ISRAELI TALENTED WOMEN IN SCIENCE: THE STATE OF THE ART

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Abstract

Israeli high ability girls have achieved highly in science at all educational levels. The number of girls learning high level mathematics in high school has already outnumbered that of boys; more girls than boys learn biology and chemistry at the highest possible level, more of them pass the matriculation examinations and more excel in them. As a result there is already a female majority in many scientific areas at the university level, without any decline at the graduate level. The rate of girls and young women participation in each scientific area varies, with a maximal rate in life sciences and minimal – in physics. Among Arabs, the largest minority in Israel, girls and young women outperform male's achievements even further, and thus Arab women have been doing the largest educational advance in comparison to any other sub-population in the last 30 years.

Key words: talented women, Israel, science.

MUJERES ISRAELÍES TALENTOSAS EN LAS CIENCIAS: ESTADO DEL ARTE

Resumen

Las niñas israelíes con altas capacidades han tenido grandes logros en la ciencia en todos los niveles educativos. El número de niñas que aprenden matemáticas de alto nivel en la secundaria supera el de los hombres; más mujeres que hombres aprenden biología y química en el nivel más alto posible, mientras que muchas más pasan los exámenes de admisión y muchas más adquieren buenos puntajes. Como consecuencia, ya existe una mayoría femenina en las áreas científicas en el nivel universitario, sin ninguna baja en el nivel de posgrado. La tasa de participación de niñas y mujeres jóvenes en cada área científica varía, con una tasa máxima en ciencias naturales, y mínima en física. Entre los árabes, la minoría más grande en Israel, las niñas y las mujeres jóvenes superan los logros masculinos aun más, y por ende, las mujeres árabes han llevado a cabo el mayor avance educativo en comparación con cualquier otra sub-población en los últimos 30 años.

Palabras clave: mujeres talentosas, Israel, ciencia.

Forward:
How to avoid a discussion about "what is science"?

"Science" is a geographically-financially-historically dependent term. Is definition depends on place, money/economics and time. Let us look at a most striking example: in Israel, the first academic program in computers sciences was opened at the Technion, Israel Institute of technology in 1970. 8 young women and 10 young men were in the first class learning for the degree of "computers engineer", 2 of the men dropped out but all women got to the end of the race. All students in that program studied math with mathematics students and physics with physics students, so there was a lot of "science" learning. However, nobody could know that studying computers was the fast track to be a millionaire, so women were welcome to participate and they sure did (Zorman & David, 2000). However, in 2004, about of a quarter of century later, only 27.6% of all computer sciences students were women (Statistics, 2005) (Table 6). This has been the situation in the last decade, in spite of the fact that in all university programs, except the one at the Technion, computer sciences students do not have to take physics, a field that girls still prefer not to take in high school, and the amount of mathematics they learn is, in average, no larger than that of what math students learn during their first year. Furthermore, the percentage of female math students is about 50% higher than those learning computers. We can thus conclude that no lack of mathematical ability contributes to the very low rate of female computer students.

On the other hand, in Israel psychology students must learn statistics during all three years of undergraduate studies. In spite of this mathematically-related path, in 2004 1846 of the 2508 psychology students in Israel were females (Ibid). As less than 20% of psychology graduates are accepted to a Masters degree in all Israeli universities, it is of great interest to observe that in 2006 the female rate of MA psychology students was as high as 78.7% (Statistics, 2007) (Table 8). It should also be noted that all MA Israeli students of psychology must take advanced statistics courses throughout their graduate studies. While mathematics and statistics might be considered "male" subjects, when a female student wishes to become a psychologist she is certainly able to satisfy all requirements in these areas.

For a conclusion let me cite Prof. Richard LYNN, the famous intelligence scientist:

> I am pure English & most of my family has been biologists & geneticists – as I am – I regard Psychology as a branch of Biology (private communication, November 2, 2005).

Biology and psychology, the sister-sciences, have never been as close to each other as here and now. However, psychology is not always considered a science; neither is economics, and needless to mention – sociology or education. As I do not wish to draw a strict line as to "what is [not] science" my data will refer mostly to math, "hard" and "soft" sciences, but in many cases to their under-appreciated sisters from social sciences.

Designing the gender aspect of Israeli science: The high school years

The increasing participation rate of highly able females in the Israeli world of science has been a direct result of the changes girls and adolescent females have gone through. Breaking many of the "glass ceilings" – especially in the world of biology-related subjects, has made a change in the economic situation of talented females followed by their reaching high positions both in the academia and industry. Let us review some of the stages young women have climbed through during the last years.

Israeli population consists of a majority of men in the following age groups: 0-4 (51.3%); 5-14 (51.3%); 15-19 (51.15%); 20-24 (50.9); 25-29 (50.25); and 30-34 (50.3) (Statistics, 2007) (Table 2.10). Thus, it should have been expected that more boys than girls would participate in the education system. However, the picture is somewhat different due to the relatively high dropout rate of boys in the upper stages of high school (David, 2003). The minimal female advantage in high school participation rate of girls is translated to a larger gap favoring young women at all stages of tertiary education. Table 2 will show us the female advantage in education at the end of high school.

Table 1. 12th graders in Israel: 2005/6*

12th graders No.	Took matriculation exams No. (% of 12th graders)	Entitled to certificate No (% of 12th graders)	Met university entrance requirements (% of 12th graders)
Boys: 46,424 (48.3)	Boys: 37,648 (81.1)	**Boys**: 22,376 (48.2)	**Boys**: 19220 (41.4)
96,021	80,627 (84.0)	52,068 (54.2)	44,260 (46.1)
Girls: 49,597 (51.7)	**Girls:** 42,979 (86.7)	**Girls:** 29,659 (59.8)	**Girls:** 25,046 (50.5)

* Processed from Statistics (2007) (Table 8.24).

In the 2005/6 academic year the 12th grade population in Israel consisted of 46,424 boys and 49,597 girls (Statistics, 2007) (Table 8.24). Females were the majority of 12th graders in spite of the fact that they consisted of only about 49% of the population. Only 81.1% of the boys, versus 86.7% of the girls took the matriculation examinations. The success rate among boys was only 59.4% in comparison to 69.0% among girls. Thus, only 22,376 boys but 29,659 girls were entitled to the matriculation certificate. In addition, while the number of boys meeting university entrance requirements was just 19,220 that of girls: 25,046 (Ibid) Taking into consideration that in 2006 only 43.4% of those eligible to university education were boys it is very well understood why the rate of females among first year students has been well over 50%.

The results of the matriculation examinations show that girls have outperformed boys in school achievements in all scientific subjects since 2000. In addition, the rate of girls taking the 4- and the 5-point matriculation examinations has been higher than among boys in mathematics, biology, and chemistry. The percentage of those successful in the matriculation exams has been higher among girls in most scientific subjects, including physics; the only two exceptions have been computers in the Jewish sector and chemistry in the Arab sector, where boys were equally successful as girls. Let us see some of this data.

Table 2. Percentage of entitled to certificates among matriculations examinees in selected enhanced subjects, by gender: 2004*

	Jewish education			Arab education		
	Girls	**Boys**	**Total**	**Girls**	**Boys**	**Total**
Math	97	94	95	92	87	90
Physics	98	96	97	94	90	92
Chemistry	98	97	97	87	86	87
Biology	93	87	91	78	67	74
Computers	97	96	96	96	93	94
Agriculture	82	75	78	69	(58)	65

* Processed from Statistics (2007) (Table 8.27).

We can see from Table 2 that both Jewish and Arab girls in Israel not only outnumber boys in the matriculation entitlement, but also outperform than in the success rate in all subjects[1].

[1] As this article concentrate on scientific subjects, I have not shown the large gender disparity favoring girls both in participation and in achievement in all school subjects.

The educational point where gender differences favoring females first appear is observed at the end of high school. In Israel in addition to the minimal requirements for being accepted to one of the 5 universities, where a degree in science can be obtained, students need to succeed at the minimal 3-point mathematics matriculation exam, as well as in English and at least one more subject at the 4-point level. In the 2005/6 academic year only 41.4% of 12-grade boys in comparison to 50.5% of the girls met these requirements (Statistics, 2007) (Table 8.24). The percentage of girls entitled to the matriculation certificate among those taking the 4- and 5-level examinations in math, physics, chemistry, biology, and agriculture, was higher than that of boys (Ibid) (Table 8.27).

No wonder there are areas – like biology – where female superiority is substantial from high school level on. Only about one third of students studying high school biology at the highest possible level are boys. More girls than boys take the highest level matriculation examination in biology; a higher percentage pass them, a higher rate excel in them, and thus a higher rate apply to the four Israeli universities with undergraduate biology departments, many more girls than boys are accepted to these high-prestige departments, so there is a quite stable female rate of 60-70% in all educational stages.

The first stage of materializing the potential: University students

The highest rate of female students studying science for the first degree has been observed – for as long as 20 years – at the Bar Ilan University. Let us look at the data of female applicants and females admitted to science learning in all Israeli universities.

Though the rate of female first year science students varies by subject, the total percentage has been 45.7%, including engineering and architecture, in the year 2004/5. Had we calculated the mean female rate without this subject it would have been 56.6%. We can conclude that even if we do include engineering and architecture the rate of women is well over 40%, the "magic number" defined for taking affirmative action against any discrimination.

The glass ceiling is getting higher: Women and graduate degrees in science

When speaking about women learning high level science we must note the following data:

- Since 1987 more women than men received first degrees.
- Since 1995 more women than men received second degrees.
- In 2004 more women than men received third degrees.

Table 3. Female and male participation in scientific areas: Applicants for First degree by field and subject of study, 2004/5*

	No. of women	% of women	No. of men	% of men
General Medicine	359	51.7	336	48.3
Dental medicine	53	58.9	37	41.1
Para-medical studies**	1348	82.0	296	18.0
Mathematics	122	31.4	267	68.6
Statistics	70	50.7	68	49.3
Computer Sciences	165	23.6	535	76.4
Chemistry	159	64.9	86	35.1
physics	63	19.3	263	81.7
Environmental sciences/ earth and space sciences	34	43.6	44	56.4
Biological sciences***	724	62.5	434	37.5
Agriculture	123	54.7	102	45.3
Engineering and architecture	764	25.2	2265	74.8
Total	**3,984**	**45.7**	**4733**	**54.3**

* Processed from Statistics (2005) (Table 8).

** Para-medical studies include the following 10 areas: Pharmaceutics, Communication disabilities, Nursing, Human services, Emergency medicine, Occupational therapy, Physiotherapy, Nutritional sciences, Medical laboratory sciences and Optometry. In All these areas there is a massive majority of women, except in Emergency medicine, where of a total of 32 students only 13 are women.

***In addition to biology, biology studies include the following 7 areas: Biochemistry, Biophysics, Ecology, Brain sciences, Biotechnology, Medical sciences and „Other biological sciences". In most of them, except of bio-physics with 8 female- and 10 male students, and brain sciences, with 21 female- and 28 male students, the vast majority of students are women.

The way from acquiring most academic degrees in general to "conquering" the last masculine fortress of science was straight. In the year 2005/6 more

women than men studied most of the scientific areas for the BSc, MSc, and Doctorate, as can be seen in Table 4.

Table 4. Percentage of Israeli female students: 2005/6*

	Engineering and Architecture	Agriculture	Math and science	Medical Scien.	Medicine	Law	Social Scien.	Humanities	Total
BA/BSc	27.8	54.5	45.9	78.7	51.2	53.8	62.2	64.8	55.0
MA/MSc	26.7	60.2	45.9	84.1	53.1	51.7	56.0	69.9	56.6
Ph.D.	27.0	54.5	47.2	70.4	61.2	36.9	62.1	58.7	52.5

* Processed from Statistics (2007) (Table 8.53).

Table 4 demonstrates that female students were the majority in many scientific areas in the 2005/6 academic year. Moreover, the percentage of female students studying for graduate degrees was higher, in the cases of agriculture, science and mathematics, para-medical studies and medicine than that of undergraduates.

Not only were the majority of students in most areas and most degrees, when looking at the female rates of graduating we can see that women out-numbered men in most areas.

Table 5. Percentage of Israeli female graduates: 2005/6*

	Engineering and Architecture	Agriculture	Math and science	Medical Scien.	Medicine	Law	Social Scien.	Humanities	Total
BA/BSc	27.3	64.1	46.5	82.0	52.7	55.7	67.7	70.9	58.9
MA/MSc	29.0	51.1	48.0	83.3	51.7	50.7	54.7	75.2	56.8
Ph.D.	(29.1)**	***	42.6	****	****	****	61.2	63.8	52.0

* Processed from Statistics, 2007) (Table 8.56).
** The total number of Ph.D's in Engineering and Architecture agriculture was only 86, thus the female rate has no statistical significance.
*** Only 33 students awarded a Ph.D in agriculture in the 2005/6 academic year.
**** The numbers of Ph.D's in Medical Sciences, medicine, and law awarded in 2005/6 were 6, 41, and 22 subsequently.

Table 5 demonstrates that female students were the majority of BA/BSc as well as MA/MSc graduates in agriculture, paramedical sciences, medicine, law,

social sciences and humanities. In mathematics and science, where the female rate was 46.5% for BSc holders, the rate increased to 48.0% entitled for the MSc degree. These results are tightly connected with the high achievement of high-ability girls in all scientific areas during all school stages.

If we look at the picture in medicine – in the year 2005/6 females were already 51.2% of first-degree students, 53.1% of masters' students, and 61.2% of third degree students in medicine! (Statistics, 2007) (Table 8.53).

Let us look at the data from the Tel Aviv University: a world-known institution famous for its scientific level (Press release, 27/3/2008). At the Tel Aviv University talented young women receiving Ph.D's outnumbered men in 2007, as can be seen from the following table.

Table 6: Number of Ph. D. recipients in 2007 at The Tel Aviv University*

	Law	Life scien.	Management	Arts	Medical sciences	Humanities	Social sciences	Engineering	Exact scien.	Total
Women	1	24	4	3	27	45	21	7	21	**153**
Men	2	18	7	1	15	21	8	19	24	**115**
Total	**3**	**42**	**11**	**4**	**42**	**66**	**29**	**26**	**45**	**268**

* Processed from the data released by the Tel Aviv University in June 2008. Available at: http://www.tau.ac.il/acad-sec/cermo3/nat.pdf (accessed: 18 September, 2008).

In 2007, 79 women in comparison to 76 men were entitled to a doctoral degree from the Tel Aviv University in all scientific areas. In the humanities and social sciences men entitled to the Ph.D. degree consisted in 2007 just more than a third of all Ph.D. recipients: their number was 39 in comparison to 74 women.

The case of Tel Aviv University is not unique. The picture is similar at the Weitzman Institute, one of the most prestigious scientific institutions in the world: women are the majority at the MA, Ph.D. and Post Doctoral levels. Women also consist of 40% to 68% of the participants in the research teams in neurobiology, materials and interfaces, molecular cell biology, biological regulations, structural biology, plant sciences, chemical physics, and biological chemistry. Prof. Hadassa Degani, a world known cancer researcher from the Biological Regulation Department at the Weizmann Institute has stated that in 2005 the rate of students – including post-docs – at the Weizmann Institute was about 60% (Womanhood activities at the Weizmann Institute). Table 7 demonstrates her argument in detail.

Table 7. Women students and post-docs at the Weizmann Institute*

2005/6	Female MA Stuendts (total)	% Female MA students	Female Ph.D Students (total)	% Female Ph.D students	Female Post Docs (total)	% Female Post Docs
Biological Chemistry	20 (25)	80.0	45 (95)	47.4	12 (24)	50.0
Biological-regulations	10 (14)	71.4	32 (47)	68.1	6 (10)	60.0
Chemistry**	24 (46)	52.2	83 (161)	51.6	19 (43)	44.2
Immunology	6 (11)	54.5	28 (41)	68.3	7 (10)	70.0
Materials Interfaces	11 (15)	73.3	22 (41)	53.7	6 (11)	54.5
Math	15 (59)	25.4	20 (72)	27.8	4 (15)	26.7
Mulecular-cell-biology	11 (15)	73.3	33 (52)	57.7	10 (17)	58.8
Neurobiology	9 (17)	52.9	23 (59)	39.0	7 (13)	53.8
Physics			22(111)***	19.8		
Plant Sciences	5 (9)	55.5	15 (24)	62.5	4 (6)	66.7
Total****	**101 (211)**	**47.9**	**323 (703)**	**45.9**	**75 (149)**	**50.3**

* Processed for each department and each level of studies from the Weizmann Institute web: http://www.weizmann.ac.il.

**"Chemistry" includes: Biophysics/Biological Physics, Chemical and Structural Biology, Chemical Physics, Environmental Chemistry and Climatology, Experimental Physical Chemistry/Chemical Physics, Light-Matter Interaction and Coherent Control, Materials Science and Nano-science, Molecular and Bio-molecular Spectroscopy and Imaging, Organic and Organo-metallic Chemistry, Supra-molecular Chemistry, Theoretical and Computational Chemistry.

*** Combined number of MA and Ph. D. students.

****The list of students and pos-docs in Molecular Genetics are not available. However, I expect that the percentage of females among them will be higher than in chemistry and lower than in biology, and in any case - higher than 50%.

As can be seen from Table 7, no "pipe-line" phenomenon has been observed for women in the 3 stage-career shown. The percentage of MSc female students is very close to that of Ph.D. students; among Post-Docs it is somewhat higher. The 2-percent difference between female rate of MSc and Ph.D. student can be explained by the fact that all physics students – with the lowest female rate – are included in the "Ph.D." rubric and thus lower the female total rate; no

information is given about Post Docs in physics, and thus the total female rate of post-doctorate residents is higher than 50%.

In addition, it is possible that comparatively higher percent of women apply for post-doc positions at the Weizmann Institute because they find it too complicated to move with their families abroad, as most men in science do. The Weizmann Institute offers a decent living grant for all staff members, and due to its special arrangements of housing, day car possibilities and help in finding house help the option of spending the 2-year post-doctorate period there is quite appealing to many women in science.

If things are so good: What else should be changed?

Unfortunately, breaking the ceiling glass in scientific higher education has not helped women aquire suitable scientific positions yet. Female rate among tenured staff members was in 2005 only 10% at the Weizmann Institute. This situation is similar in all areas, as Toren (2006) has shown. Thus, when educating and counseling gifted girls we must be completely open and prepare them for the real problem: finding their way, or rather – making it in the labyrinth of un-written, sometimes unknown rules of the male world. The glass ceiling in science is much higher than it has ever been, but it should be self-deceiving to ignore its existence. Playing by the rules is fine but not always enough; being excellent might be rewarding as well, but the real combat to be fought should not be either for learning science or for being good at it. It is rather for getting a position that a man equally competent would get without declaring World War 3 against one's society, family, and sometimes oneself.

Conclusions

1. Talented young females outnumber males in their educational achievements while still in high school. A higher percentage of girls than boys take the matriculation examinations; the female rate of entitlement to the matriculation certificate is higher than the male one, and the quality of the matriculation certificate of girls is better than that of boys. Israeli young women have better achievements at the end of high school not only in the humanities and social sciences, but also in all scientific high school subjects: mathematics, physics, chemistry, biology, computer sciences and agriculture.

2. The rate of science female students in Israel has been 45.7% in the year 2005/6. This rate is high above the international mean, and places

Israel much higher than most European countries regarding high education of women in science.

3. Female students were the majority in most scientific areas in the 2005/6 academic year. In the fields of agriculture, science and mathematics, para-medical studies and medicine the percentage of female students studying for graduate degrees was higher than that of undergraduates.

4. Unlike the situation in many countries, where '"climbing in the scientific ladder" means a reduced rate of women, in Israel female students were the majority of BA/BSc as well as MA/MSc graduates in agriculture, paramedical sciences, medicine, law, social sciences and humanities. In mathematics and science, where the female rate was 46.5% for BSc holders, the rate increased to 48.0% entitled for the MSc degree.

5. In 2007, more women than men were entitled to a doctoral degree from the Tel Aviv University in all scientific areas. In the humanities and social sciences men entitled to the Ph.D. degree consisted in 2007 just more than a third of all Ph.D. recipients.

6. Even at the Wizmann Institute for science, the most traditionally "masculine" fortress, hegemony of men has been gradually faded. In 2005 the number of post-doctoral females at the Weizmann Institute already outnumbered that of men.

7. The current task of Israeli women of science is translating their talent, good achievements in all educational levels and high motivation to academic positions which will reflect their true abilities.

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