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Article

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RESEARCH

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Women engineers' lack of precedence: the 'virgin territory' of robotics

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Abstract

In recent history, information and communications technologies (ICTs) have been radically advanced and largely infiltrated daily routine. Additionally, modern educational methods encourage the use of ICTs in the learning processes. Especially in the education of hard sciences like Physics, the use of ICTs is favored because the students can more easily understand the natural laws and observe in real time the results of the experimental process. Women engineers approach this kind of educational process better as they combine a variety of traits due to their feminine nature that gives them precedence. It is widely accepted that females outperform males in verbal ability, are raised to be more sensitive, have maternal instincts, and can be extremely supportive not only to same sex peers but also to both genders. These inherent genetic traits result in women's ability to be naturally tuned into the world around them. In a man's world - more importantly when ICTs are concerned - women are often discouraged and need to work a lot harder than men to achieve a favorable situation. This pressure makes women more active and persistent. According to the Foundation for Economic and Industrial Research report for 2010 to 2011, only 3.7% of the entrepreneurs between 18 and 64 years old are women (Ioannidis and Chatzichristou http://www.iobe.gr/index.asp?a_id=853, 2012). In the last two decades, the field of robotics has been advancing more radically than ever. Many distinctive robotic mechanisms have been implemented due to the innovative ideas and the outburst of technology. During author MT's PhD research, she noticed that few women participate actively in state-of-the-art educational methods including ICTs. More distinctively, women involved in robotics seem to have been excluded from the productive or research process. The absence of contributions by women engineers in robotics and in the assistive educational tools it provides has led to a more masculine approach in the field that may result in more stiff, plain design, or even less imaginative functionalities. Generally, the stereotypes and biases that exist with regard to gender have hatched and produced the behavior of women and the way they are encountered and treated by the society.

Keywords: Women engineers, Gender biases, Gender gap, State-of-the-art methods, Robotics

Background

Women engineers in a man's world

The excessive use of the information and communications technologies has led to an increased demand of scientists, researchers, and engineers in the sector. Modern technology influenced every company, public sector, and daily routine. New trends in

production lines, new methods in management, and even new approaches to educational processes were established and have improved living standards. Interactive whiteboards, video conferences, remote-controlled laboratories, and simulation of experiments have managed to be the best educational approach to knowledge.

Many individuals turned toward informatics, hard sciences, computer engineering, and communications, and this proved to be right because such sectors kept rising and rising during the last two decades. At first, only males were interested in these fields, but soon after, females followed. As far as the robotic sector is concerned, it is unfortunately still underrepresented by women (Ioannidis and Chatzichristou 2012).

Males have been dominating the engineering industry since its beginning, and women - if any - have been excluded one way or another. In an attempt to achieve a higher level of advancement, women have been working remarkably harder and under more pressure than men. As mentioned above, in this male-dominated sector, women feel less valued and less worthy. In some cases, this feeling of exclusion made women more active, persistent, and willing to sacrifice their social life entirely in order to prove that they are making valuable contribution to their sector. On the other hand, many women started to feel like second-class employees and never asked for recognition (Yoky 2006). The truth is that it is not just that feeling of exclusion that they have. Women are evaluated based on their performance, while men are evaluated according to their potential skills.

During the last decade, there are few examples of successful women in the engineering field, so few that ambitious young women did not have role models. The opportunities for career advancement were significantly fewer than men, and this led many women to quit and focus on other fields.

The most important obstacle that needed to be overleapt was the bias about the work-life balance. In many companies, the balance between work and personal life was a drawback only for women. It was largely assumed that women could not work long hours, could not travel for work purposes, and when someone got married or gave birth, her family was the first - if not the only - priority.

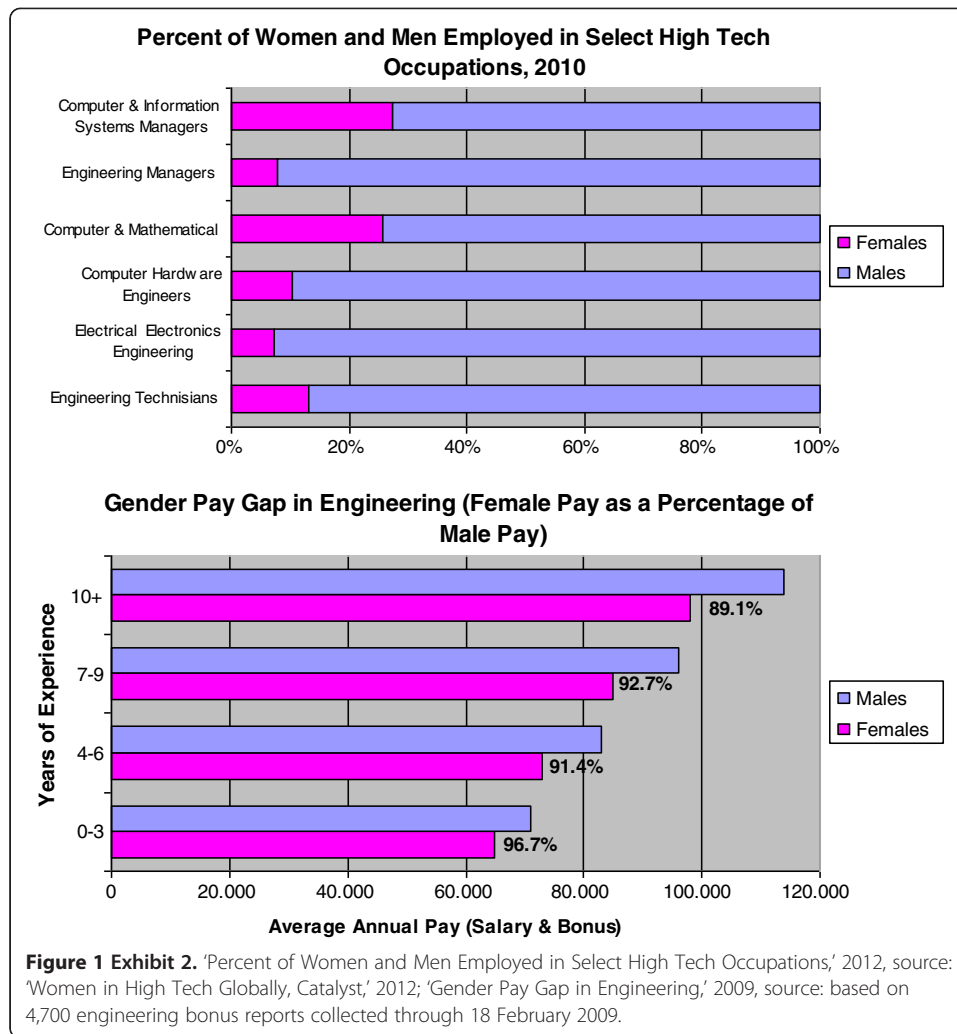
Under these circumstances, the gender biases were established, and the gap between male and female employees in engineering was raised.

Results and discussion

There are few women engineers employed in large companies. This happens not only due to the organizational culture obstacles or the social biases that have been described above. Reports worldwide show that few women want to study engineering and far less want a career in the engineering field. According to the California State University, Long Beach (CSULB)'s College of Engineering, women represent less than 15% of CSULB's engineering population^b (Engineering Student Success Center 2012) (see Figure 1). The American Association of Engineering Societies in 2004 reported that only about 10% of the nation's professional engineers and 20% of undergraduate engineering students are women. This fact is an omen of the potential isolation that women students might experience in a male-dominated field.

Today, CSULB's College of Engineering is currently developing more aggressive strategies for increasing the participation of women students in its programs.

These percentages are encountered around the world. From personal experience, during MT's studies in Computer Engineering at the University of Thessaly, only the 20%

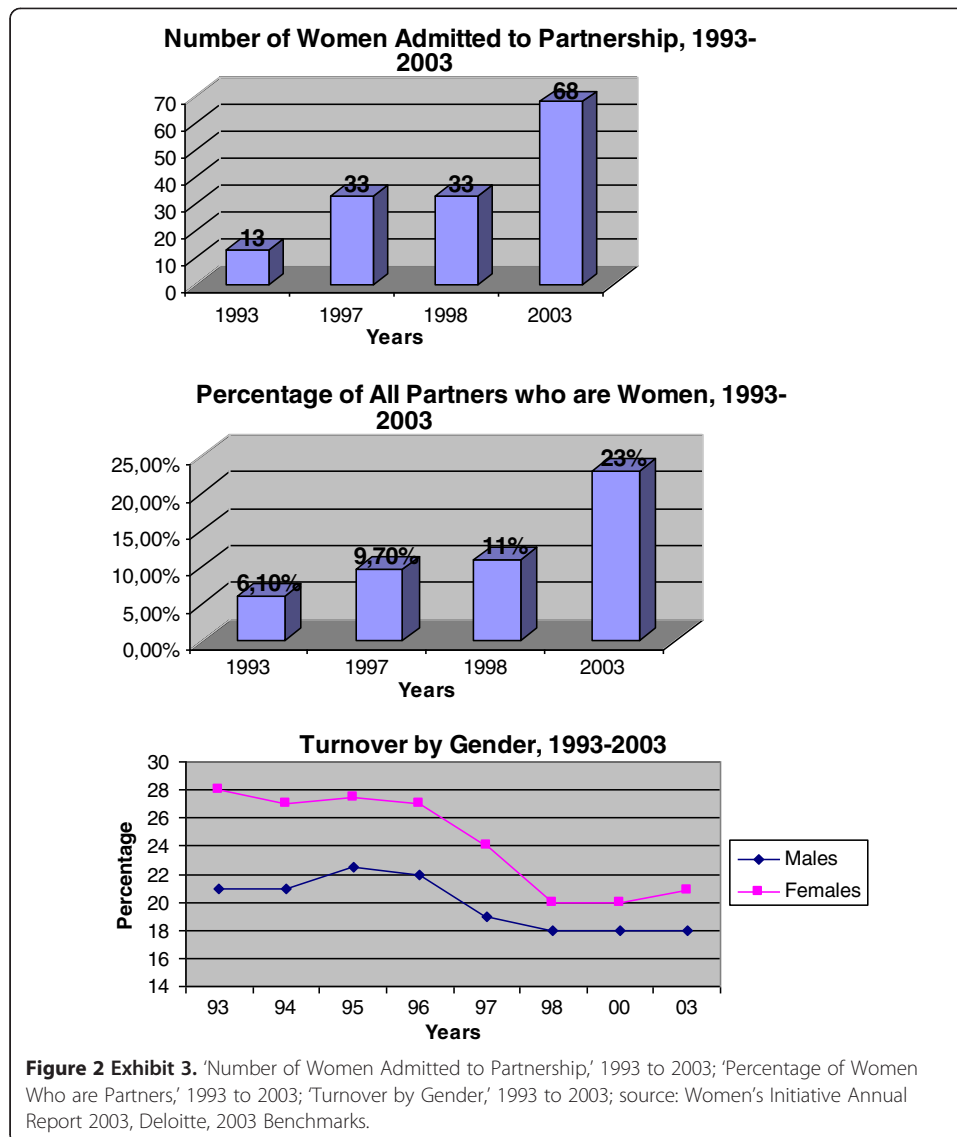


of the students that graduated each year were women. Thus, this indicates the importance of embedding gender into business school curriculum worldwide.

Conclusions

The characteristics of the feminine nature need to be highlighted in order to indicate the importance of their participation in the engineering sector. The differentiation is crucial in order to provide separate points of view. Reports demonstrate that the feminine nature combines traits that outperform men. Their verbal ability is more developed, and they are keen on listening carefully. By nature, women are less aggressive and more patient than men. This is very important in today's business-hostile environment. Additionally, they are comfortable with multitasking, and they do not crash when their schedule is full. The maternal instincts are considered a plus, along with intuition and sensitivity. These characteristics make women approach assignments in an entirely different way than men. As a result, gender diversity helps business provide better results.

However, the engineering sector has been underrepresented by women for years. Additionally, pay gaps between genders were a brutal reality (Besse 2009) (see Figure 2).



This sector not only is difficult for women to enter into but also is almost impossible to advance their career. Empowering women to participate fully can lead in the advancement of productivity and effectiveness, qualitative change in the organizational culture, and generally, improvement in the quality of life of the community.

At present, the goal that needs to be achieved is to support companies in reviewing their organizational culture and establishing new policies to realize women's empowerment. Globalization could be a challenge: not only companies can be committed to undertake this initiative and empower the role of women but also they must respect the cultural morals that may apply in local businesses.

Robotics: male-dominated grounds

The sector of robotics did not grow substantially until the second half of the twentieth century. These autonomous mechanisms have been manufactured in order to perform assignments more accurately, affordably, and reliably than humans. Their use applies in

a wide variety of fields, such as military, pharmaceutical, hard sciences, industry, etc. The last decades a lot remarkable robotic mechanisms have been designed and implemented, and some of these are considered as massive technological breakthroughs. Robotic laboratories that focus on biological experiments, robotic arms designed for individuals with kinetic disabilities, and robotic mechanisms that substitute human labor are few examples of the innovative advances.

Due to author MT's participation in the 'Smart and Adaptable Information System for supporting Physics Experiments in a Robotic Laboratory' project (SAIS-PEaRL project), she had to engage herself in the field of robotics (SAIS-PEaRL 2010). During her 3 years of research for her PhD, MT noticed that it was a highly male-dominated sector. The vast majority of the female scientists was in the educational fields, informatics, or physical sciences and had an advisory role in the robotic implementations, and women represented just the 10% of the community of robotics. MT followed the field of robotics because it fascinated her, and she would like to encourage more women pursuing a career in the field.

The reasons why women are excluded from the robotic sector might be many and controversial. Robotics combines informatics, engineering, computing, artificial intelligence, and hardware and software technologies. These are considered more masculine fields, and women are not very interested in them. Furthermore, the stereotypes that are established regarding robotics have discouraged women from pursuing a career in the field. Additionally, there are few female role models in the field. This absence of feminine contribution resulted in more stiff and plain design that lacks of female approach. Additionally, one of the reasons why women are not very familiarized with high-tech products is actually their conscious absence of the design and implementation of software and hardware solutions. Women are more sensitive in engaging themselves in issues that provide practical benefits to society.

It seems a challenge to shorten this gender gap, but it is crucial that it should actually be shortened. More women must be recruited and retained in the field of robotics. At first, it is crucial to change the perception that robotic mechanisms are cold metallic objects. Robotic mechanisms can provide functionalities that improve the quality of life. Women must be inspired by the benefits of robotics. They could be assessed with issues that concern social sensitiveness, such as the improvement of lives of elderly or handicapped individuals. If women engineers are encouraged by their academic communities, they will be more interested and will offer new ideas, talents, and skills to the field of robotics. By bringing their talents to the male-dominated engineering field, women can create sparking innovation.

Women's initiatives

In an attempt to approach more women engineers and to exchange information about engineering developments and challenges across disciplines and countries, many international groups and events have been organized worldwide. The Society of Women Engineers, in conjunction with the India Institute of Technology, Bombay, and Indo-US Science and Technology Forum, has launched the symposium 'Women Engineers Leading Global Innovation' in India last August 2012 (Women Engineers Leading Global Innovation 2012). In addition, the PRME Working Group on Gender Equality has been focusing on promoting gender equality in the workplace, marketplace, and community,

and UN Women have launched the Women's Empowerment Principles, which offer practical guidance to business and the private sector on how to empower women (Principles for Responsible Management Education 2012).

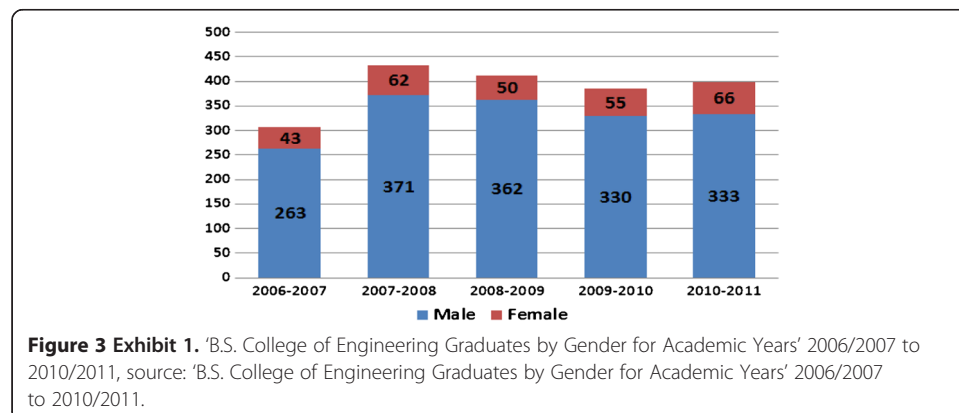
Another community that aims in highlighting the contributions of women in robotics is the 'Women in Robotics and Automation towards Human Science, Technology and Society' (Otake et al. 2006). It targets students, engineers, and researchers in robotics, automation, human sciences, and technology, and everyone that is interested in research and development activities conducted by women.

Methods

Two of the most remarkable case studies which acknowledge that change in the organizational culture is difficult but yet possible are the Deloitte & Touche case studies by the Harvard Business School^a. During the last two decades, 50% of the recruitments of Deloitte & Touche were women, but 90% of them never stayed enough so as to be nominated for partnership. Mike Cook, the CEO, wanted to take action in order to stop losing talented women and make sure that there was no 'glass ceiling' for women at Deloitte (Deloitte 2005, 2012; Roessner 1999; Roessner and Kanter 1999) (see Figure 3).

In order to explain why women left the company at a faster rate than men and develop recommendations to reverse that trend, Cook established the 'Task Force on the Retention and Advancement of Women.' Next, the Task Force hired a consulting company, and after many interviews and extensive analysis, the conclusion was just this: Deloitte was a lousy place for a woman to work. Most women explained that they did not feel valued, that the minute they start a family they are written off, that nobody was willing to invest in them, that they did not have mentors, that they do not see women in leadership positions, and that they do not see role models. On the other hand, the male interviewees explained that it would be awkward to mentor and instruct women due to their sensitive character and also that they could not trust them with important assignments, assuming that they would break down. Most of them assumed that women would not want to travel or stay late at the office due to their commitments to their families.

These biases and assumptions had been nourished for years until it began to constitute the organizational culture of Deloitte (Knowledge@Emory 2009). It became a highly male-dominated environment where all the best projects were assigned to males,



the opportunities for career advancement of women were faint, and the role models of successful women could be counted with the fingers of one's hand.

Unfortunately, phenomena like these have been observed in many cases, mainly in sectors related to hard sciences, finance, engineering, and informatics. Many companies have been warding off women due to the organizational culture and the biases that grow since the first years that women employment was constituted.

Today, Deloitte is recognized as a leader in advancing women, thanks to the Initiative for the Retention and Advancement of Women that is still in operation.

Endnotes

^aAll the statistics that are studied and presented in this paper have been published in the official website of the 'Task Force on the Retention and Advancement of Women.' Further information and case study analysis are available by Harvard Business School, in 'Deloitte & Touche (A): A Hole in the Pipeline,' and 'Deloitte & Touche (B): Changing the Workplace.'^bThe statistics that are presented in this paper are retrieved from the B.S. College of Engineering Graduates reports.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

MT and DV carried out the research and drafted the manuscript. Both authors read and approved the final manuscript.

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