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WOMEN AND GIRLS IN SCIENCE AND TECHNOLOGY: INCREASING OPPORTUNITIES IN EDUCATION, RESEARCH AND EMPLOYMENT

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Science and Technology – Overview

Science and technology (S&T) is never gender neutral. Men and women have different attitudes to, and relationships with, all aspects of S&T. In most parts of the world, women continue to be highly under-represented in the *creation* of new technologies. However in all parts of the world they are active *users* of technology and this fundamental truth is usually not taken into consideration by those who design technologies and formulate science and technology policies.

For science and technology to achieve an optimal societal impact, both men and women must be equally involved in its conceptualization, design, management and utilization. Women must be part of the technology creation process as producers, developers and decision-makers, doing their part to ensure that technologies are designed to reflect the preferences and meet the needs of both sexes.

Increasingly, individuals with the greatest capacity to understand and use science and technology are gaining access to more and better information, opportunities, and jobs. This has been facilitated by the massive expansion of information communications technologies (ICTs), particularly mobile telephones. In March 2008, there were about 1.4 billion internet users worldwide, representing about 21 percent of the world population. The expansion of cell phone coverage and their widespread adoption has been much faster, and even the least developed countries now have more than 60 percent coverage (ITU 2008). This is opening new areas of employment and new possibilities for local entrepreneurs. For example, call centres have become an important source of employment for educated young people, especially for women, in many countries with substantial English-speaking capacity. Moreover, computer and mobile phone-based work can often be carried out from home, providing new opportunities for secluded women in Moslem societies.

New opportunities are also developing in many other technology-based areas including biotechnology, renewable energy, water treatment and conservation, reproductive health, etc.

The global concern with climate change has led to a search for technology-based solutions and strategies for both, mitigation of, and adaptation to, climate change. These technologies can have different implications for women and men. To be effective, they need to reach those who are most in need – the poor and the vulnerable. Women are often over-represented in these categories, therefore, efforts must be made to ensure that technologies are designed in such a way as to be relevant to their circumstances and that they are given full access to technical knowledge and information.

Entrepreneurship, innovation and technology development are present in the formal and the informal sector, but they often go unrecognized in the latter. In many parts of the world women have been important innovators, especially in agriculture, e.g. in seed development, plant breeding. Their innovations have usually been developed after years of experimentation but this so-called “indigenous knowledge” usually has been given less value than science-based knowledge. Scientific knowledge in the formal sector is based on logic and empiricism, both of which are considered to be masculine traits. Women have seldom been recognized as intellectual sources of innovation in S&T, whether in the informal or the formal sector (UNU 2005).

Formal science and technology training is a prerequisite for work in the applied sciences, however, in most parts of the world women face major barriers in regard to such opportunities. Women who study science are somewhat more likely to come from families with educated parents and slightly higher than average economic status. They are likely to have received parental support and encouragement to study science (Park, 2001; Hanson, 1996; Sonnert and Holton, 1995). Although girls may enjoy science in primary school, as they advance in the school system they frequently tune out and eventually drop out of science (Hanson, 1996). Those who persevere to study science at the university level tend to concentrate in fields with a human component such as life sciences. Nonetheless, women who graduate with a B.Sc. are less likely than men to continue for graduate studies. Women who graduate with a M.Sc. are less likely to continue for a Ph.D., even if they have better grades (Glover, 2001; Rosser, 1997). Women who graduate with a Ph.D. in the sciences are less likely to find good employment (Holden, 2001). Women who find positions in universities or in industry are less likely to be perceived as 'high flyers' and they are likely to have fewer research grants and publications and heavier teaching responsibilities than men (MIT, 1999). This female experience of science, which is replicated to a greater or lesser degree in most countries of the world, has been termed 'the leaky pipeline', because so many women drop out along the way.

There is a large academic literature on the subject and some of the obstacles often mentioned include lack of family and school support to encourage adolescent girls to excel in science; few role models of successful female scientists; the masculine culture of science and technology; difficulties of combining time-intensive careers in science and technology with family responsibilities; etc. While none of these barriers has been entirely overcome, there has been considerable progress over the past few decades, more in some regions than in others.

Current status of women in S&T

Education for girls has received international attention for many years. Recent UN figures suggest that the biggest gender gap now exists at the level of secondary education. However worldwide, there are more women than men enrolled in tertiary education. In developed regions the ratio is dramatic: 129 females to 100 males; in developing regions the gap is also closing: 96 females to 100 males. Girls are much more likely to proceed to tertiary education in the developed regions, CIS countries, Latin America and the Caribbean, and South-Eastern Asia. Fewer have advanced to tertiary education in sub-Saharan Africa, Southern Asia and Oceania (UN 2009).

Research capacity is a critical component in the development of S&T- based enterprises. In industrialized countries, R&D activities are largely financed and conducted by the private sector but in most developing countries the public sector plays a major role. Globally, the number of researchers in S&T is increasing – from 5.8 million worldwide in 2002 to 7.1 million in 2007. At the same time, the locus of science and technology research is shifting. In 2002, Europe and

North America together had 57.1 percent of human resources in S&T research. By 2007, this figure had dropped to 50.6 percent. In contrast, Asia had 35.7 percent in 2002 and by 2007 this had increased to 41.4 percent. The increase in China was particularly striking – moving from 14.0 percent in 2002 to 20.1 percent in 2007. During this period, the share for Latin America and the Caribbean increased from 2.9 percent in 2002 to 3.6 percent in 2007, while Africa remained stable at 2.3 percent (UNESCO 2009).

UNESCO figures reveal that in 121 countries with available data, women comprise 29 percent of researchers but there were big disparities among regions. For example, in Latin America and the Caribbean, 46 percent of researchers are female and Argentina, Cuba, Brazil, Paraguay and Venezuela have achieved gender parity. In Asia, women constitute only 18 percent of researchers overall. India and Japan have 13 percent female researchers and South Korea has 15 percent. In Africa women comprised about 33 percent of researchers (UNESCO 2009).

In Europe, women comprise 29 percent of S&T researchers. They also comprise 29 percent of those employed as scientists and engineers across the EU, but the growth rate in their participation between 1998 and 2004 was lower than that of men (European Commission 2006). Preliminary EU figures from 2009 show that the share of women graduating at a Ph.D. level in sciences grew by an average of 7.3 percent per year between 2002 and 2006, compared with a 3.8 percent increase for men (http://ec.europa.eu/research/science-society/document_library/pdf_06/preliminary-results-of-she-figures-2009_en.pdf). In the U.S. in 2006, women comprised 39 percent of science and engineering doctorate holders in academia with adjunct faculty positions and 41 percent of those with postdoctoral positions. They were 37 percent of deans and 30 percent of presidents of colleges and universities (http://www.nsf.gov/statistics/wmpd/figh-2.htm). In private industry, women scientists and engineers fared less well. They comprised 19 percent of all managers and 15 percent of top-level managers in business or industry compared with 34 percent of all scientists and engineers in business or industry in 2006. They were eight percent of engineering managers and 11 percent of natural sciences managers. Women comprised more than half of managers only in medical and health services (http://www.nsf.gov/statistics/wmpd/figh-4.htm). Overall women in industrialized countries are making slow but steady progress in achieving opportunities in S&T in research and academia but less so in business and industry.

It is more difficult to obtain data about female scientists in developing countries. A recent study in Costa Rica found that female enrolment was substantially higher than male enrolment in all of the country's institutions of higher education except in the Technological Institute which offers training in engineering and technology (Salas 2005). Another study, focused on agricultural research, estimated that one fifth of all agricultural researchers in developing countries were female. However there were large variations across regions and countries. For example, in Sub-Saharan Africa, female researchers comprised more than more than 30 percent of agricultural research staff in Botswana, Mauritius, and South Africa in 2000. In contrast, in Eritrea and Ethiopia only four and seven percent, respectively, were female (Bientema 2006).

Culture of S&T

Increasing the actual numbers of women in science and technology is necessary, but not sufficient. It is equally imperative to address the culture of science and technology to make it more hospitable to women. Many of the values considered core to good performance in S&T, such as independence, competitiveness, assertiveness, respect for hierarchy, etc. are based on male models of behaviour and differ from the nurturing, consensus-seeking roles into which women are socialized as girls.

Because the culture of S&T is biased towards men, there continues to be a 'leaky pipeline' effect with women dropping out at different stages. The practice of science is structured to suit men who have time and personal freedom to devote long hours to their work, while most domestic and family responsibilities are looked after by wives. Many women perceive difficulty in combining science careers, especially in research, with home/family responsibilities. Studies of female professionals and managers in Canada and Europe have found that most employers make little effort to accommodate work/life balance. Most see work and personal/family life as separate concepts. They do not consider it their responsibility to change the structure of working days, working hours or working locations to accommodate the changing gender demographics of the workplace (Rathgeber 2002).

Despite the recognized importance of the ICT sector, a 2001 survey of six countries showed that the numbers of women graduates at the first degree level in computer science had actually decreased in the UK, USA and Canada during the late 1990s (Millar and Jaggar 2001). More recent research in Costa Rica confirms this trend (Salas 2005). Research in Kenya illustrates some of the difficulties faced by women in the ICT sector. Largely as a result of prevailing social stereotyping, women tended to enroll in word processing courses rather than in more technical ICT training. Those who did become computer technicians found that their skills and knowledge were constantly questioned both by employers and by clients (Abagi, Sifuna and Omamo 2009). Similarly, in Costa Rica it was found that women in the IT sector had to conform to male norms of success and that they were often relegated into the areas of ICTs that conformed with female role stereotypes, such as word processing or editing rather than computer hardware and cabling (Salas 2005).

Disincentives for women to stay in S&T

Researchers have identified three different types of segregation often faced by women in science and technology. *Vertical segregation* relates to the concentration of women at lower levels in S&T, such as the B.Sc. for students or lower level professional positions for women in the workplace. *Horizontal segregation* relates to the tendency for women to cluster in certain areas of science, such as the biological and medical sciences. *Contractual segregation* relates to the tendency for women to be given short term or part time contracts (UNU 2005). All of these types of segregation are heavily influenced by the overwhelmingly male culture of science and technology.

Gender discrimination is usually subtle, both difficult to identify and measure, especially since it appears throughout a career. Among female academic staff in the sciences it commonly effects promotions, tenure and salary allocation. In the private sector discrimination can be even more pronounced, with few women moving into management positions or sitting on company boards of directors. Studies in the UK revealed that women in S&T often are better educated than men in similar positions but paid less. Despite their qualifications, they are often concentrated in the lower status jobs in the information technology, electronics and communications areas (Millar and Jaggar, 2001).

Not surprisingly, drop-out rates for women in S&T are often high. Because of prevailing stereotypes about "appropriate" gender roles, it is difficult for women in some countries to obtain employment in the sector, even with good qualifications. In other cases, they may leave the workplace temporarily or permanently for childbearing and child rearing. Still others may leave because they have been unable to advance within their careers at a reasonable rate. In the academic sphere it is increasingly recognized that women are often disadvantaged by measuring an individual's achievements and publications in relation to chronological age. Various institutions in Europe and America have introduced the notion of 'academic age' whereby research fellowships or other scientific awards are allocated on basis of number of years in the academic/research system rather than strictly on biological age (Glover, 2001).

Lack of self-confidence can also be an important impediment. Numerous researchers have found that girls and women often underestimate or undervalue their own capabilities, while boys and men may overestimate theirs. A Quebec study of college students found that girls believed they had to be better than average to succeed in male-dominated fields (Kubanek and Waller, 1996). Not surprisingly, female scientists often have less self-confidence than male scientists, and they often assume personal responsibility for the structural constraints that mitigate against their performance (e.g. time away for childbearing, limited time in the lab because of family responsibilities, difficulty with travel or being away from home for extended periods) (Rathgeber 2002).

What has worked to enhance women's opportunities in S&T?

A wide range of actors, including the UN system, national governments, the private sector, and academic institutions have employed many different strategies to help attract girls into science and technology careers and to encourage women to stay and succeed in S&T when they have completed their studies. While there are few tracer studies that have examined the impact of such strategies, the fact that more women are enrolling in science programmes worldwide suggests that such strategies may have had some positive impact. The strategies can be categorized into those aimed at helping individual girls and women to enter and stay in science, and strategies aimed at helping to make the field of S&T more female-friendly through the introduction of role models and targeted opportunities.

1. Strategies aimed at influencing individual girls and women

Mentors. The practice of formal mentoring is relatively recent outside the United States, although in the European tradition, young scientists have always been attached to the laboratories of senior scientists. The mentorship model provides an introduction to the social structure and the politics of science. Mentors give sponsorship, exposure and visibility, coaching, protection, challenging assignments, role models, acceptance and confirmation, counseling and friendship to their protégés (Rathgeber 2002). Mentors are perceived as having the power to advance careers and to provide upward mobility in organizations. The Gender and Diversity programme of the Consultative Group for International Research in Agriculture (CGIAR) has provided mentoring programmes for female scientists throughout the CGIAR system. The programme has developed guidelines and workbooks both for mentors and mentees and has supported both on-line and face-to-face mentoring (http://www.genderdiversity.cgiar.org/).

Networking. While mentors are usually associated with young people in the early stages of their academic or professional careers, networking is practiced actively by most successful scientists throughout their careers. Networking and professional and social contact with others working in the same field are recognized as major sources of information and opportunities. Networking is often more difficult for women, especially in fields where there are relatively few female professionals. Women may be excluded from male social networks simply because they do not have the time for socialization outside the workplace or they do not feel comfortable meeting in bars after work. Male networking is often through informal linkages in golf clubs or other sports associations. It may be even more difficult for non-Western women to forge strong links with male colleagues because of the gender role expectations and/or biases prevalent in their societies. Increasingly, women professionals in science and technology have established their own networks such as the Association for Women in Science (AWIS), or the Society for Women Engineers (SWE) in the USA. Finally, the growing accessibility of email has played a critical role in enabling both male and female scientists to maintain contact with others around the world, although it has not replaced the necessity for at least occasional face-to-face contact. Email today plays a major role in networking, allowing scientists in geographically remote areas to continue to interact with colleagues in more central locations.

Science camps. Science camps and other short-term out-of-school activities aimed at girls have proved to be a useful vehicle for introducing them to the idea of S&T as a career choice. For girls who have not been exposed to female role models in science, such camps can provide important information and ideas at a time in their lives when they are considering their future career choices. For example, Ryerson University in Toronto established the Discover Engineering summer camp in 1991 as a one-week camp for high school girls to introduce them to the challenges and rewards of engineering. The camp provided hands-on projects and discussions led by women engineers, scientists and students, and helped to increase their awareness of engineering as a viable career option. The programme has since expanded to include a one-day career conference for high school girls and various other activities. An evaluation in 1996 revealed that a high proportion of participants in the camps had actually gone on to enrol in engineering programmes at university (Gilbride et al 1999).

2. Strategies aimed at advancing the participation of women in S&T

UNESCO Chairs. Since 2001, UNESCO has established six Chairs in Gender, Science and Technology (one each in Argentina, Egypt, Pakistan and Togo, and two in Sudan). The UNESCO chairs have different areas of focus, including science education, ICTs, environment and water management, but all are trying to promote gender equality and empower women in science and technology within their countries and regions.

A closer look at the activities of the UNESCO Regional Chair for Women, Science and Technology in Latin America provides insight into the sustained activities that have been undertaken in the region. The Chair is focused on gender and ICTs and it has undertaken numerous activities aimed at bringing more Latin American women into the knowledge society. For example, it has established virtual courses on bringing a gender perspective into ICTs; on youth and ICTs; on career development and transformative leadership of women researchers in health sciences; and on women's leaderships in current contexts. The Chair has also established a virtual mentoring programme whereby gender specialists provide support to students enrolled in the virtual courses. Virtual mentoring is carried out through web conferences, forums, and Skype or telephone communication. Finally, the Chair has established a Latin American and Caribbean Centre in Gender and Information Society.

UNESCO–L'ORÉAL Awards. The collaboration between UNESCO and L'Oréal, a French cosmetics company, provides a good example of a public/private partnership with sustained commitment to improving the position of women in science. The "For Women in Science" Award was launched in 1998 to promote and encourage women in science globally. Each year five scientists from five continents are selected from potential candidates nominated by more than 1,000 scientists from around the world. Since 2000, 135 international fellowships have been awarded to doctorate or post-doctorate women from 71 countries to permit them to pursue their research abroad in some of the most prestigious laboratories in the world. Programmes of National Fellowships have also been introduced to help students pursue their scientific careers. By 2009, more than 500 national fellowships had been given in 43 countries.

Professional associations. There are many professional associations of women in S&T or within specific sectors of S&T, including engineering, ICTs, biotechnology, nuclear science, etc. Increasingly, they are also being established in the South and play an important role in creating networks and contacts for female scientists. The Third World Association for Women in Science (TWOWS) is one of the oldest, having been established in 1989 to unite women scientists from the South with the objective of strengthening their role in the development process and promoting their representation in scientific and technological leadership.

What still needs to be done?

All of these activities are important but they do not directly address the central problem of changing the culture of S&T. It is possible that, as more women move into senior positions in

S&T, the culture will become more open to issues such as work/life balance. To date, many affirmative action programmes, gender equality programmes and other mechanisms have been put in place to promote the inclusion of women in science and technology, but they have not been applied uniformly and thus have not had a strong impact on removing the masculine bias from the culture of S&T.

Even within the UN, which has been a key driver, gender equality ideology is not uniformly applied. For example, although the promotion of gender equality is one of the MDGs, the recommendation papers prepared for the UN Millennium Project appear not to have been asked to integrate gender analysis into their conceptual framework. The report on **Science, Technology and Innovation** (http://www.unmillenniumproject.org/reports/tf_science.htm), while far reaching in many respects, does not address the issue of participation of women in S&T although it notes that women have much to gain from improvements in S&T especially in ICTs, agriculture and health.

It is not the purpose here to provide an exhaustive list of recommendations about how the S&T culture can be changed. However it is clear that further attention has to be given to the workplace. Further affirmative action to increase the participation of women in S&T should focus on the workplace, ensuring that equal opportunities exist for women and that, where possible, measures are taken to move towards gender parity. Some examples might include:

In academic institutions:

- Ensure that women are hired into full-time tenure track positions in science and engineering faculties (They are over-represented in part time and sessional positions)
- Develop mentoring and networking opportunities for female faculty members (Women need mutual support to advocate for gender sensitive policies and approaches)
- Develop mentoring and networking opportunities for students (Female students need reinforcement that they have made a good choice in studying science and that they will have good career opportunities)

In the private sector:

- Provide gender equality training for senior staff (Senior staff members often engage in inappropriate behaviour without even recognizing that it may be insulting or hurtful for women colleagues)
- Make special efforts to recruit qualified female professional staff (Advertise positions through networks of women professionals)
- Ensure that boards of directors include at least 30 percent women (Women should be well represented at the policymaking level)
- Provide flexible working hours and recognize the need for work/life balance (Encourage both men and women to work reasonable hours, take vacations, etc.)

By national academies of science:

- Include female scientists on selection boards for prizes and recognition (The achievements of female scientists are often overlooked if their work is not well known by male scientists)

- Promote the social components of S&T (e.g. human impact of climate change, of advances in renewable energy, etc.) to make science careers more attractive to girls and women

What good practices could be scaled up?

One very recent initiative is a Code of Best Practices in ICTs, launched by the European Commission in October 2009. The Code aims to attract girls at school or university to the high-tech sector but also to retain and promote women already working in this sector. It covers four areas: Education, Recruitment, Career Development, and Return to work after leave, listing specific activities that could be undertaken within each of these areas. Signatories to the Code include some major ICT companies such as Google, Microsoft and many others (http://ec.europa.eu/information_society/activities/itgirls/doc/code.pdf). In signing the Code they have promised to address at least some of the issues related to women in the ICT industry. Most importantly, this Code outlines a list of actions and provides potential guidelines for what could be done. Similar codes could be drawn up for other S&T sectors, not only in Europe but also elsewhere in the world. The development of such instruments provides clear indicators against which progress can be measured.

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