunch work. Haigh (2010) states that by a 1960 survey of data processing salaries and employment patterns by *Business Automation* magazine, it was informally reported that less than 15% of programmers in these corporate computing departments were women. (p. 54) Though just years earlier programming was considered ‘clerical’ work appropriate for women, it was now a sex-typed male job, along with that of the system analyst job. With this dramatic turnaround for female programmers and systems analysts, Hague (2010) argues “that the intersection of two powerful social mechanisms, sex typing and status anxiety, gave ambitious data processing supervisors making the transition into the computer age a powerful motivation to ensure that women remained in their place.” (p.55)

Only by removing the low status clerical image associated with data processing work, could computing departments reach a more elevated status in the corporate workplace. The power of sex typing meant that increasing status, by workplace norms, would necessarily limit the participation of women in order to remove the clerical ‘stigma’ of these new jobs. Thus programming, typecast as clerical early on, could only change its image by reducing the number of women. Women, however, were not exclusively singled out in corporate computing work as obstacles to corporate status, since the blue-collar image of machine

operation had to be overcome too. To really elevate this new computing field and as a result corporate computing departments, they could not be identified with either factory work or clerical work. (Haigh, 2010)

The new era of data processing in the 1950's pointed to an evolving social construct in computing, in which gender 'appropriate' labor did not shape corporate computing so much as the need to elevate computing jobs into the professional realm, conferring with it added status and higher pay. With the low status of women's clerical work and the image of machine operators still viewed through the historical lens of blue-collar, factory workers tinkering on machines, both gender and class issues shaped a new myth about computing professionals what specific attributes defined them. "Machine men" (Haigh, 2010, p.56) as they referred to themselves, in the midst of a brand new electronic age, had the opportunity to redefine the machine and the machines old link to class. "The problem was not that the 'machine men' were not masculine enough. The problem was that they were identified with the wrong kind of masculinity." (Haigh, 2010, p. 57)

As computing and data processing moved into the 1960's however, the logic of constructing computing departments for the purpose of increasing status and pay gave way to predictable outcomes of these constructions. Once fewer women were counted in the ranks of certain jobs, stereotypes followed and influenced

cultural beliefs within companies. If initially a dubious pragmatic decision by managers of corporate computing departments to elevate their departments within the corporation, these decisions gave way to beliefs about ability and became entrenched not just as a reflection on aptitude, but eventually as a reflection of feminine and masculine traits and gender identity through occupation for many in the corporate workforce. As Haigh (2010) notes “association with keypunch work remained a threat to masculinity into the 1960’s and beyond. (p.61) Thus a division of labor stripped of facts about actual ability and aptitude or feminine and masculine traits, became a social constructs that greatly increased the chances of stereotypes about traits, abilities and aptitudes of both men and women. Once roles were established by gender, the roles over time became self-reinforcing for gender identity.

While ‘keypunch girls’, with their historical clerical roots, remained at the bottom of corporate computing departments, transformed from worker who once did a job appropriate to their gender, to a worker with who now did a job appropriate to aptitudes of their gender, college educated women did fare better over the course of the 1960’s. As corporate computing through the 1950’s and the 1960’s established a certain status quo in many computing departments, labor shortages due to the meteoric rise of the computer industry changed the landscape for women with a college education as the 1960’s unfolded. By the time the first government statistics appeared in 1970, the ranks of women programmers had

started to rise again and women were estimated at 22.5% of all programmers. (Gilchrist & Weber, 1974)

College-educated women in computing fields became enough of a trend over the decade that they spawned feature articles in both the *New York Times* and in *Cosmopolitan* magazine, and illustrated the first beginnings of a fascination with computer science, which was still relatively mysterious to the public at large. These articles as pieces of cultural history, give insight into broader societal views, not just of working women at the time, but the public perception of computer science. Both the articles profile young female college graduates, who were hired as programmers and systems analysts and describes their jobs to a world where computer science does not yet have a mainstream image already understood by the average reader. And both articles illustrate even the writer's fascination with these women who are not just working, but working in a science and math based area at 'serious' jobs. Reading these articles, it is clear that to the journalists reporting the stories, the myth of masculinity is not yet an absolute given attribute of computer science.

In a featured article on March 12,1964 entitled "Computers Are Getting Ideas From Women: I.B.M. the Leader in Employing Girls as Programmers", V.G. Vartan of the *New York Times* informs the reader that some 1200 hundred women are working as programmers and systems engineers, along side 2500

male programmers and 4000 male systems engineers at I.B.M., reflecting broader statistics from the time period. Vartan (March 12,1964) tells the reader “a programmer instructs the electronic computer, which won’t do anything until it is told” and “the science of programming lies in analyzing problems and reducing them to sequences of steps the computer can understand and perform.” Mixed into the story detailing what computer programming is, are details about the female systems engineer who, “looks like a Vogue model but who has conducted seminars for brain surgeons and worked on physics projects with university professors” and that she “uses her knowledge, judgment and ‘a little bit of feminine intuition’”, as well as that “the girl programmers at I.B.M. are known affectionately as ‘the calculating females’. (Vartan, March 12, 1964)

While it is easy to now read the colorful details as sexist and as unnecessary to the story, it is the details that paint a picture of computing in 1964. Unlike journalism years later will, the article does not explicitly expose wider cultural values about who is expected in a computer science job, or imply that the female systems analysts have somehow crossed existing gender barriers to achieve their positions. Vartan (March 12, 1964), in fact, conscientiously describes to the reader the qualifications for computer science work and how the women procured these jobs through their educational backgrounds and skills sets. He also details that the women programmers and systems analysts were sought out and recruited by I.B.M. The novelty for the feature writer in fact seems to be that

these programmers and systems analysts are highly skilled working women, not that they are computer scientists per se.

In a similar vein to *The New York Times, Cosmopolitan* published a feature in 1967 called “The Computer Girls”, in which Lois Mandel celebrates the careers of female programmers and the highlights the high pay these jobs command. Mandel also writes in this article from 1967, that talented ‘computer girls’ are in high demand and that opportunities for women in computing are ‘unlimited’, since sex discrimination is virtually ‘unheard of’ in a rapidly expanding computing industry. (Ensmenger, 2010)

While Ensmenger (2010) points out in reviewing the *Cosmopolitan* article that stereotypes in it abound, like a comparison of programming to ‘planning a dinner’, it also shows computer science is open to women and to inviting them in as the field experiences rapid expansion. It also reveals that a large concern of female job seekers during those years was finding a work environment in which discrimination was less prevalent. Ensmenger (2010) says, “As the Cosmopolitan article rightly points out, compared to most of the traditional professions, computer programming was remarkably receptive to females.” (p.116) Ensmenger (2010) goes on to say “the unusual freedom of opportunity available to women in computing was simply an outgrowth of the rapid growth of the commercial computer industry. An industry that was doubling in size every year

or two simply could not afford to discriminate against women." (p.117) While in contemporary times it is hard to imagine the computing industry recruiting college grads with slogans like "you're not losing a daughter--you're gaining a career girl…Let her give Control Data a try." (Ensmenger, 2010, p.117), in the 1960's this was the new reality of computer science. Women having been the most suitable programmers in the 1940's, then became unsuitable programmers in the 1950's and then again became suitable again in the 1960's, showing that as a hypothesis, gender myths around computing might possibly correlate to economic trends and need. "One of the time –honored strategies for dealing with labor 'problems' in the United States has been the use of female workers." (Ensmenger, 2010, p.133)

Well into the 1970's and the 1980's, there was in fact a steady growth if the numbers of women entering computer science after the 1960s. Women programmers comprised 23% of the programming ranks and 13% of systems analysts by 1971, and by 1982, women comprised 34% of all programmers and 24% of all systems analysts (Haigh, 2010). And among the ranks of what was once considered the clerical workforce, women comprised 85% of all keypunch operators and by 1981 made up 95% of all keypunch operators. (Haigh, 2010) Though not discrimination free for women, considering the number of women in the low status and lower paying keypunch jobs, by contrast to other professions the field had become more open and accessible to women over time. Women

could not expect the opportunities in other occupations with longer institutional histories and more entrenched cultures than found in many areas of computer science, and the numbers show women were making steady inroads.

An era of decline and gender and computing.

By the onset of the 1980's, and by most available statistics in workforce participation and educational attainment women were poised to reach a significant presence in computer science jobs complete with the status, the higher pay and the prestige of science and technology skills attached to their attainment. But as women made strides overall, computer science itself was becoming less a field about temporary solutions and idiosyncratic gifts applied to the limitations of hardware and memory and a field that was increasingly 'professionalized' with standards and a culture that was slowly becoming institutionalized.

With the increased shortages of programmers and systems analysts, the computing industry had begun to make use of both aptitude and personality tests for recruiting and job placement purposes, and for potential programmers in particular. With the need to train a large number of employees who had no educational background in computer science, these tests seemed to be a logical avenue for hiring decisions. "By the end of the mid-1960s the majority of companies (80%) were using such tests and profiles as their primary tool for

identifying programmer trainees." (Ensmenger, 2010, p.126) These aptitude tests, on the surface, appeared objective and non-biased and a potential avenue for non-discriminatory hiring practices based on merits. Still, the profiles of programmers often embodied many stereotypical masculine characteristics, like favoring "intellectual challenge over interpersonal relations" (Ensmenger, 2010) and the tests, like the IBM PAT, often required formal mathematical training, which left out many more women than men. (Ensmenger, 2010)

Adding to the 'profiling' of computer professionals was the use of the SVIB (Strong Vocational Interest Bank), particularly by the System Development Corporation (SDC), a part of the RAND Corporation and charged with developing software for government air-defense. Having to hire unprecedented numbers of programmers in the sixties, the SDC used the SVIB, a questionnaire that elicited emotional responses (likes and dislikes) from the person answering the questions and then compared the answers with 'keys' for various occupations.

The SDC company psychologists during that time period, Dallis Perry and William Cannon, used the SVIB with significant samples of potential recruits, and eventually published a series of influential studies in the journals *Personnel Psychology* and the *Journal of Applied Psychology.* In their journal articles, they detailed how they had developed a distinct profile of the 'vocational interests of computer programmers'. "There was only one 'striking characteristic' about

programmers that the Perry and Cannon study identified. This was their ‘disinterest in people’. Compared with other professional men, ‘programmers dislike activities involving close personal interaction.” (Ensmenger, 2010, p.128) This characterization and the published studies helped give academic legitimacy to of the one of the most widespread myths in computer science, that programmers lacked ‘people skills’. In doing this, they powerfully linked a perceived male characteristic to programming aptitude. Ensmenger (2010) notes “the association of masculine personality characteristics with inherent programming ability helped create an occupational culture in which female programmers were seen as exceptional or marginal.” (p.129) Over time the myth took hold and the studies helped substantiate an idea that became industry lore.

With the seemingly necessary and pervasive use of aptitude tests and personality profiles, it could have been the case that the tests and profiles used, in fact, accurately reflected a true profile of the computer programmer or that perhaps with the standard profiles largely leaning more and more to male characteristics, they underscored how biology was destiny in computer science and innate abilities and traits did determine success. And it was also possible, given the legacy of the “machine men” of the 1950s, to ask whether the use of the tests was something of a conspiracy to keep the numbers of women in the profession low. Still the most reasonable analysis according to Ensmenger (2010) is that:

> Programming ability has no correlation at all with biologically determined predispositions, but that the widespread use of the gender-biased testing regimes by industry employers nevertheless did create a feedback cycle that ultimately selected for programmers with stereotypically masculine characteristics. The primary selection mechanism used by the industry selected for antisocial, mathematically inclined males, and therefore antisocial, mathematically inclined males were overrepresented in the programmer population; this in turn reinforced the popular perception that programmers *ought* to be antisocial and mathematically inclined (and male), and so on ad infinitum. (p. 129)

As a result, though the numbers of women in computer science were still increasing well into the 1980s, the foundation for a less inclusive computing culture was taking shape slowly in the computing workplace, just as the ranks of women studying computer science reached a significant representation. Though the aptitude tests and personality profiles rarely had significant hard evidence to back their large-scale use, especially in the case of the unscientific psychometric tests, the computing industry continued to use them for lack of other methods and standard criteria for evaluation of potential employees, and the industry culture increasingly reflected their biases, right or wrong. Potentially over time

this had impact on the numbers of women participating in computer science, as the industry culture institutionalized these values. Computer science, which had experienced a number of years in which it was perceived as gender neutral, was “transformed into a high-status, scientific, and masculine discipline.” (Ensmenger, 2010, p.136)

Simultaneous with the forces shaping the computing industry well into the 1980s, was the advent of the personal computer, with models introduced in 1977 by Apple, and in 1981 by IBM. With the personal computer came a new opportunity for a wider range of people to not only learn computing skills, but for a mainstream culture narrative about computer science and computing skills to take shape in the public consciousness, and that was not directly molded by the already existing computer industry. In the end, the personal computer experienced a brief window of gender neutrality before it was too linked extensively with a specific gender and created a larger social construct for computing, that all discourse about computing was compared against.

Corneliussen (2012), doing linguistic research in Norway, has focused attention on gender and information and communication technology in the era of personal computing and lends an informative perspective to American computing history in this time period. Norway, which has had a notable political drive for gender equality (Corneliussen, 2012), still has significant underrepresentation of women

in the computing fields, much like the U.S., and provides a compelling backdrop for researching computing in an environment that is potentially less influenced by more widespread societal discrimination. Like the United States, Norway also has an educational system which graduates more women than men from universities overall.

Corneliussen (2012), tracked the discourse and language in popular computer magazines and newspapers in Norway from the time of the introduction of the personal computer in the 1980's, and makes note of specific narratives that would be familiar to many computer users throughout the United States in the both the 1980s and the1990s. As Corneliussen (2012) states, "The most common focus on girls and women in *Aftenposten,* [a large Norwegian newspaper] concerned their lack of interest, experience and skills [with computers], while by contrast the dominant focus on boys and men was their fascination and extraordinary computer skills. This trend contributes to making computer skills both visible and invisible in a certain gendered discursive pattern." (p. 35)

Corneliussen (2012) in her analysis of media articles notes that the though the statistics behind many statements could be held as true, the most common narrative about men and women and their computer use and knowledge resulted in a narrative with a larger fallacy. While numbers in Norway and elsewhere did

show more men were using computers and often in more sophisticated ways, these men were still themselves a still a significant minority. And while women using computers and excelling with them could be found in fewer numbers than men, they still existed. Corneliussen (2012) points out that, for every story in the media about men out pacing women, there could have been an equally accurate story with the headline stating that 'men and women using and excelling with computers are still among the minority'. This emphasis on gender then, shaped the narrative about computing and helped propel the growing narrative.

As the most common forms of the narrative took hold, Corneliussen (2012) shows how the majority of men in the statistics cited about male usage were still numerically in the ranks of non-users of computers and how these men who knew little about computers increasingly became invisible in the stories as the cultural construction of gender and computers was underway, along with the women who were avid users of computers. In the discourse about computing and it's continual repetition, facts that did not fit were discarded and often overlooked. In a letter to the editor at the *The New York Times*, on March 5, 1989 four women underscore this parallel narrative in America over the course of the 1980s and into the 1990s:

> To the Editor:
>
> As educated computer literate women, we found "Computing in America: A Masculine Mystique" (front page, Feb. 13) offensive. The

> article's inaccuracy and that it lends credibility to such sexist generalizations as "Women and girls use computers; men and boys love them," serve only to impede women from advancement in such fields as computer science.
>
> ALICIA BROOKE CAREW
>
> BARBARA L. HAGNER,
>
> A. ERIN RUANE
>
> KIMBERLEE J. SCOTT New York, Feb. 14, 1989

The original article, by John Markoff, was published on February 13, 1989. He wrote:

> While legions of women work with computers in their jobs and many excel as computer scientists and programmers, they are almost without exception bystanders in the passionate romance that men conduct with these machines, whether in computer science laboratories, video game parlors, garages or dens. Social scientists and computer experts say this difference leads to disparities far beyond recreation - to limits on how far women can go in the computer business and to a disappointment of the hopes that this new industry would be free of the sex disparities of older fields of work.

Markoff (1989, February 13) goes on: “women's principal involvement with computers thus consists of painstaking but routine tasks like word processing and data entry, say researchers who have studied the industry.”

Though it was again unlikely the word ‘conspiracy’ could be applied to the mass media narrative about computer science, it is clear much of the real history of computing was unknown to people in positions that influenced others, as a narrative about computing was solidified throughout American culture. The tendency to link computers with masculine characteristics was increasingly culturally embedded, supported in data and slowly institutionalized by the computer industry over the time period of the 1990s as computer science became ‘professionalized’. (Ensmenger, 2011) This contributed to linking gender and computers in increasingly predictable and sweeping ways.

Unlike two decades before, in the profile of women at IBM in *The New York Times,* computers are now equated with a set of personal characteristics, perhaps ultimately traceable to the profiles of programmers that had been created in the computer industry for well over two decades. In *The New York Times* article by Markoff, there are strong implications that women themselves are the most likely origin of their own marginalization, with quotes from several women computer scientists discussing how women often lack the necessary “risk-taking” personalities to excel in the field. As Ensmenger (2011) explains “to

suggest that a discipline has been made masculine, however, is not to claim that all of it's practitioners are male, but rather that ideals of the profession are masculine ideals." (p.136)

The New York Times in the 1990s continued to write articles that decisively linked computing and gender, as well as competency in computing and specific characteristics. As a major U.S. paper, *The New York Times* both reflected and simultaneously influenced mainstream conventional wisdom about computer science. On August 29, 1993, for example, the paper published a story by Katie Hafner with the headline, "Woman, Computer Nerd – and Proud". The story confirmed that women who excelled in computer science, once moved out of the shadows of the 'invisible' users, were now tied to labels they had to reconcile with their own individual identity. The article, which reports on three female graduates of MIT computer science, states "in their undiluted sense of who they are rather than who society says they ought to be, they have spent their lives turning a stereotype -- that women don't belong in technical fields -- squarely on its head."

There is an irony in the story and it's focus on challenging stereotypes. Women now, in the 1990s, had to reject the stereotypical role of women as technically limited or impaired, and take on the stereotype of the 'nerd' in a trade. Unlike articles twenty years prior, this mainstream newspaper article reveals a full scale social 'profile' of the computer scientist, down to gender. As Turkle & Papert

(1990) elaborate “Thus women are too often faced with the not necessarily conscious choice of putting themselves at odds with either the cultural associations of the technology or with the cultural constructions of being a woman.” (p. 151) and the “the computer culture alienates by putting one in conflict with oneself.” (p. 151) It is not surprising then that over the course of the 1990s the numbers of women entering computer science reversed year by year and fewer women emerged from computer science.

As the field of computer science incorporated into the culture the ‘nerd’ identity, born from the personal computing era, it became “a staple of modern American culture” and was “invariably represented as eccentric, unkempt, antisocial —and male” (Ensmenger, 2011, p.137) And additionally computer science professionals adopted a nocturnal culture, that also posed a barrier to women, where normal work hours were discarded and replaced with late night and all night marathons that not only ruled out women for reasons of personal safety, but also excluded women who often had responsibilities beyond a job. “Ideas about *how* computing should be done corresponded closely with perceptions of *who* should be doing the computing. In the case of computer programming, these ideas and perceptions changed dramatically over the course of the mid-20th century, often in ways that were invisible to practitioners.” (Ensmenger, 2011, p.138)

Moving into the 21st century, it was clear that computing and computers

were now entwined with traits tied to specific genders, and to cross over the barriers, perhaps in either direction involved asking more than whether one had passed calculus, taken AP computer science or liked problem-solving. Still, another cultural transformation was underway and about to force rewrites of old narratives. With the growth of the web, and technology seemingly everywhere, the ubiquitous nature of computers and computing devices would slowly have to erode some of the gender typecasting of the decade before. If technology was everywhere, and everyone was now involved in using it, could it logically be the domain of one gender? Eventually it might not be possible to fully believe some of the myths, no matter how embedded in mainstream culture they have been. One of the most popular technology narratives of the late 2000's is not really that my 'husband or brother or son' is using the computer, but that my young child is learning a computer or computing device faster and better than the adults around them. As Corneliussen (2012) points out, in the discourse around computers "by this overemphasis of gender, a conception of gender as the primary difference was sustained and differences within the genders as well as other differences, such as age or income were made seemingly unimportant." (p.42) Given her point, it is possible to imagine age catching up to gender in new cultural narratives of the future. This is seen, for example, in the new century debate around 'digital natives' and 'digital immigrants' introduced by Prensky (2001).

Corneliussen (2012) notes that since 2000 newspaper articles in Norway about computing can now roughly be divided into four new categories, in contrast with the previous two decades: criminal men, computers as everywhere, differences between computer users and women in IT in education/business. She notes, that far from glorifying hackers as in the previous decade, they are now classified in the popular press as criminals and threats to security, and no longer have mythological status or shine they once had. Likewise, the preoccupation with men as the preeminent users of computers has morphed into stories about users who occupy every class, age group, gender, race and occupation. And the numerous articles detailing men as the majority of computer owners have shifted to what technology is out there, who owns which technologies and who uses which technologies. The grandmother on Facebook or the teen-age girl using chat software or the woman at a university developing a website are no longer discarded from the stories as aberrations to a trend, but are just another face of technology use in the new millennium.

It is the last category in which Corneliussen (2012) finds the most interesting change. “The fourth and final main topic since 2000 is the ongoing focus on girls’ and women’s low level of participation in computer education and the computing workforce. Here the image of ‘nerdy men’ is still repeated (although not in such a celebratory tone) and we find echoes of feminized discourse emphasizing computing as mostly about people and communication, which is assumed to

interest women more than technical aspects." (p. 49) Corneliussen (2012) also says "the most interesting development in this discourse is new images of men fighting the image of the nerd/hacker/geek, which has been seen as one of the main problems…" (p. 49)

Again there are parallels to this shift in American culture too, where stories that focus on gender and computing now tend to revolve around concern about the status quo and the low participation of women. *The New York Times,* for example, in 2008 wrote an article entitled "What Has Driven Women Out of Computer Science?" In *Nature* in 2007 a completely new perspective in could be found in "Declining Female Participation May Be a Harbinger for Computer Science as a Whole." The *Chicago Tribune* in 2012 wrote a feature story called "Technical Difficulties: Lack of Women in Computer Science" and in the *Huffington Post* in 2012 there was "Women Computer Scientists – Yes, They Exist!"

There have also been new academic publications in *Gender Codes* (2011) and *Recoding Gender* (2013) that trace the problems of gender and computer science, and are no longer concentrating on 'unlocking a clubhouse' as much as on how the clubhouse was built and thus can be rebuilt on a different foundation. And to add to the changing picture, it is now possible to find online at *nytimes.com* (and at *code.org*), media featuring prominent computer sciences

like Bill Gates and Mark Zuckerberg, along several women computer scientists promoting programming skills to younger students, as part of an effort to make programming more widely available in schools to all students.

If coding and programming was exclusively the domain of men in the last part of the last century, it may be once again be poised to be the domain of both genders, and involve women as a permanent part of the computer science culture in a way that is ‘unremarkable’ and ‘normal’, as they are in Malaysia. As the education website, Edutopia.org stated on it’s site “Programming is the new literacy.” (Prensky, 2008) Writers like Thomas L. Friedman have also promoted this idea. He has advocated the position that everyone in the future should be a competent computer scientist, along with a primary set of skills. It is not unthinkable to imagine code as the new math someday or the new composition class all students are required to take. But will it end the gender divide? As pure speculation, it will go a long way.

Summary

Women’s participation in computer science has seen significant declines in participation in the U.S. and around the globe. (Cohoon, 2011) From 1985 to 2005, the proportion of computer science degrees awarded to women dropped from 37% to 22% in the U.S. (National Science Foundation, 2008), while science and engineering degrees earned by women overall increased from 12% in 1980

to 27% in 2007. (National Science Foundation, 2010) Globally countries like the UK, France, Brazil, South Korea and others have also witness significant declines also, while countries like India produce many graduates in computer science, who do not subsequently join the workforce. (Huyer & Hafkin, 2012)

In reviewing the numbers in the U.S. and countries around the globe, the future for women's participation as computer scientists, and using computing skills to create technology is uncertain. Here in the U.S., the United States Department of Commerce reports that women in STEM fields overall earn 33% more then their non-STEM counterparts (U.S. Department of Commerce, 2011), making a potential gender gap in earnings and employment for women more certain. Employers in technology fields, aware of little diversity in their workforce have marginally prioritized gender issues, often due to pressing business concerns in remaining competitive, and without the expertise to prescribe research driven solutions.

With educational support and research ongoing, the U.S. and other countries have a history of computing to look back on, complete with high points of cultural acceptance of women and employment of women in computer science and low points, where women were marginalized. In each country experiencing the decline in participation by women in computer science, unique cultural history and social constructs contributed to the decline, along with the many mythologies

ascribed to computer science by popular culture, mainstream media and the computing industry itself. Looking back on this history, particularly in the U.S, can inform a way forward by more clearly exposing some of the myths around computers and the industry that employs them. Many of these myths have come to serve as barriers to women's involvement in computer science.

Here in the U.S. gender has been linked to specific kinds of work with computers in every era of computer science from WWII forward. In a constantly evolving computing world, women were first utilized as programmers (Light, 1999) because of their history of clerical work and the sex-typed labor of the era. Women, in effect wrote the first programs and the first manuals for computers, and continued to work in this area through the fifties in what was then considered gender appropriate work.

As the 1950s progressed, women however were marginalized in corporate computing in an effort to remove the stigma of sex-typed clerical work from the profession, and to assist computer departments in gaining stature and increased compensation. Many male operators were marginalized also at this time, in a tandem effort to separate blue-collar machine work from computing machinery, assuring computing labor would imply a certain class status and be seen as a 'white' collar job. (Haigh, 2010) Women were then recruited back into the ranks of

the programmers and systems analysts in 1960s as labor shortages made inclusion a business necessity.

As the 1960s progressed, 80% of computing companies (Ensmenger, 2010) began to rely on psychometric tests, profiles and tests like the PAT, used at IBM to the large numbers of jobs they had. Many of these testing methods and profiles were unscientific and leaned heavily toward masculine traits and a specific profile, creating a feedback loop in programming departments and across the industry. Though the numbers of women acquiring education in computer science continued to grow well into the 1980s, the industry feedback loop of testing and the link of computer science and masculine traits slowly began to reverse the numbers of women entering computer science.

With the advent of the personal computers in the 1980s, popular culture and the media first seized on the gender gaps in the initial diffusion of this innovation, and along with the computing industry linked computing and gender together, making only certain users ‘visible’ publicly and helping to build a social construct and narrative about computing that affected participation by women further.
In the 1990s computing skill was linked almost exclusively to men, and a culture that eliminated any feminine characteristics, placing women who chose computing fields at increased odds with core aspects their identity.

As the new millennium has approached, however, and the Internet, technology devices and computers have become ubiquitous and part of everyday life, myths and social constructs from the past have begun a shift in another direction. Past myths held as truths to some extent have been undone by the wide range of ages, races and genders engaged with computers, and influential elements in culture have started to ask why computer science is the activity of one gender. This gives rise to hope the old myths, once vetted more thoroughly will morph and make computer science as a part of gender identity increasingly dated.

Conclusions

Fisher and Margolis (2002) said early in the last decade, “Along with technology’s power come responsibilities to determine what computing is used for and how it is used.” Women must not just become adept at using technology; they must also be part of designing and creating it. (Margolis and Fisher, 2002, p. 3) Now a decade later, women are on track to be the dominant users of technology and to significantly influence what is created, according to Intel researcher Genevieve Bell (Madrigal, 2012), but they still have with little involvement in development and creation of computing technologies.

It is not difficult, looking at the barriers set up through the decades both within and outside of computer science, to understand why women have opted for this

role. Historically, women have embraced computer science at points in time where the barriers were lowered. Looking for a career paths where sex discrimination is not prevalent and where economic security is a certain outcome, technology creation and innovation as a career choice has been slowly been excluded by educated women. While computer science programs are advertised as a pragmatic choice for women, women have collectively come to understand this it is not the same field for women as for men. Why do women want to adapt to fit in a highly masculine culture, when other fields do not demand this? And with diversity not part of most businesses agendas, the stage is set for dwindling participation.

Still, the positive note in understanding history is that things change, and sometimes they change so rapidly the evolution of institutions falls behind newer mindsets in a global world. As more and more people find navigating smart phones, apps, iPads, e-readers, laptops, web creation software and the like easier than they imagined, demystification of technologies and computer science is potentially inevitable. And as more and more ages, races and genders embrace the technology that is created for them, the more likely it is the transition to development and creation will seems like natural transition, not clouded by questions about what is gender appropriate. While possibly overly-optimistic, the history of computer science and women has proven to be dramatic and changing every decade.

Beyond hoping for changes in culture to spur changes in attitude, faster change can happen through social policy. As seen in countries like Malaysia, government can promote change. And educational institutions can institute change by reshaping curriculum and rewriting admission standards, as seen in the computer science department at Carnegie Mellon University. And certainly K-12 schools in the United States could introduce programming concepts as part of the Common Core State Standards Initiative. Over the coming years social institutions will have to decide to what degree does matter to a productive society and act.

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