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Women in Science, Engineering and Technology: Changing Roles and Perception within the Technical Services Industries

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Abstract: Services have surpassed agriculture and manufacturing as the leading contributor to gross domestic product in the world today. As the global economy has become more integrated and the demand for a workforce required to run service-focused organizations in an efficient manner grows, the level and variety of skills needed in this new service economy have also changed and grown. In particular, the growth rate of technology-driven service industries is significantly outpacing the growth in other service-oriented sectors. It has been argued that women in general possess many characteristics that make them optimal candidates to fulfill this workforce gap. However, the percentage of women enrolled in engineering, technology and related programs have been dropping. This study attempts to create an awareness of the skills and job roles required for future labor workforce demands in the engineering and technology services industry and argues that these current and future roles makes them more appealing to women.

Key words: STEM, women in engineering, US education, IT services, service industries

INTRODUCTION

Services have surpassed agriculture and manufacturing as the leading contributor to gross domestic product in the world today. By the year 2007, Real Estate, Securities and Internet Services and Retailing are listed among the top 5 fast growing industries in the Fortune 500 list (Fortune, 2008). As the global economy has become more integrated and the demand for a workforce required to run service-focused organizations in an efficient manner grows, the level and variety of skills needed in this new service economy have also changed and grown. Specifically, in regards to Science, Technology, Engineering and Math (STEM) fields, these changes have led to an increasing need for building soft skills in current and potential employees, essentially bridging the gap between technical and business skills. In one area of services, IT services, there are thousands of jobs in the market that are left unfulfilled due to the lack of updated qualifications. There is a lack of awareness of this growing trend for current skills and available job roles, which needs to be addressed, especially by educational institutions. Of particular concern is the fact that female candidates, who constitute a significant portion of the potential work force are not being utilized correctly. It has been argued that women in general possess many characteristics that make them optimal candidates to fulfill this workforce gap. Work performance traits that are generally viewed as feminine include relationship building, interpersonal communication, sensitivity, organization and the ability to anticipate (Joshi and Kuhn, 2007). These skills are particularly well suited to the new, dynamic service industry where relationships between partners may become more important than quality of the product itself. This study attempts to create an awareness of the skills and job roles required for future labor workforce demands in the engineering and technology services industry and argues that these current and future roles makes them more appealing to women.

MATERIALS AND METHODS

Today, for the first time in history, there are more people living in urban than rural areas (UN, 2004; Crane and Kinzig, 2005; Bettencourt *et al*., 2007; Marshall, 2007), contributing to the significant increase in demand for services in the US, while agriculture and

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manufacturing are losing their shares. According to the Bureau of Labor Statistics (2008). Current Establishment Survey, the total number of employees in the service sector reached 115.4 million, corresponding to 84% of total nonfarm employment in 2007. To meet this elevated demand, the number of service providers and hence, the need for related research and work force development are also rising in the country. As with every industry, science, technology, engineering and math play an important role in the implementation and sustainability of service operations. However, historical data show that career impediments based on gender, racial or ethnic bias deprive the nation of talented and accomplished researchers (US National Academies Committee, 2006) and build barriers limiting the number of women entering the service businesses that require extensive science and technology background.

Furthermore, one can easily argue that future STEM positions will require a blended skilled employee, having both technical and business related (relationship-building, interpersonal, organizational) skills. Therefore, a female candidate holding an STEM degree would be the most optimal candidate for companies such as IBM, for example.

However, the relatively lower number of women working in STEM areas surfaces as one of the main reasons of the unsatisfied demand in the service sector.

This phenomenon is mainly caused by three reasons: influential organizations, including educational institutions, are not sufficiently focusing on the growing importance of women enrollment in the technology-driven service industry and thus, are not creating solution mechanisms to overcome this problem, The gender gap in science participation in the United States is well documented (Gilmartin *et al*., 2007) and it is shown that there is significant bias against female candidates, leading to a high attrition rate among women working in STEM fields and there is lack of interest regarding STEM fields among female candidates.

The latter is mainly caused by the fact that the attributes required for success in technology-driven service related jobs are not clearly defined. Even though, women tend to have a natural tendency toward improving society and making a difference in the world, they also tend to perceive science and technology related positions as positions that do not require team work, human interaction or personal communication skills (Phipps, 2007). Therefore, the majority of women avoid entering these fields through their careers. Today, successful women students mostly consider law, medicine and business as their future profession while giving less thought about engineering, technology or computing fields (Haupt, 2006).

RESULTS AND DISCUSSION

There are several reasons for the gender gap in STEM fields; even though institutional prejudice is more likely to play a contributing role in limiting the involvement of women in assumed masculine dominant areas. Educational or not many organizations tend to favor men even though the basis of this decision is not statistically supported. Table 1 aims at listing major factors stereotyping some male and female traits and attempts to construct a scientific response to correct these misperceptions.

Literature indicates that today the problem is hardly caused by the number of female students in engineering programs. Despite the fact that earlier research points to most girls reporting a loss of interest in STEM around the age of 12 (AAUW, 1998), there are now many studies reporting cases (Wahid, 2006) where, women enrollment is much higher than men in engineering societies.

Table 1: Deconstructing commonly held beliefs about women in science and engineering 2006 (Phipps, 2007)

Girls/women	Boys/men	Response
Identified with home (private)	Identified with work (public)	Many women scientists and engineers persist in their pursuit of academic careers despite severe conflicts between their roles as parents and as scientists and engineers. These efforts, however are often not recognized as representing the high level of dedication to their careers they represent
Unable to deal with difficulties	Able to deal with difficulties	The publication productivity of women science and engineering faculty has increased over the last 30 years and is now comparable to men's. The critical factor affecting publication productivity is access to institutional resources; marriage, children and elder care responsibilities have minimal effects
Collaborative	Competitive	Similar proportions of men and women science and engineering doctorates plan to enter postdoctoral study or academic employment
Not very good at math	Good at math	Female performance in high school mathematics now matches that of males
Ignorant of opportunities	Aware of opportunities	Although, scientists like to believe that they choose the best based on objective criteria, decisions are influenced by factors-including biases about race, sex, geographic location of a university and age that have nothing to do with the quality of the person or work being evaluated
Biologically governed (body)	Able to escape biology (mind)	On the average, women take time off due to childbearing responsibilities during their early careers. But, by middle age, a man is likely to take more sick leave than a woman

Phipps (2007) and US National Academies Committee (2006)

The collaborative environment of the activities arranged by these societies may be a contributing factor in the change.

Historically, about one-third of all bachelor's degrees have been awarded in science and engineering. Even though women are 56% of the college population, women earned only 19.5% of engineering bachelor's degrees in 2005. Despite this high retention rate, in the long run we observe an increasing trend. Since 1970, the number of bachelor's degrees in Science and Engineering (S and E) awarded annually to men has fluctuated around 200,000, while the number of S and E bachelor's degrees earned by women has steadily increased, reaching parity (Fig. 1) in 2000 (Chubin *et al*., 2005; Sonnert *et al*., 2007).

Today, international data suggest that women now constitute over 20% of the student body in engineering and science subjects across Europe and in the industrialized world (Kusku *et al*., 2007). And whereas, women receive approximately 60% of the bachelor's degrees awarded in the United States, they make up only 21% of the recipients of degrees in computers and information science and an even smaller percentage of students in fields such as computer science and computer engineering (US Department of Education, 2007). These percentages have fallen from highs near 36% a decade ago.

The US National Academies Committee on Maximizing the Potential of Women in Academic Science and Engineering (2006) shown their finding as follows:

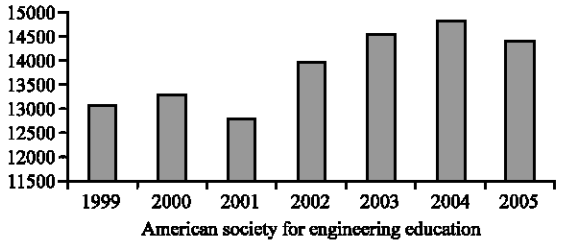

Fig. 1: Women earning B.S. engineering degrees (Grose, 2006)

- Women have the ability and drive to succeed in science and engineering
- Women, who are interested in science and engineering careers are lost at every educational transition
- The problem is not simply the pipeline
- Women are very likely to face discrimination in every field of science and engineering
- A substantial body of evidence establishes that most people-men and women-hold implicit biases
- Evaluation criteria contain arbitrary and subjective components that disadvantage women
- Academic organizational structures and rules contribute significantly to the under use of women in academic science and engineering
- The consequences of not acting will be detrimental to the nation's competitiveness

Wage discrimination is also another important factor, why women tend to avoid entering STEM fields. Table 2 depicts the median annual salary of individuals employed in S and E occupations.

In addition to the bias, there is also a gap between the needs of industry and the skills that the engineering students acquire during their studies. Table 3 depicts engineering as the field that has the majority of graduates entering post-doc studies due to lack of employment opportunities compared to other disciplines. Restructuring of the existing curricula, infusing today's market needs into academia and producing qualified candidates that are able to meet these changing needs can provide efficient solutions to this problem.

A good example of the gap between education and industry skills is the IT sector. It is estimated that approximately, 70 million baby bloomers will exit the workforce during the next 15 years, with only 40 million

Table 2: Median annual salary of individuals employed in S and E occupations: Selected years, 1993-2003 (Dollars) (NSF, 2003)

Sex/race/ethnicity	1993	1995	1997	1999	2003
S and E employed	48,000	50,000	55,000	60,000	66,000
Male	50,000	52,000	58,000	64,000	70,000
Female	40,000	42,000	47,000	50,000	53,000

Table 3: Primary reason for taking current postdoc by field: 2003 (NSF, 2003)

Doctorate field	Additional training in doctorate field	Training outside doctorate field	Post-doc generally expected in field	Association with particular person or place	Other employment not available	Others
All S and E fields	21.8	14.2	30.7	18.1	11.6	3.5
Biological sciences	19.1	15.1	37.2	17.4	8.2	3.0
Chemistry	21.9	26.9	21.8	16.7	10.9	1.9
Engineering	26.3	12.9	18.4	8.2	31.2	3.0
Geoscience	12.9	15.5	12.5	25.3	29.1	4.7
Physics	22.1	12.1	36.0	21.5	2.0	6.3
Psychology	29.1	8.9	24.0	23.1	10.7	4.2

Table 4: Current IT related openings in the US (hotjobs.com, 2007)

Services	No. openings
Incident management	1,565
Database administrator	2,103
IT architect	4,260
Solution architect	5,220
Programmer	5,336
Computer operations	18,940
Problem management	39,157
IT service management	39,090
Systems management	73,300

new workers joining the workforce in 2008. Table 4 shows the number of openings in the US market for various IT service related positions.

This unsatisfied demand can easily be interpreted as a proof of lack of skilled employees sine, there is a large unutilized potential workforce capacity generated by educational institutions. In addition to the significant number of job offerings, IT sector also important due to its vulnerability in the global competition. As also, stated by McLaughlin and Fitzsimmons (1996). IT jobs are more likely to go overseas due to their labor-intensive and information-intensive nature.

CONCLUSION

As the data presented demonstrate, there is a gap between the number of women entering STEM fields and the potential number who could be contributing in these areas. The types of skill sets needed have changed along with changes in the economy to focus more heavily on skills that women more typically possess such as organization, communication and flexibility. There are a number of corrective actions that can be considered to attract women to the field and more importantly to get them to stay in the field.

As stated by the Committee on Maximizing the Potential of Women in Academic Science and Engineering, the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine (2006) increasing and sustaining women enrollment in STEM can only be possible by a collaborative effort rather than independent individual institutional projects. In this regard, universities, businesses and government agencies should research together to support research, create programs and develop and implement regulations to promote women in engineering, technology and computing.

One such group, the National Center for Women and IT (2008), has sponsored a number of studies which have shown the importance of mentoring, encouragement and role models in influencing young women to enter STEM fields. Therefore, professional societies and higher education organizations would be well served to develop and enforce guidelines to ensure that keynote and other invited speakers at society-sponsored events reflect the diverse membership of the society (US National Academies Committee, 2006). Additional research on the impact of media sources on girls' science self-concept is needed to develop effective interventions for encouraging girls, not only to see other women as scientists and engineers, but also to see themselves as future scientists and engineers (Steinke *et al*., 2007).

Industry also has a responsibility to accelerate readiness of the female workforce, which will help alleviate skills availability issues and bridge the communication gap between IT functional jobs and business leaders' vision with academic institutions.

Honorary societies, funding agencies-including federal agencies and foundations, along with the congress, should take the necessary steps to encourage adequate enforcement of female workforce development. There is also no doubt that family-friendly policies help women to combine paid jobs with family work (Hakim, 2006).

Women are well positioned to make major advances in interdisciplinary research. They like to integrate across various academic fields and use multi-pronged, multi-disciplinary approaches. They research well in teams and are committed to connecting their research with societal concerns. Using interdisciplinarity to attract women, as well as other under represented minority groups into science is only practical and ethical if it leads to stable and secure pathways through scientific and academic careers (Rhoten and Pfirman, 2007).

Once, in STEM academic programs or careers, it is important that the environment is conducive to retaining female participants. Women tend to quit their jobs due to male-dominant cultures (Shanahan, 2007). This fact is of particular concern for women working in the technology sector because women are more likely to leave IT professions (Joshi and Kuhn, 2007). In part this may be due to reported biases in evaluation structures. Even if evaluators feel that interpersonal skills are as important as technical skills, the recall for and actual weight given to technical skills (or other masculine-typed attributes) may be greater (Joshi and Kuhn, 2007). Such biases and other subtle and not so subtle discriminatory practices must be eliminated if women are to succeed equally in STEM professions.

A start has been made in the understanding of the factors that have influenced young women in their choice of a career in a STEM field. However, much research is yet to be done in determining, how to encourage even more young women to make this choice, perhaps by highlighting the intellectual challenges of integrating both hard and soft skills, a position for which they are uniquely suited.

As Carly Fiorina, the former CEO of Hewlett Packard stated, the ability to collaborate with others, the ability to communicate clearly and the ability to see the forest and not get lost in the trees are skills that many women possess (Morell, 2007). Unless these characteristics are perceived as attributes characterizing top performers, there will be a continuing bias against women in male-dominated businesses resulting in a significant loss of job opportunities due to increasing global competition in the service industry.

REFERENCES

AAUW, 1998. Gender gaps: Where schools still fail our children. Washington, DC, American Association of University Women.

Bettencourt, L.M.A., J. Lobo, D. Helbing, C. Kuhnert and G.B. West, 2007. Growth, innovation, scaling and the pace of life in cities. PNAS, 104 (17): 7301-7306.

Bureau of Labor Statistics, 2008. Table B-1. Employees on nonfarm payrolls by industry sector and selected industry detail. Current Establishment Survey, Bureau of Labor Statistics.

Chubin, D.E., G.S. May and E.L. Babco, 2005. Diversifying the Engineering Workforce. J. Eng. Educ., pp: 73-86.

Crane, P. and A. Kinzig, 2005. Nature in the Metropolis. Science, 27: 308-225.

Fortune 500, 2008. Top industries: Fast growers. Retrieved Dec. 11. http://money.cnn.com/magazines/fortune/fortune500/2008/performers/industries/fastgrowers.

Gilmartin, S., N. Denson, E. Li, A. Bryant and P. Aschbacher, 2007. Gender ratios in high school science departments: The effect of percent female faculty on multiple dimensions of students' science identities. J. Res. Sci. Teaching, 44 (7): 980-1009.

Grose, T.K., 2006. Trouble on the Horizon. ASEE Prism.

Hakim, C., 2006. Women, careers and work-life preferences. Br. J. Guidance and Counseling, 34 (3): 279-294.

Haupt, R.L., 2006. Should my daughter become an engineer? Part 1. IEEE Antennas and Propagation Mag., 48 (4): 156-157.

Hotjobs.com, 2007. Current IT Related Openings in the US Independent Search.

Joshi, K.D. and K.M. Kuhn, 2007. What it takes to succeed in information technology consulting: Exploring the gender typing of critical attributes. Inform. Technol. People, 20 (4): 400-424.

Kusku, F., M. Ozbilgin and L. Ozkale, 2007. Against the tide: Gendered prejudice and disadvantage in engineering. Gender Work and Organization, 14 (2): 109-129.

Marshall, J.D., 2007. Urban land area and population growth: A new scaling relationship for metropolitan expansion. Urban Stud., 44 (10): 1889-1904.

McLaughlin, C.P. and J.A. Fitzsimmons, 1996. Strategies for globalizing service operations. Int. J. Service Ind. Manage., 7 (4): 43-57.

Morell, L., 2007. Women in Engineering. ASEE, EDI 2007-Diversity in Engineering. San Juan, PR.

National Center for Women and IT, 2008. Evaluating Promising Practices in Informal Information Technology (IT) Education for Girls PHASE III: Women in IT-Survey Results.

NSF, 2003. Science and Engineering Indicators 2006, (1993-1999) and preliminary estimates. Scientists and Engineers Statistical Data System (SESTAT). http://sestat.nsf.gov.

Phipps, A., 2007. Re-inscribing gender binaries: Deconstructing the dominant discourse around women's equality in science, engineering and technology. Sociol. Rev., 55: 768-787.

Rhoten, D. and S. Pfirman, 2007. Women in interdisciplinary science: Exploring preferences and consequences. Res. Policy, 36 (1): 56-75.

Shanahan, B., 2007. A Climate for Inclusion. ASEE, EDI 2007-Diversity in Engineering, San PR.

Sonnert, G., M.F. Fox and K. Adkins, 2007. Undergraduate women in science and engineering: Effects of faculty, fields and institutions over time. Soc. Sci. Quar., 88: 1333-1356.

Steinke, J., M.K. Lapinski, N. Crocker, A. Zietsman-Thomas, Y. Williams, S.H. Evergreen and S. Kuchibhotla, 2007. Assessing media influences on middle school-aged children's perceptions of women in science using the Draw-A-Scientist Test (DAST). Sci. Commun., 29 (1): 35-64.

US Department of Education, 2007. Integrated Postsecondary Education Data System. US. D.O. Education, National Center for Education Statistics.

US National Academies Committee, 2006. Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering. US National Academies Committee on Maximizing the Potential of Women in Academic Science and Engineering. Washington, DC, National Academy of Sciences, National Academy of Engineering and Institute of Medicine.

UN, 2004. UN World Urbanization Prospects: The 2003 Revision. United Nations, New York.

Wahid, P., 2006. IEEE women in engineering membership data. IEEE. Antennas and Propagation Mag., 48 (4): 174-176.