Women in Mexican Nanotechnology

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Abstract: - Women activity has been computed at given instances of undergraduate engineering studies, graduate studies and faculty research in nanotechnology. Although low women activities are found at the faculty and undergraduate levels, there is a high level of women participation at the graduate level. These measurements indicate the need of improving women participation in Nanotechnology to the undergraduate and faculty levels in Mexico via both special programs to strengthen faculty such as PROMEP and student scholarships like PRONABES.

Key-Words: - Nanoeducation, Women in Nano, Scholarships,

1 Introduction

As expected for the Nanotechnology revolution, immense market forces will support a new labor market of two million nanotechnology jobs ever since by 2015 nanomarkets will move one trillion dollars, requiring a new educational system producing these new workers [1]. A strategy to attract these capitals into the realm of nanotechnology is to secure the control of the ecological effects of these products, as we are entering into a stage of toxicity concerns related to these new technologies [2]. This poses new educational challenges that will require women participation in engineering majors and graduate studies related to the development of these new careers. As long as women abilities for chemistry and nanotechnology have been recognized, there are clear signals that the revolutionary stage of nanotechnology might lead to a gender equity in this new labor market. The Interamerican Development Bank (BID) has recommended public policies that warrant women access to both education and family, community and State economic resources, and it seems to be that in the following years special funds will have to be allocated to include women in Nanotechnology [3].

The great affinity between nanotechnology and chemistry has motivated women participation in nanotechnology, as long as there were several women leaders in the chemistry field before the eclosion of nanotechnology. This might explain why there is no visible women segregation in nanotechnology unlike the case of computer science, as a result of the continuity in the nanotechnology use of experimental and scientific technique developed by the chemistry scientists. Therefore, in this respect there has been an evolutionary rather than revolutionary behavior in nanotechnology that leads to the incorporation of women in nanotechnologies and nanosciences.

Notwithstanding women face very well known problems to pursue university studies, there is no Mexican educational policy oriented to increase women activity in engineering. According to studies performed in Granada, Spain, women are overrepresented in hotelery, business and cleaning services but lack opportunities to be employed in technical or managerial positions. Seems to be that cultural issues inhibited the incorporation of women to computer science courses [4]. Cuny and Aspra have indicated that one of the strategies to include women is to reject those clichés such as the idea that only nerds can learn computer science or the assumption that full time compromise is required to be successful in the computer studies [5]. It is fundamental to identify those women abilities that can contribute to their success in the professional field and as reported elsewhere, those departments that appreciate women abilities have a higher percentage of female students [6].

Low participation in science majors seems to be related also to the social perception about science usefulness. As Sheila Tobias indicated, there was a sensible decrease of science enrollment derived from the reduction of funding for science, as happened by the end of the 80's, when science budget was transferred to military projects [7], leading to a enrollment reduction from 11.5% (1966) to 5.8% (1988) [8]. A lack of interest for science and technology studies might be also a consequence of the absence of collaboration between universities, research centers, government and firms. According to

Zucker y Darby, several factors lead to a regional development of new technologies such as nanotechnology, namely the scarcity of research leaders and the tacitness of science knowledge, which seems to be more important than the size of the city or the strength of the local resources for science and technological research [9].

Several organizations support Mexican women participation in Science such as the Sofia Kovaleskaia Foundation and the Mexican Mathematical Society, which conjointly have funded advanced women students in mathematics. This effort is devoted to the last stage of women training in science and technology notwithstanding the high women desertion rates in undergraduate studies. Seems to be that the criterion followed is "strengthen the stronger", which could worsen the lack of women activity in science and engineering majors. A similar idea is followed by the L'Oreal–UNESCO Fellowship that funds a selected and reduced number of women in science and technology.

Fortunately, social programs such as the PRONABES that support less favored sectors seem to improve women activity in university majors. PRONABES scholarships have increased in number from 44000 to 135000 from 2001 up to 2005, benefiting students with economical drawbacks. Although PRONABES federal funding has reached a saturation by the years 2003 and 2004, PRONABES grew from 588 up to 1400 million pesos from 2001 to 2003, with 75% of the scholarships given to students enrolled in the three first years of the baccalaureate. Nevertheless, only 17% of the recipients had a family income in the range of a minimum salary, which indicates that PRONABES is limited in the support to the most needed students. As will be addressed hereby, there has been a significant change in women activity in the engineering majors at UAMA, which might be related to the support of PRONABES to our students, although this case study needs to be extended to the study of other institutions funded by PRONABES in order to establish the impact of PRONABES on women university enrollment.

PROMEP (Teachers Improvement Program) was founded at 1996 and has provided additional funding to Mexican universities and graduate studies scholarships for teachers, enhancing the quality of the teaching profession all along the country. Academic research groups have been registered by PROMEP in order to allocate them funds and faculty scholarships to improve the quality of teaching and research in Mexico [10].

2 Problem Formulation

Three case studies of women activity have been pursued to have an idea about women participation in the undergraduate, faculty and research level. An statistical analysis of women activity en UAM-Azcapotzalco undergraduate academic programs has been performed. The activity coefficient is obtained once the number of women registered in an academic program is divided by the total number of students registered in that given academic program. Low values of this activity have been found for the Basic Sciences and Engineering Division, in the range of 21%, almost half of those attained by the Social Sciences Division (48%). Slightly lower values were found for the Design Arts Division (36%) almost equal to the 40% recommended by the Helsinski Group. This activity index, was also applied in the case of an advanced seminar on Nanotechnology as long as it measures women participation in nanotechnology graduate studies. In addition, this women activity index was computed for the PROMEP faculty groups devoted to nanotechnology and nanosciences, in order to compare the rate of woman participation in nano faculty by 2004.

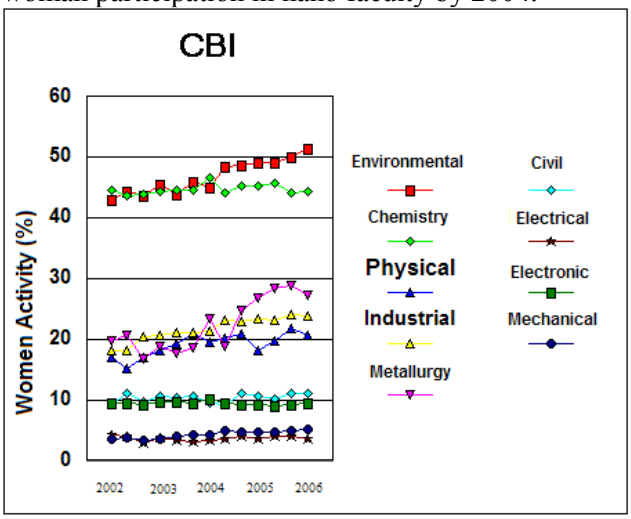

Fig. 1.- Shows women activity in Engineering majors (CBI) at UAM-Azcapotzalco. Data provided by Archivo General de Alumnos (AGA) of UAM-Azcapotzalco

3 Problem Solution

In the very case of Physical Engineering, there was an increase of women activity from 16% in 2002 up to 21% in 2006, which is about half of the women activity for Social Sciences majors at UAMA (48%), although it was more than double of the women activity registered in Electrical Engineering and Electronics (9%) (cf. Table 1). Chemical and Environmental Engineering attained a high value of women activity in the range of 48%,which might be

linked to a high women activity (50%) in UAM-Azcapotzalco PROMEP faculty groups devoted to nanotechnology and the intense participation of women in UAMA Chemistry faculty.

LEVELS OF WOMEN PARTICIPATION	Activity(%)
High(Environmental-Chemistry)	48
Middle(Metallurgy - Industrial- Physical E.)	24
Low (Computational-Civil)	14
VERY LOW (Electronic- Mechanical- Electrical)	9
High(Social Sciences and Humanities)	48
High(Art and Design)	36

Table 1.- Levels of Women Activity.

Women student activity at UAM by 2001 was 16% (cf. Fig. 1), in the same range as women activity for the National Polytechnic Institute of Mexico (14%) [11], indicating a low participation of women in science and engineering undergraduate programs. This activity in the range of the percentage of women students in Senegal reported by 1992 and is lower than the Mexican women activity in undergraduate studies reported by Olga Bustos in 1999 (27%) [12].

	NANO PROMEP WOMEN ACTIVITY BY MEXICAN ECONOMIC ZONE (2004)							
ECONOMIC REGION	1	2	3	4	5	6	7	8
WOMEN ACTIVITY	11.3	16.2	8.6	2.1	21.4	0	18.8	0

Table 2.- Women activity in faculty PROMEP academic groups as reported by 2004.

These low women activity indexes are different of those reached (35%) at the Panamerican Advanced Institute on Nanoestructures, celebrated this year at Zacatecas, Mexico. Participants mainly included graduate, doctoral and postdoctoral students from the Americas [13]. This high value might be due to both the high women activity in chemistry undergraduate programs and the close link between nanotechnology and chemistry. This indicates both a leveling of nanotechnology in relation to gender equity and the convenience of recruiting more women in those engineering careers that support nanosciences and nanotechnologies. This gender equity effect might be due to the evolutionary stage of nanotechnology which is not yet a revolutionary technology. Nanotechnology still uses methods inherited from conventional technologies and there are not yet nanoproducts that dramatically alter the market [14].

There is a low women activity (14%) in PROMEP academic groups devoted to Nanoscience and Nanotechnologies, which can be even lower when these groups are divided in economic zones. As shown in the Table 2, Mexican economic zone 4 (Jalisco, Aguascalientes, Colima, Michoacán and Guanajuato) had a very low women activity in PROMEP academic groups devoted to nanotechnology and nanosciences by 2004. Zones 6 (Guerrero, Oaxaca y Chiapas) and 8 (Campeche, Yucatán y Quintana Roo) did not report PROMEP nano academic groups by 2004. This suggests the allocation of special funds to include women to the faculty level in nanotechnology groups in order to attain equity in this level.

Fig. 2 shows an enhanced women activity in engineering at UAM-A along the last years although this activity levels are almost half of those recommended by the Women in Nano Group that received a funding of 500,000 euros to improve the inclusion of women in the nanosciences and nanotechnology research networks. Remarkably this improvement of women activity in engineering majors is correlated with the PRONABES scholarships program that started operations since 2001, with an equitative women participation in the range of 51% (2001-2002) that has been enhanced up to the 55% in 2004 [15]. Therefore, this improvement of women activity in engineering at UAM-A could be interpreted as a consequence of the support to the less favored students although this hypothesis should have to be tested in detail on future studies.

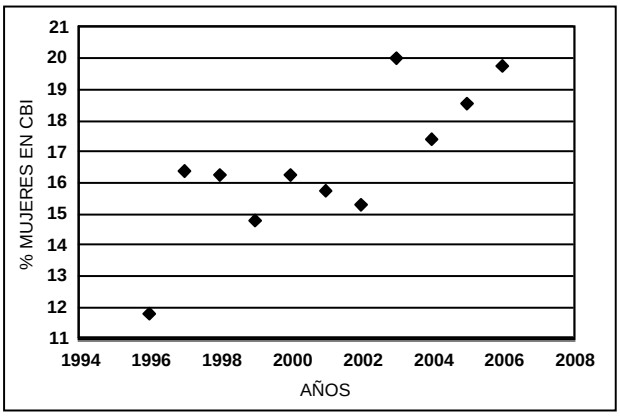

Fig. 2.- Shows the improvement of women activity in engineering majors at UAM-A.

These results suggest that similar scholarships for minority students in Nano should be part of the National Nanotechnology Initiative discussed in Mexico since 2006 as part of the Megaprojects Call issued by the Mexican National Council of Science and Education (CONACYT) in 2006 [16]. Lakhtakia has indicated the need of changing the Educational System in order to make it compatible with the multidisciplinary character of nanotechnology by means of integral courses that develop in the student a multidisciplinary approach to sciences and technologies [17]. And Paruelo has indicated the convenience of involving philosophers of science to address the epistemological issues related to this new methodologies of teaching. Philosophers of science might detect the epistemological cost related to the

differences between the theory taught and the scientific theory that come out from the didactic transposition. Therefore the design of the curriculum for Nanosciences and Nanotechnologies should involve the use of epistemology as a fundamental tool [18]. And all these activities most surely will involve special funds to include women in order to level the gender participation in these future tasks, securing a balanced composition of genders in all levels of nanotechnology education. Fig. 3 shows that by 2009 there are several Mexican States without women in Nanotechnology research groups registered in PROMEP (Baja California, Zacatecas, Aguascalientes, Guanajuato, Morelos, Veracruz). Nevertheless there is a large group of Mexican States with women participation larger than 20% (Chihuahua, Tamaulipas, San Luis Potosí, Hidalgo, Puebla, Jalisco, Tabasco, Distrito Federal).

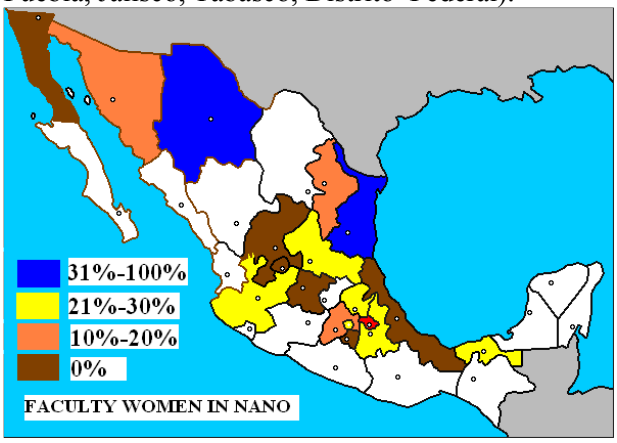

Fig. 3.- Shows that by 2009 there are several Mexican States without women in Nanotechnology research groups registered in PROMEP.

4 Conclusion

The expected Nanotechnology revolution will demand the inclusion of women in the new labor market associated with nanotechnology. Millions of new jobs will be opened in the field of nanotechnology and statistics indicate that women will have a major participation in this new revolution. Low women activity indexes observed in Engineering at UAM-A (20%) indicate enormous opportunities to involve women in this new technology all along Mexico, with scholarships programs that enhance women activity at all levels of university education like PRONABES. These low levels of women activity are also observed at the faculty level (14%), as indicated by a survey of the 2004 PROMEP academic groups devoted to nanosciences and nanotechnology, which might be addressed by allocating special funds to promote the inclusion of women to these PROMEP academic groups. Nevertheless, there is a high activity of women at the graduate level, as appreciated by the high attendance of women to a Nanotechnology Advanced Seminar (35%), which might be interpreted as a signature of a major change in the women activity in nanotechnology research at Mexico. Recruitment strategies must be designed in the next years in order to achieve this goal. In the case of Mexico, the University of Las Americas has already implemented an undergraduate program in Nanotechnology in a Mexican region where there is a convergence of government, universities and firms oriented to nanotechnology. This model might be followed in the rest of the Mexican States in order to promote Nanoeducation and gender equity. Author acknowledges the support of a Postdoctoral Fellowship at CINVESTAV granted by CONACYT-48795 Fund.

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