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WOMEN IN STEM
WHERE DO WE STAND, AND WHERE ARE WE GOING?*

by

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*The views expressed in this paper are those of the author and do not necessarily represent those of the United Nations.

Summary

Women in science, technology, engineering and mathematics (STEM) are believed to be underrepresented, and the target of increasing the retention and recognition of women scientists and engineers seems to be well within the scope of the UN Commission on the Status of Women (CSW). The question is, however, what level of intervention needs to be taken by states and institutions. In this paper, I present updated data on women employed in science and technology, and identify trends. Based on the international data, as well as on a close analysis of the case of Israel, I suggest the thesis that the proportion of women in STEM is naturally increasing because of changes in the nature of technology in the 21st century toward more human-related aspects. Moreover, the presence of more women in STEM can potentially change technology into an environmentally friendly area, and increase innovation in science. However, the recognition of women in STEM, as indicated by evidence of a glass ceiling, will not improve without intervention.

This paper consists of three parts: the first provides data on women in STEM employment, beginning with the total share of women researchers in different countries around the globe; continuing with data on their distribution among different STEM fields; and then introducing the "scissors diagram" showing the decreasing participation of women at higher levels, which indicates the existence of a glass ceiling for women in STEM. In the second part, I focus on data from Israel, which is considered a leader in high-tech. In the final part, I analyze the data and suggest the following main conjectures:

1. The retention of women in STEM will *increase* because technology is becoming more interdisciplinary and heavily involved with human-related factors. This is mainly because of the green revolution, which forces technology to be more environmentally-oriented.

2. While more and more business leaders realize that gender diversity yields a competitive advantage, I do not anticipate the disappearance of the glass ceiling in STEM employment.

3. More women in STEM will result in more innovation.

I. Women's participation in science and technology employment

1a. International data and trends

Recently published data from the Organisation for Economic Co-operation and Development (OECD) on the proportion of women researchers in OECD countries reveals that it varies from as low as 13% in Japan to as high as about 44% in Portugal (2008).[1] A similar image arises from European Commission (EC) data, which cites an average of 30% women researchers among EC members (2006).[2] These data suggest that the proportion of women researchers in all fields does not reach their share in the population.

What are the trends? OECD data from 2001 through 2008 for 28 countries show that the share of women researchers either did not change, or increased. In some countries, such as Germany, Italy, Norway and Switzerland, there was a moderate increase during this period of 10-20%. The increase was more dramatic, up to about 30% in others, including Japan, the Republic of Korea and the Netherlands. Naturally, the smaller the initial share of women researchers at the beginning of the 3rd millennium, the higher the change rate.

1b. Horizontal distribution and trends

The data above related to women researchers in all fields, while we are interested in STEM, so it is important to examine the distribution of women researchers across the different fields, known as "horizontal distribution."[3] It is well known that the participation of women in STEM employment is lower than in other academic areas, so if the overall proportion is less than 50%, the situation in STEM is even worse. A recently published report entitled "Why so Few?" provides data from different sources on women in STEM professions in the United States of America.[4] It indicates that more than 50% of the biological scientists employed in the United States in 2008 were women. Woman chemists and material scientists have the next highest percentage, slightly above 30%. Women civil engineers barely exceed 10%, while in electrical and electronic engineering women are employed at an even lower rate, with the lowest representation of women in mechanical engineering.

Trends can be identified by looking at data about bachelor's degrees awarded to women in science and engineering in the United States over four decades, from 1966 through 2006.[5] Almost 60% of the graduates in the biological sciences in 2006 were women, as compared to 25% in 1966. The increase in female graduates ranges from 5% to almost 15% from one decade to the next. In mathematics, on the other hand, between 1986 and 2006, there was a slight decline, from the high percentage of 46.5% in 1986. Engineering maintains its status with the lowest percentage of women in each decade in

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[1] OECD data on women researchers, http://www.oecd-ilibrary.org/science-and-technology/women-researchers_2075843x-table3
[2] *She Figures 2009*, report published by the European Commission, ISBN 978-92-79-11388-8 http://ec.europa.eu/research/science-society/document_library/pdf_o6/she_figures_2009_en.pdf
[3] For a definition and discussion, see, for example, *She Figures 2003*, available at: ec.europa.eu/research/science-society/pdf/she_figures_2003.pdf
[4] In *Why so few?*, report published by AAUW in 2010, written by Catherine Hill, Christianne Corbett, Andresse St. Rose. http://www.aauw.org/learn/research/whysofew.cfm
[5] Ibid.

comparison to other fields, though there is a slight increase in the field in each decade. In computer science, the high of 35.8% was reached in 1986, declining in 1996. Following the same trend, in 2006 there was a decline in the percentage to 20.5%, almost the same level from which it had risen in 1976.

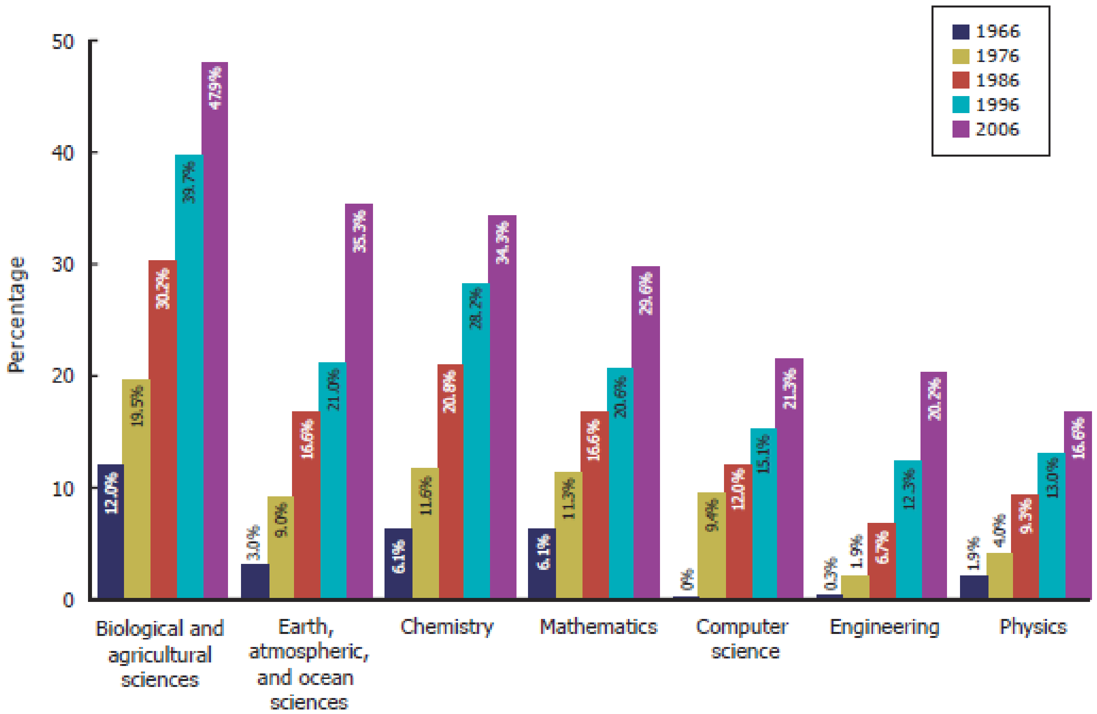

Figure 1: Doctorates earned by women in selected STEM fields, 1966-2006. *Source*: National Science Foundation, Division of Science Resources Statistics, 2008, *Science and engineering degrees: 1966–2006* (Detailed Statistical Tables) (NSF 08-321) (Arlington, VA), Table 25, Author's analysis of Tables 34, 35, 38, & 39.

Fig. 1 depicts the share of women who earned doctorates in science and engineering between 1966 and 2006. While there are differences in the proportion of women in the different STEM areas, it is evident that in all STEM areas, there is a constant and dramatic increase in Ph.D. graduates over the years. None, however, has reached the level of 50%.

One of the most traditional male fields is electrical engineering. Indeed, Table 11 in the United States Department of Labor report, *Women in the labor force: A databook*, suggests that in 2008, fewer than 10% of electrical engineering employees were women.[6] This observation is supported by looking at the data for percentages of women in electrical and electronic engineering, as per membership in the IEEE – the Institute of Electrical and Electronics Engineers, which in 2009 had close to 400,000 registered members, only 9.54% of whom were women (including students), with an almost negligible increase of about 1.6% in the last three years.[7]

1c. The Glass Ceiling

We now proceed to the vertical distribution, which is illustrated by European Union (EU) data comparing percentages of men to women on a typical academic career path.[8]

[6] United States Department of Labor, Bureau of Labor Statistics, Report 1018 (Washington, DC, 2009).
[7] IEEE Women in Engineering http://www.ieee.org/membership_services/membership/women/index.html
[8] *She Figures 2009*.

Data for the years 2002 to 2006 for 22 countries yield a scissors diagram that shows a minor increase in the proportion of women. The scissor phenomenon appears also when we isolate science and technology professions (see Fig. 2).

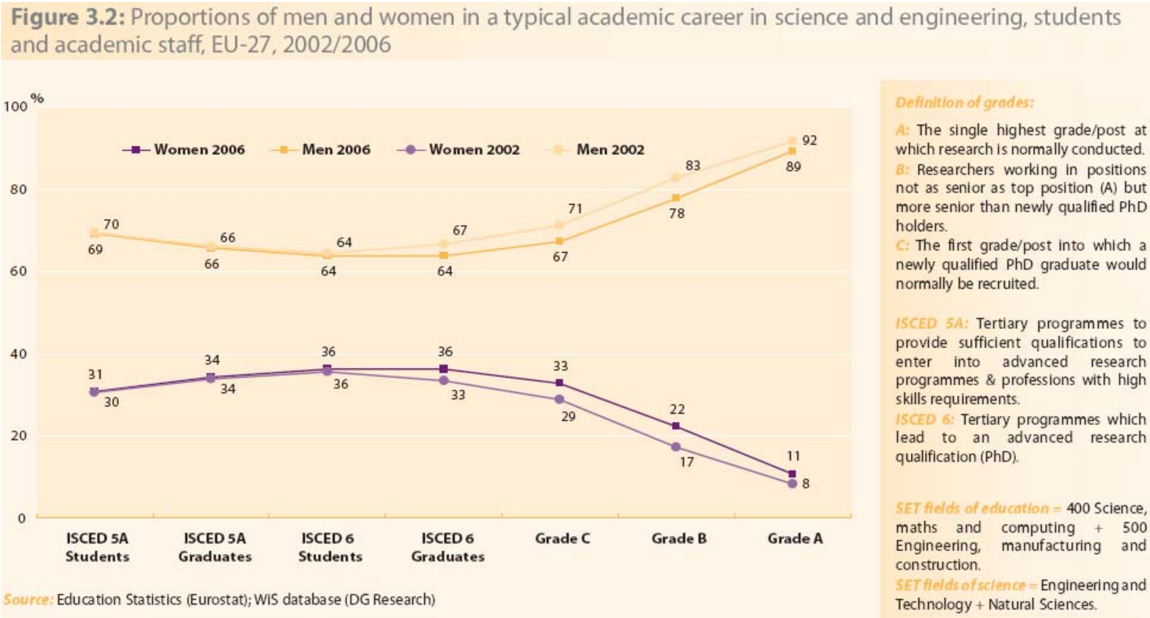

Figure 2: The scissors diagram for women in STEM, and the negligible improvement over the years.[9]

It is interesting to examine the existence of a scissors diagram in a field in which women's participation is less than 10% and is of great importance to modern industry – electrical and electronics engineering. To consider this, I look again at the IEEE data on 2009 membership, which shows that while about 7% of the voting members are women, only 5% of the *senior members* are women, and only about 3% of the *fellows* are women (187). This clearly indicates that the glass ceiling exists, independent of field and of whether the field is traditionally male or female.

II. A closer look at the R&D state of ISRAEL

In 2000, the EU set a goal of spending 3% of the gross domestic product (GDP) on civilian research and development (R&D) by 2010. Israel is known as a high-tech state, a leader in enterprise and in innovation. When we examine the expenditure on civilian R&D as a percentage of the GDP of many countries (in 2007), we see that it typically varies between 1.2% (Italy, New Zealand, etc.) and 3.6% (Sweden) with an OECD average of 1.9%.[10] With these figures in mind, it is amazing to see that Israel spent 4.8% of its GDP on civilian R&D in 2007.

Considering these data, it is compelling to consider the extent to which women are represented professionally and academically in Israel in a range of disciplines.[11] The lowest percentage of women in a given field in Israeli universities in 2008 was 28.3% in engineering and architecture (grouped together in the data available). In 2007-8, among those earning a Ph.D. in this group, 23.7% were women. In fields designated as legal,

[9] Ibid.
[10] Central Bureau of Statistics, Israel www.cbs.gov.il
[11] Ibid.

paramedical, humanities and life sciences professions, we see far higher proportions of women, exceeding the number of men. Generally speaking, the share of women in STEM in Israel, and its horizontal distribution, is similar to that of many other OECD states, and it is definitely not significantly better.

In particular, if we examine the number of women studying mechanical engineering today at Tel Aviv University, we find only 14.5%. The rate is slightly higher for electrical and computer engineering, with 17.1% women. These fields seem to have remained a male bastion, as in the United States. It is interesting, however, to see that in other areas of engineering, there is a definite change. Bio-medical engineering at Tel Aviv University currently boasts 389 students, **59.5%** of whom are women, while industrial and management engineering has 208 students, 50.6% of whom are women.[12]

III. Where are we going?

Clearly, to increase the proportion of women in STEM, one should start by asking why there are so few women in these fields. It is beyond the scope of this paper to begin to address that question. Research shows that there is no single bottleneck.[13] There are many different issues involving culture, structure, tradition, and others that prevent women from choosing a career in STEM. However, analysis of the distribution of women in the different STEM fields suggests that women feel more comfortable in areas that are more human-nature related, such as biological science. Moreover, the fact that the share of women students in engineering fields such as bio-medical engineering, industrial and management engineering, and environmental engineering, is considerably higher than in the core technical fields such as mechanical or electrical engineering, suggests that engineering fields more involved with human issues and interpersonal interactions attract more women. Since engineering is now changing toward more interdisciplinary linkage with health and environmental consequences, *I view the increased retention of women in engineering as a by-product of the green revolution.*

Another modern twist is indicated by the fact that CEOs of top international companies (*Airbus, Air Liquide, EADS, Hewlett Packard, Rolls Royce, Schlumberger, and Siemens*) have publicly acknowledged the value of having women executives. In 2003, they published a wake-up call to their colleagues,[14] in which they not only expressed a desire to see twice as many women graduating in science and engineering, but also stated their intention to see that women's skills be used in industry to the best advantage. However, while more and more business leaders realize that gender diversity yields a competitive advantage, I do not anticipate the disappearance of the glass ceiling in STEM employment.

Thus, the question of where we are going can be answered with an optimistic view: we will see more women in STEM in the 21st century, both because the industry needs women and because up-to-date engineering has become more attractive to women. Unfortunately, there are no signs of change in the vertical dimensions – the glass ceiling is still there – in STEM as in other professions.

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[12] Tel Aviv University (Israel), Faculty of Engineering, private communication.
[13] Why so few? Report published by AAUW in 2010, written by Catherine Hill, Ph.D. Christianne Corbett Andresse St. Rose, Ed.D. http://www.aauw.org/learn/research/whysofew.cfm
[14] "Women in Technology and Science in the Private Sector, A Wake-up Call from CEOs" 2003 http://ec.europa.eu/research/science-society/women/wir/pdf/ceo-position-paper_en.pdf

The presence of more women in STEM, particularly in core technical topics such as electrical and electronic engineering can also lead to greater innovation. For example, the idea of using existing measurements taken from wireless communication networks for environmental monitoring,[15] initiated by a female electrical engineer (myself), has opened a new field of research and applications. Thinking differently, as women do, introduces diversity – and enrichment.

[15] Messer, H; Zinevich, A; Alpert, P, Environmental monitoring by wireless communication networks, *Science*, 312 (5774): 713-713, 2006.