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United Nations
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Science, Technology and Gender

An International Report

Science and Technology for Development series
UNESCO Publishing

Science, Technology and Gender: An International Report

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Preface

The gender dimension of science and technology (S&T) has become an increasingly important and topical issue worldwide.

For over thirty years now, the United Nations General Assembly and the UN Economic and Social Commission have emphasized the inequalities and disparities in the educational opportunities open to women and girls, and in women's access to training and the labour market. Since the 1976–85 'United Nations Decade for Women: Equality, Development and Peace', which directed particular attention to the role of women in S&T, the call for action regarding science, technology and gender (STG) has steadily intensified. When, in 2000, gender equality became one of the eight United Nations Millennium Development Goals (MDGs), the gender dimension of S&T was pushed even further into the spotlight.

In this context, and given its mandate in science, UNESCO has a major role to play in taking up these issues and working to overcome gender disparities in access to, influence over, and use of science and technology. To do so, it is crucial that UNESCO advocates and affirms the crucial role of women and the gender dimension of science and technology throughout its programmes and activities.

The UNESCO Natural Sciences Sector prepares an analytical UNESCO Science Report every four years. In the intervening years, it will be publishing thematic reports on key issues in science. The present *Science, Technology and Gender: An International Report* is the first of such reports, a concrete example of UNESCO's commitment to integrating gender perspectives in science and technology.

This Report has been prepared in active partnership with specialists in areas relating to science, technology and gender from numerous institutions worldwide, under the technical coordination of UNESCO's Division for Science Policy and Sustainable Development. We highly appreciate the valuable efforts and contributions of these specialists and firmly believe that the present report is a solid step towards the political and institutional mainstreaming of the gender dimension in S&T activities.

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Introductory Note

Many women and girls around the world are excluded from participation in science and technology (S&T) activities by poverty and lack of education (at all levels), or by aspects of their legal, institutional, political and cultural environments. *Science, Technology and Gender: An International Report* is designed to support efforts being made worldwide to analyze, discuss and change this situation. It represents a solid step towards the political and institutional mainstreaming of the gender dimension in S&T activities.

As the first publication of an ongoing initiative, this report is a dynamic document that will be constantly evolving and updated. It will provide a much-needed instrument for change to help educators, policy-makers and the scientific community address the underlying causes of gender disparities in S&T areas, both in the public sector and in technology-based companies. A technical study based on empirical research and data, the Report incorporates substantive inputs from institutions involved in science, technology and gender studies and policy worldwide. It primarily covers the natural sciences, engineering and technology. As it evolves and benefits from updating however, future versions will hopefully cover wider fields of science and technology – notably the social sciences, medicine and agriculture.

Both a conceptual and analytical tool and a framework for action for policy-makers with regard to science, technology and gender (STG) strategies at national, regional and international levels, this report seeks to promote serious discussion of gender within national and international scientific and academic communities. It highlights the pressing need to enhance STG-related actions by: 1) increasing women's participation in S&T and R&D careers worldwide, 2) building public awareness surrounding STG-related issues, and 3) increasing STG data collection and promoting rigorous research on STG issues.

Follow-up to the report

Major actors at the forefront of science, technology and gender equity

Attaining STG equity depends on the cooperation and collaboration of major social actors on a global scale. Fourteen major social actors have actively participated in the debate on, fundraising and dissemination for, implementation, monitoring and evaluation of the key issues and policy recommendations of this report:

1. National, regional and local governments (ministries/national councils of science and technology / R&D, ministries of education, of labour).
2. Parliaments.
3. STG Coordinating networks, committees, and gender national bodies.
4. Higher education institutions and faculties of science and engineering.
5. R&D centres.
6. Scientific associations, societies and academies.
7. United Nations agencies.
8. International and regional inter-governmental organizations.

9. International, regional and sub-regional development banks.
10. Multilateral and bilateral development-assistance organizations.
11. Non-governmental organizations (NGOs).
12. Foundations.
13. Major companies, private and public.
14. The media.

Future research and monitoring needs in science, technology and gender

A suitable framework has yet to be developed that takes account of the most urgent future research areas needed in STG. These include identifying the missing links, data gaps, key issues and critical shortcomings to be addressed: career entry and exit points, the effects of short absences on a career, different types of leave and their impacts on career structures (long service leave is of a similar span to maternity leave, yet it has no negative connotations, whereas strident objections to maternity leave still exist), redesign of workplace (childcare on premises), etc.

Report dissemination and debate at regional and national levels

By its very nature, this report is a work in progress; we envision it as constantly evolving, based on the periodical updating and the collective input of specialists from science, technology and gender-related institutions worldwide. The translation, publication and dissemination of this report in the six UN official languages (Arabic, Chinese, English, French, Russian and Spanish) is of particular importance. The six-language Internet version of the report will be periodically updated.

Training at regional and national levels

Regional and national forums need to be organized to present, debate, disseminate and follow-up on the report. Regional forums could be organized in: Latin America and the Caribbean, Africa, the Arab Region, Central Asia, South-East Asia, India, China, Oceania, North America, Eastern Europe and Western Europe.

The need for fund-raising

Fund-raising is vital in order to support:

- dissemination and debate at regional and national levels
- training at regional and national levels
- implementation of research projects and new studies
- implementation of policy recommendations (through the agendas for major actors).

Overview

Science and technology for political and socioeconomic development

Pr. Ameenah Gurib-Fakim – Laureate of the L'ORÉAL/UNESCO Awards for Women in Science 2007

As we enter the twenty-first century, the pace of technological advances continues to accelerate, with great potential to improve the lives and livelihoods of people in developing and developed countries, and with profound implications for the global economy. Despite some global trends, only part of the world's population has benefited from scientific and technological advances and the resulting improvements in quality of life and life expectancy. Over 1 billion people are living in poverty, and most of them are women and children. Worldwide, 1 billion people have no access to safe water; 2.7 billion do not have access to adequate sanitation; and over 800 million remain chronically undernourished (WWAP, 2006; UNDP, 2004). The role of science and technology (S&T) in promoting sustainable and equitable development has not yet been fully recognized, but already there is consensus that S&T is critical to any strategy to improve quality of life and the socioeconomic and environmental situation of any country.

Poverty and hunger can have political, social, cultural, environmental and economic roots. S&T can help to meet some of these challenges and reduce poverty by promoting economic development, creating job opportunities and increasing agricultural and industrial productivity. S&T can provide clean and renewable energy sources, and can help to improve health and education and predict and manage the effects of climate change and biodiversity. Science, technology and innovation also have the potential to improve nutrition, increase crop yields, provide clean water and improve soil management, and can lead to the development of vaccines and cures for diseases.

In many countries, women have unrecognized and invaluable traditional and local knowledge and are major producers of commodities, merchandise, food, energy and water. Using scientific and technological knowledge in a way that complements and

Box 1: The success of microcredit in developing countries

Recent campaigns, such as the Microcredit Summit Campaign (an international Washington, DC-based non-profit organization launched in 1997), have been successful in aiding women to increase their income and improve their quality of life. This global campaign aims to tackle worldwide poverty by providing some of the world's poorest families, especially women, with small, uncollateralized loans for self-employment and other financial and business services. With microfinancing, families are able to improve living conditions as well as start or expand tiny businesses. Putting extra income into women's hands not only increases women's confidence, but empowers them to escape the poverty cycle and expand their opportunities for employment and development.

According to UNDP's 2003 Human Development Report, the number of poor people with access to microcredit schemes rose from 7.6 million in 1997 to 26.8 million in 2001 – 21 million of them women – enabling them to control assets, make economic decisions and assume control of their lives. According to some estimates, 5 percent of microfinance programme participants could lift their families out of poverty each year.' In Bangladesh, thanks to the programmes of the Grameen Bank – 95 percent of whose beneficiaries are women – over 50 percent of the villages are served by over 1,000 rural branches. In addition to providing credit to those who lack physical collateral, the Bank's programmes are designed to achieve social goals such as raising living standards and improving women's social status.

Sources: UN-OHRLLS, 2003; www.un.org/special-rep/ohrlls/ohrlls/hr%20statement%209%20October%202003%20GA%20second%20committee.htm.

refines such traditional and indigenous knowledge can increase productivity levels and improve monitoring and managing of our ecosystems. Yet imbalances in how S&T is applied for social development often disadvantage women in particular.

The gender issue

Women make up the majority of the population in rural areas in many developing regions, particularly in **Africa**, **South Asia** and **the Caribbean**. Yet women in these regions generally have lower levels of literacy and education than men and less access to land, credit and other resources, meaning that the women-headed households are poorer and have little control over productive resources (UNIFEM, 2000; Blackden and Banu, 1999). In many of the world's poorest areas, girls and women also have lower levels of nutrition than do boys and men.

Due to their family and social roles, and because they tend to migrate to urban areas less than men, women are often especially aware of the social, economic and environmental needs of their communities. Gender-based education and divisions of labour also frequently result in women and men possessing different kinds of knowledge about environmental management and use. In a great number of communities around the world, women play a vital role in the incubation and transfer of critical local knowledge on which survival strategies are based (ITDG, 2000; Appleton et al., 1995). Not only can modern science validate this local or traditional knowledge and the skills arising from women's roles – food production, energy provision, traditional healing practices and the management of natural resources – but technology has considerable potential to reduce the labour of such work and increase the marketable skills and productivity of women working

In many countries, women have unrecognized and invaluable traditional and local knowledge and are major producers of commodities, merchandise, food, energy and water. Using scientific and technological knowledge in a way that complements and refines such knowledge can increase productivity levels and improve monitoring and managing of our ecosystems.

in these areas, thereby adding value to their economic activities (Juma and Lee, 2005; Huyer, 2004). S&T can be important tools to empower women.

The complex interrelationships between women and technology may be illustrated by looking at three vital areas: food security, water and sanitation, and energy.

Despite the fact that agriculture is the foundation of many African, Caribbean and Pacific countries' economies, most women in these countries do not own or have direct access to land rights for farming.

Food security

In **sub-Saharan Africa**, women are responsible for up to 80 percent of food production – through subsistence farming, food processing and marketing – yet they are too frequently overlooked when it comes to providing technology and other resources to support agricultural development. As a result, women's food production activities have been marginalized (Muntemba and Chimedza, 1995; Stamp, 1989). In some sub-Saharan African countries, virtually all unpaid work carried out by women is agriculture-based. Despite the fact that agriculture is the foundation of many **African**, **Caribbean** and **Pacific countries**' economies, most women in these countries do not own or have direct access to land rights for farming. Although natural resources determine the availability of sufficient food for the household, women often have little or no control over or access to them, as these tend to be governed by gender, class and intrahousehold relations. Other important and less-studied components of women's agricultural activities include livestock management and the preparation and sale of street foods (Lee-Smith, 2004; Tinker, 1997; Maeda-Muchango, 2003).

Economic development and the development of sustainable livelihoods are closely linked to food security (Muntemba and Chimedza, 1995). Food supplies can be dramatically reduced by natural disasters such as droughts or flooding or human-caused crises such as war. Severe ecological degradation can quickly diminish land productivity, and policy choices concerning which crops are grown and where (and who profits from them) can have an immediate impact on primary producers. With adequate economic resources, including increased mobility and access to credit and markets, food crises can be ameliorated and families helped to raise their income to a sufficient level for basic livelihood.

Water and sanitation

In many cultures, women and men have different roles and responsibilities in the use and management of water. Women and girls are frequently responsible for collecting water for cooking, cleaning, health and hygiene, and, if they have access to land, food cultivation. Lack of convenient access to clean water sources costs women countless hours in fetching water, and adds the burden of caring for those ill from polluted supplies. In many rural areas of developing countries, women and girls can spend four to five hours per day carrying heavy containers and waiting in lines, a burden that inhibits their involvement in education, income generation, and cultural and political activities, and denies them time for rest and recreation (Khosla and Pearl, 2003). Domestic water-supply programmes often overlook the many productive uses women make of water for irrigation, household gardens, livestock or other enterprises.

In many rural areas of developing countries, women and girls can spend four to five hours per day carrying heavy containers and waiting in lines, a burden that inhibits their involvement in education, income generation and cultural and political activities, and denies them time for rest and recreation.

Women often determine domestic water usage, but are rarely involved in making vital decisions relating to sanitation and hygiene (such as decisions over the availability and placement of toilets). In many communities, women have to walk long distances to use toilet facilities, and about one in ten school-age African girls does not attend school during menstruation or drops out at puberty because she has no access to clean and private sanitation facilities at school (Khosla and Pearl, 2003).

Other water issues include pollution, environmental degradation, and the contamination of groundwater and aquifers. Clean drinkable water is in increasingly short supply. Eighty percent of all sickness in the world is attributable to unsafe water and sanitation. Water-borne diseases kill 3.4 million people, mostly children, annually, and millions more are sickened with diarrhoea, malaria, schistosomiasis, arsenic poisoning, trachoma and hepatitis – diseases that are preventable by access to clean water and healthcare information (UN WWAP, 2006, p. 208, Table 6.2; Khosla and Pearl, 2003). The *Report of the World Summit on Sustainable*

Box 2: Gender and watershed management, Patan District, India

Patan District in India is arid, with an average annual rainfall of just 175 mm. Frequent droughts and sandstorms, high temperatures, and severe land and water salinity have reduced the communities of Patan District to survival level. When crops fail due to drought, there is no option but migration. Two-thirds of water users in this region are women.

In 1995, the Self-Employed Women's Association (SEWA), a trade union of 215,000 low-income, self-employed women, launched a ten-year water campaign in nine districts of Gujarat, India. Watershed committees were set up, consisting of eleven members, seven of whom were women. Each committee elected a chairperson from the women members. The committees constructed and repaired ponds and dams throughout the community to reduce the salinity of the land through soil and moisture conservation work. With more productive land, the women began growing organic cash crops and earning higher and more sustainable incomes.

SEWA has created a green belt in the area and generated employment opportunities for approximately 240 women. Nearly 2,500 hectares of land that could formerly be used only for rainfed agriculture is now sustainably irrigated, ensuring clean drinking water.

Source: UNDP, 2003.

Development states that 'women and children and vulnerable populations in general are bearing the brunt of the negative impacts of the lack of action on water and sanitation' (UN, 2002, p. 99).

Energy

Biomass – plant matter grown for use as solid, liquid or gas fuel – is the main energy source of a great number of the world's rural households. Biomass is grown from several plants, including switchgrass, hemp, corn, poplar, willow and sugarcane. In poorer countries, however, it is often of low quality, producing smoke and particulates that are damaging to human health. Through long hours of exposure to smoke and particulates in kitchens, women in developing countries experience higher levels of lung and eye diseases than men. As Joy Clancy, Margaret Skutsch and Simon Batchelor point out in *The Gender-Energy-Poverty Nexus* (2003) women and girls in rural areas also tend to be responsible for gathering biomass (commonly for several hours each day), with further health repercussions, and girls are frequently kept away from school for this task. Households in urban areas have to buy their cooking fuels, which can cost up to 20 percent of their income.

The burden of biomass fuel use is a major aspect of many women's lives. It necessitates large amounts of time in heavy work and can have negative effects on women's health. Although this problem has been recognized for 30 years, very little has been done about it (Clancy et al, 2003, p. 12). Photo by Bruce Skinner.

There are a variety of aspects to gendered perspectives on energy use. Although women are generally responsible for household energy provision and use – particularly through cooking, cleaning and fuel collection – when energy is purchased, men more often make the decisions. Studies have found that men tend to see the benefits of electricity in terms of leisure activities, improving quality of life and educating children, while women think in terms of reducing their workload and expenditures, and improving health. Batteries, for example, are very expensive for poor rural households, and are thus often reserved for luxury items such as radios and televisions, rather than for labour-saving appliances (Clancy et al., 2003).

By upgrading energy sources, agricultural and handicraft technologies, and water and sanitation, many technologies have the potential to improve lives, especially those of women. Recognizing gendered patterns of behaviour and improving opportunities to benefit from S&T for social development can have an impact not only on women, families and communities, but on a country's socioeconomic development as a whole (ECOSOC, 2004; UNCSTD, 1995, pp. 1–25). Women are very often active agents of change in the use and application of energy, both in their roles as producers and users of energy and in their economic activities and involvement in community organization.

Box 3: Science, technology and innovation for sustainable development and democracy

As regional and international agencies recognize the crucial, and growing, importance of science, technology and innovation for sustainable development and democracy, S&T has moved to an ever-more prominent position on the international political agenda. The World Summit on Sustainable Development in 2002 (WSSD) brought S&T to the centre of the development agenda, and the World Summit on the Information Society (WSIS), held in two phases in 2003 and 2005, examined the far-ranging implications of the information society for the global economy and society.

Countries are increasingly acknowledging the importance of integrating science, technology and innovation into national development strategies, at both national and regional levels. Brazil, China, India, South Africa are some examples that highlight the relationship between science and social development, combining S&T for competitiveness with S&T for poverty and social development.

Sources: Juma and Lee, 2005; Bezanson and Oldham, 2005; Paterson, 2004.

Gender discrimination practices thus truly limit the ability of many developing countries to grow and to reduce poverty. Recent studies clearly show that improving women's situations and increasing the efficiency of their work will reduce individual poverty and encourage economic growth (Clancy et al., 2003; McDade and Clancy, 2003). Reducing gender gaps in health and education increases women's incomes and levels of production, improves children's well-being, causes school enrolments to rise and birth rates to decline, and improves environmental conservation.

Sustainable S&T capacity development

S&T plays an important role in promoting long-term economic growth, and in building a base for a science-based knowledge society[1] – which is increasingly central to socioeconomic development. The establishment and maintenance of an indigenous S&T workforce allows countries to be more than just consumers of other nations' technological exports, and provides means for citizens actively to improve their own situations and economic well-being.

The ability of countries, and their public and private sectors, to create, acquire, assimilate, utilize and diffuse S&T knowledge is now a major determinant of economic competitiveness. The rapid exchange of new knowledge in practically all fields means that economic and social well-being derives as much from the mastery

1. A knowledge society is a society and economy that is organized around the role and importance of knowledge (learning, knowledge generation, knowledge adaptation, knowledge utilization and dissemination). See glossary.

and creative application of knowledge as from the possession and exploitation of tangible materials.

Highly qualified researchers, professionals and technicians are required to manage the maintenance and expansion of a country's science, technology and innovation capacity.

Social (national) systems of innovation vary substantially both in their dimension and in their method of operation. They encompass networks of institutions, resources, interactions and relations, political mechanisms and instruments, and scientific and technological activities that promote, articulate and materialize the technological innovation and diffusion processes in society (generation, import, adaptation and diffusion of technologies).

The potential of S&T to contribute to national socioeconomic development cannot be realized without making the best use of *all* sectors of a nation's population.

S&T capacity and gender

Achieving sustainable development depends on the active participation in the global knowledge-based society, taking into account the varied economic, social, political and cultural conditions of each region or country. The potential of S&T to contribute to national socioeconomic development cannot be realized without making the best use of *all* sectors of a nation's population.

Worldwide, the translation of 'scientific human capital' into professional scientific occupations is low for both men and women, but for women the rate of translation is lower (Glover and Fielding, 1999, pp. 57–73). Many highly trained women are subsequently 'lost' to S&T-related activities, representing a great loss in investment in human capital for countries, especially considering the high performance of girls and women in science education (European Commission, 2000, p. viii).

Creating and maintaining a workforce equipped to meet the scientific and technological issues and needs of today and the future involve many challenges:

- recruiting and retaining professionals with research and scientific skills
- facilitating mobility of research skills
- identifying skill sets that will be required in the future
- generating information to guide study and career choices
- strengthening education in science, mathematics and engineering for all segments of the population
- popularizing science and technology
- encouraging lifelong learning
- facilitating the active participation of women and other under-represented groups in the S&T workforce
- helping researchers to achieve a shared vision with society concerning the ethical aspects of their work (APEC, 2004).

Knowledge is at the centre of a strong, dynamic and evolving innovation system, which depends upon the inputs and contributions of all stakeholders, in all sectors. Although women and girls in many countries are enrolling in and succeeding at the full range of science courses at all educational levels (and in some countries the participation of women in the life sciences is at least equal to that of men), a great number of the world's women still face socio-cultural, economic and religious barriers to full participation in S&T.

Innovation and sustainable development

From 1990 to 2000, world expenditure on research and development (R&D) almost doubled, with developed countries' expenditures making up 80 percent. Despite this growth and the growth of world GDP during this period, global R&D *intensity* declined slightly, from 1.8 percent to 1.7 percent.[2] In 2000, most countries allocated a smaller share of their total economic resources to these activities than in 1999 (UIS, 2004).

Investment in R&D remains especially low in less-developed countries, despite scattered efforts to increase it. In 2000, developing countries spent an average of 0.9 percent of GDP on R&D, just short of the 1 percent target set by international declarations over the past thirty years. From 1990 to 2000, R&D investment had remained stable in **Latin American** countries, at about 0.6 percent of their GDP, while in **sub-Saharan Africa** it fell from 0.6 percent to 0.3 percent of GDP. **Arab States** showed a consistently low level of expenditure, averaging 0.15 percent of GDP. However, there is considerable variation within less-developed regions, with the growth in R&D investment in **Brazil**, **South Africa** and the (then) newly industrialized economies of East Asia – **Hong Kong**, **Taiwan**, **Singapore**, and the **Republic of Korea** – being notable exceptions.[3]

Many countries lose part of their investment in S&T capacity through the persistent difficulty of keeping S&T talent at home. They often then face the challenge of attracting back those nationals who have gone abroad for training at foreign institutions. Current data indicate that about one-third of qualified scientists and engineers who were born in developing countries move to developed nations to work (10 percent of the total S&T workforce in the **United States** is of foreign origin, while in **Australia** the figure is 25 percent: Meyer, 2003). Reasons for the brain drain vary,

2. Measured by the ratio between Gross Domestic Expenditure in R&D (GERD) and Gross Domestic Product (GDP).

3. *UIS Bulletin on Science and Technology Statistics*, No. 1, April 2004.

Box 4: Information and communication technologies (ICTs)

ICTs affect the generation, flow and use of information and knowledge. They promote collaboration among scientists, researchers and policy-makers across sectoral and geographical boundaries. ICTs can greatly contribute to the generation and distribution of knowledge for social development by providing precise and up-to-date information on health, agriculture and markets, and are being used throughout the world to teach students at all levels (through e-learning[1], as well as multimedia curricula approaches) and to train teachers.

The interconnection of regional and national networks can help to build multi-national scientific communities, making critical areas of knowledge more accessible to global society, in areas such as education, health and environment. Advanced networks can support progress in these and other academic disciplines, including strategic emerging areas of research that are often multi-disciplinary in nature. Networks allow scientists to participate in international S&T communities and help to gain in broader scientific knowledge to solve local problems.

Yet the benefits of ICTs and advanced networks are unfairly distributed, both within countries and between countries. Steps need to be taken to increase the effective use of ICTs in developing countries, which face obstacles such as the prohibitive cost of access and equipment, unreliable infrastructures, a lack of user-friendly tools, and language and literacy barriers. If these barriers are not addressed, the least-advantaged groups in society, and particularly women, will be unable to participate actively in the knowledge-based society.

While efforts are being made to increase investment in ICTs and expand access to them, far less attention is being paid to the extent to which women and gender concerns are shaping the regulatory and policy environments that will ultimately determine the utility and relevance of these technologies. The strategic challenge today is to ensure not only that both women and men benefit from the opportunities presented by new ICTs, but also that new ICTs are used to support greater socioeconomic, scientific and political equality.

Sources: Huyer et al., 2005; Turley, 2002.

1. E-learning is a broader concept than online learning, encompassing a wide set of applications and processes that use all available electronic media (Internet, intranets, extranets, satellite broadcasting, audio/video, interactive TV and CD-ROMs) to deliver education and training more flexibly to students.

but generally include poor working conditions (including lack of basic instrumentation and technical support); lack of access to high-level research networks; highly uncertain socioeconomic conditions for the future; and a weak integration of basic science and technology or R&D with public or private enterprises.

There is an urgent need for developing (and developed) countries to make better use of their human capacity in S&T, both to participate actively in the global knowledge economy[4] and to improve quality of life for all citizens. Cultivating local S&T capacity will be more effective if the abilities and potential contributions of all sectors of the population are taken into account: it cannot be achieved without the full participation of women and other under-represented groups at all levels of science.

While world expenditure on R&D almost doubled between 1990 and 2000, global R&D intensity declined slightly during the same period.

In addition to R&D investment, it is vital that the potential advantages of new products and technologies correlate with the knowledge and skills of intended beneficiaries. The innovation network for S&T priority-setting and research can be expanded beyond corporations, industry and research institutions to include users of technologies, grassroots organizations, science and engineering organizations, and other members of civil society. Among many relevant questions to consider are the following (Malcom, 2003):

- Who is served by S&T?
- Who does science?
- Whose interests direct S&T agendas?
- Who benefits from these agendas?

4. In a knowledge economy, in contrast to common notions of economy, knowledge, science and technology replace the traditional assets of land, labour or capital as a basis for wealth creation, competitiveness and economic development. See glossary.

- What innovations and technologies will improve the lives of the poorest members of society?
- What would science look like if all groups, including women, were equally represented, if their priorities, approaches and views were reflected equally in science decision-making, research and development?

Globalization

These processes of socioeconomic development and innovation take place in the wider context of globalization, a phenomenon that has rapidly increased in recent decades. Globalization represents the continuous world expansion of capital to deeper and broader levels than in any previous period. This conditions the processes of production of goods and services and international capital flows, and at the same time determines the nature, dynamics and the direction of technological change.

In the last two decades of the twentieth century, two crucial changes spurred a sharp rise in the rate of globalization: economic deregulation policies and the expansion of ICTs. Globalization implies a logic of homogenization and standardization of the economy, of production and consumption, and of knowledge, education and culture. The public, international debate over the course that globalization is taking often overshadows discussions of the nature and specificity of development problems at the local, national, regional and worldwide levels. It is important to grasp the process of globalization in terms of the interrelationship of planetary financial flows that result in the segmentation and marginalization of social, political and cultural systems in developing countries (Beinstein, 1999, 2004).

It is important to grasp the process of globalization in terms of the interrelationship of planetary financial flows that result in the segmentation and marginalization of social, political and cultural systems in developing countries.

Gender perspectives on S&T

Women's participation in socioeconomic and environmental activities is thus key to achieving sustainable development. Governments, non-governmental organizations (NGOs), the United Nations and its specialized agencies, and other national, regional and international organizations throughout the world, have been striving to overcome insufficiencies and disparities in the education of girls and women and to improve women's access to education, training and the labour market. Their actions have led to a broad range of national and international strategies, policies and programmes.

Increasing women's involvement and input in S&T is essential if we are to enhance human potential in these rapidly changing areas and to improve how we use technology, especially in the vital developmental areas of water resources management, food production and processing, and sanitation. Following from the **United Nations Decade for Women (1976–85)**, the 1985 *Nairobi Forward-Looking Strategies for the Advancement of Women* proposed strategic objectives precisely in terms of increasing female access to professional formation in S&T, as well as to life-long education (UN, 1985). These goals were firmly restated at the 1995 **Fourth World Conference on Women** and in its two-part report, the *Beijing Declaration* (UN, 1995*a*) and *Platform for Action* (UN, 1995*b*), and in follow-up meetings held in New York in 2000 (Beijing+5; see UN, 2000) and 2005 (Beijing+10; see UN, 2005), all of which emphasized not just the importance of involvement in S&T to women, but the crucial role of STG inter-relationships in achieving sustainable development.

The ICT 2005 Report on gender equality and women's empowerment illustrates the importance and the benefits of these interrelationships using the example of an ICT centre in India:

> As women become involved in the Baduria ICT Centre in West Bengal, India, they reported that they gained more respect in their local communities as a result of the ICT skills acquired at the centre – learning to use a computer and accessing and distributing information to local people. This resulted in greater respect at both the family and community levels. Younger women felt they were able to approach the job market with greater confidence. There was also an emergence of solidarity; since women learned to use computers together at the ICT Centre, they often discussed their problems creating a sense of unity among them and bringing forth leadership qualities (Slater and Tacchi, 2004).

These and related issues have also been broached at major world conferences on education, such as the 1990 World Conference on Education for All in Jomtien, Thailand, and the 2000 World Education Forum in Dakar. The **1999 World Conference on Science** (WCS), held in Budapest, specifically addressed gender inequality in the sciences and suggested specific commitments and reforms to achieve the full participation of women and girls in all aspects of science and technology. WCS recommendations included actions to improve career prospects for women in education systems and science departments; to increase girls' and women's access to scientific education at all levels; and to increase the representation of women in national, regional and international policy and decision-making bodies and forums (WCS, 1999*a* and 1999*b*).

'Gender equality' describes a situation in which all human beings are equal and free to develop their personal abilities and

These initiatives restate the need for gender main-streaming and affirm that S&T can bring new opportu-nities for all women in all fields if they have equal access to resources and adequate training.

make choices without limitations, and where both women and men have equal conditions in which to realize their full human rights and contribute to (and benefit from) economic, social, cultural and political development. Structural gender inequality exists where social institutions practice gender discrimination. In 2000, gender equality became the third of eight United Nations Millennium Development Goals (MDGs)[5]: Promote gender equality and empower women. Together, the MDGs have galvanized unprecedented efforts to meet the needs of the world's poorest by 2015 and clearly call for action related to STG (see **Table 1**).

All these initiatives restate the need for **gender mainstreaming**[6] and affirm that S&T can bring new opportunities for all women in all fields if they have equal access to resources and adequate training. They bear witness to the international consensus that women should also be actively involved in the definition, design, development, implementation and gender-impact evaluation of policies related to these changes. Socioeconomic conditions are constantly changing, nationally and internationally. A number of positive changes are taking place regarding STG issues in many countries. But these changes are clearly far from enough and there remains a long way to go.

5. The UN has made a major commitment to tackling these problems through the Millennium Development Goals (MDGs), a set of eight goals agreed to by all the world's countries and leading development institutions: www.un.org/millenniumgoals.

6. Gender mainstreaming aims at integrating the gender dimension into existing institutions and practices in order to achieve gender equality. See glossary.

Table 1: Science, technology and gender, and the Millennium Development Goals

MDG	S&T contribution	Gender implications
1. Eradicate extreme poverty and hunger	**S&T can:** • Raise agricultural productivity. • Improve nutrition. • Increase crop yield. • Improve soil management. • Develop efficient irrigation systems. • Stimulate macroeconomic growth, through the sector's contribution to the economy and the effect of investment in ICTs on economic growth and job creation. **It provides the basis for:** • Increased market access, efficiency and competitiveness of the poor through micro-level interventions such as village payphones or improved access to agricultural information. • Increased interactivity to ensure the social inclusion of poor and disadvantaged groups. • Facilitating political empowerment through inclusive, informed priority-setting, increasing accountability and good governance.	• Women are responsible for 60–90 percent of food production activities in developing regions. • Women's entrepreneurial activities in processing and selling food make up a substantial portion of developing country economies. • Women possess much traditional knowledge about local seeds, cropping patterns and soil and water management.
2. Achieve universal primary education	• Science education should be part of basic education curricula, to develop a science-literate population and the basis for an S&T workforce. • ICTs can provide remote access to education resources and facilitate distance learning and e-learning in primary, secondary and tertiary education. • ICT-based distance training and e-learning enhance the possibility of providing teacher-training in remote or isolated areas. • ICTs can be used for delivery of content and curricula • Administration can be streamlined through ICT applications. • ICTs can provide invaluable digital libraries and educational resources. • S&T can develop educational content.	• Rates of enrolment of females decreases in higher levels of S&T education. • Women are less represented in senior levels of the S&T workforce. • ICTs are successful tools to facilitate the education of women and girls through distance- and e-learning. • ICTs facilitate leadership development of women scientists and engineers.

3. Promote gender equality and women's empowerment	**S&T can improve technologies for women's daily work, through:** • Developing sustainable energy resources. • Providing agricultural technology. • Providing access to clean water and improved sanitation technologies and practices. • Using technologies (including ICTs) to support income-generating enterprises for women. • Influencing public discourse and stereotypes on gender equality. • Improving women's education – providing resources and access to distance- and e-learning. • Increasing the awareness of women's rights and the participation of women in decision-making. • Reducing transaction costs, increasing market coverage, providing income-generation in themselves.	
4. Reduce child mortality **5. Improve maternal health**	**ICT health applications:** • Improving nutrition monitoring and support. • Supporting remote consultation and diagnosis. • Enhancing storage, dissemination of and access to medical information. • Coordination of research. • Training of health workers. • Disseminating healthcare information directly to the population through traditional and new media. • Health and medical software and databases can be used to track vaccination and treatments, coordinate shipment of drugs and health supplies, and spread information on treatments and diagnosis. • Patient education and monitoring. • Managing distribution of medicines. • Providing support networks for patients and families. • Health management and disease tracking software.	• Women possess much of the world's traditional and local knowledge relating to health and hygiene. • Women are predominantly responsible for the health of children in many societies. • Women would benefit from increased access to basic health and nutrition information (ICT can be a support tool).
6. Combat HIV/AIDS, malaria and other diseases	• Developing new treatments and vaccines, microbicides. • Producing/manufacturing low-cost generic medicines. • Creating new institutional frameworks to encourage new research collaborations (for example, a synthetic vaccine for Haemophilus Influenzae B Type [Hib] was developed by research collaboration between groups at the Universities of Havana and Ottawa, producing a joint patent; the synthetic version is cheaper and easier to manufacture than the non-synthetic vaccine on the market). • Monitoring and improving drug quality.	• Women possess much of the world's traditional and local knowledge. • The rate of HIV/AIDS infection among females is increasing internationally and in Africa it is higher than that of males. • Young women are especially at risk. • Women are caregivers of the sick.

7. Ensure environmental sustainability	• Integrate scientific with traditional and local knowledge for monitoring and managing ecosystems such as watersheds, forests, seas. • Predict and manage the effects of climate change and loss of biodiversity. • Develop and improve low-cost technologies for water delivery and treatment, drip irrigation, sanitation. • Develop crops requiring less water; develop drought-resistant crops using conventional breeding and genetic engineering methods. • Develop of sustainable land management strategies, agricultural systems that conserve biodiversity, and knowledge systems based on proper understanding of needs of households that depend on the ecosystem and indigenous knowledge of existing resources for their survival. • Facilitate the participation by local population in protection and monitoring of the environment through networking and information exchange. • Provide tools for observing, simulating and analyzing environmental processes. • Reduce paper consumption and facilitates telecommuting. • Raise awareness of environmental issues. • Facilitates monitoring, management and risk mitigation • GIS and spatial information.	• Women possess much of the world's traditional and local knowledge. • Women are a group that is especially vulnerable to natural disaster. • Women's survival skills underpin social responses to crises and disasters. • Women are managers of their local environmental resources. • Access and rights to land for women are important land management issues.
8. Strengthen a global partnership for sustainable development	• Promote S&T policies at the highest decision-making levels and explicitly articulate them with major economic and social policies. • Increase access to new ICT technologies to improve governance. • Develop ICTs and e-learning in less developed countries and in small island states.	• Women are under represented at top levels of S&T decision-making. • Women's strong community-level activities can greatly contribute to enhance local governance. • Flexible learning processes are specially suited to women's economic and home tasks.

Sources: Juma and Lee, 2005; Huyer 2004; Clancy et al., 2002; Khosla and Pearl, 2003.

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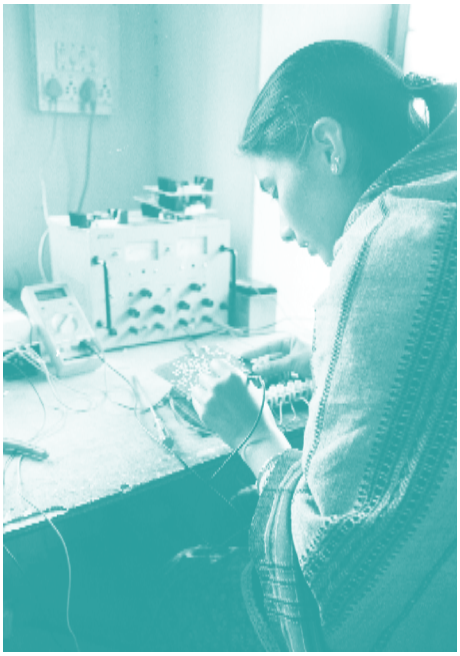
Chapter 1
S&T Policy and Gender 1

In spite of women's contributions to technological development and the existing and potential benefits that technologies can bring to women, women's concerns and contributions are frequently disregarded in S&T policy, research and development. Most often women are left un- or under-represented in S&T policy- and decision-making bodies at institutional, national and international levels. Hence, women have had little input into the science research agenda, and science research has, in turn, often neglected their situations, interests and concerns – be they physiological or social.



Hansi Devi, 23 years old, repairing a solar lantern at College © UNESCO/Peter Coles

Incorporating a gender perspective into S&T

Women represent a significant proportion of every nation's human resources base; together they constitute a pool of talent for science, technology and innovation. How best to bring more women into the study of these fields, into the S&T workforce? How are we to incorporate a gender perspective into research agendas, into the conduct of research and development (R&D), and into the development of strategies, policies, processes and products to support a development agenda? These concerns have been the focus of discussion in many international forums, those addressing women's needs, rights and advancement, as well as those on the role of S&T in supporting sustainable development and poverty alleviation.

While there has been a great deal of research on the effects of technology for development on women and gender relations over the last thirty years, the gender dimensions of new and emerging areas – technology foresight, nanotechnologies, security, technology platforms and innovation – represent new challenges.

Gender research, or research on women, involves the examination of 'conventional andocentric assumptions' (Harding, 1995) in S&T culture and in its institutions (at international, national and local levels), and among targeted beneficiaries of R&D outcomes. The goal of such gender analysis is not to politicize S&T but to 'identify the ways S&T cultures and practices are already constituted within an andocentric gender dimension' (Harding, 1995, p. 306). The principle questions here are: who are the main players? Whose priorities are represented? Who benefits?

While there has been a great deal of research on the effects of technology for development on women and gender relations over the last thirty years, the gender dimensions of new and emerging areas – technology foresight, nanotechnologies, security, technology platforms and innovation – represent new challenges (European Commission, 2005, p. 18). More research is needed on women's interests, needs and concerns: which technologies will help women to increase the rate and quality of food production? What community-based issues have had insufficient technological attention? How can S&T improve sanitation and cleanliness and provide affordable energy in ways that empower women and girls?

As all nations will face increased challenges in the coming years related to the environment, health, energy, water, food security and development, it is worth bearing in mind that S&T has potentially much to offer in addressing these concerns, and that women's increased recognition and participation promise to create the conditions for national economic development when a gender perspective is duly included in R&D activities and the products and processes are created to respond to the challenges.

International and regional cooperation

Strengthening international and regional cooperation is one of the means for countries to formulate, implement, assess and manage S&T guidelines and policies that integrate a gender perspective.

Striking differences exist between countries and regions regarding the ways in which science, technology and gender (STG) are socially perceived, differences rooted in disparate socio-economic, educational and information levels. International and regional groups that account for a country's perception of S&T use can promote the formulation of S&T development strategies and policies on a more democratic basis.

Gender-sensitive policies that take account of the environmental, cultural and social realities of the lives of both women and men – while aiming to eliminate inequalities and promote an equal distribution of resources – are the most successful. In this regard, however, goal-setting and data assessment in support of STG must become central to policy-making efforts at all levels, national, regional and international. As governments and international organizations rely incresingly more on statistics to design, monitor and assess policy interventions, reliable sex-disaggregated data and statistics are crucial for the development of policies promoting gender equity (see **Chapter 5**).

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Box 1.1 UNCSTD and the Beijing World Conference on Women

Some policies already exist worldwide that support women's participation and consider the gender implications in S&T fields – in the structure of research agendas, in the conduct of research itself, in priority setting, in education, literacy and the labour force. The most comprehensive of these policies is the 'Seven Transformative Actions', developed over a period of two years and the result of a series of studies and research by the Gender Working Group (GWG) of the UNCSTD. These recommendations were created in preparation for the 1995 Beijing World Conference on Women and functioned as guidelines for the discussions pertaining to S&T throughout the meeting:

(1) Establishing equity in science and technology education.
(2) Removing obstacles to women in scientific and technological careers.
(3) Making science responsive to the gender dimension.
(4) Making the S&T decision-making process more gender aware.
(5) Relating better with local knowledge systems.
(6) Addressing ethical issues related to gender in science and technology.
(7) Improving the collection of gender disaggregated data for policy-makers.

Concrete recommendations for actions in each key area were intended to support women's participation in leadership and decision-making and improve women's status worldwide.

During the fourth Beijing World Conference on Women, these transformative recommendations were advanced by UNCSTD and were later adopted by the Economic and Social Council of the United Nations (ECOSOC). As a result, in 1996 the Gender Advisory Board was created to act as a monitoring, technical assistance and implementation body following the 1995 acceptance of the UNCSTD recommendations by ECOSOC. Its primary mandate is to monitor the implementation of the recommendations made by ECOSOC on gender and S&T and to provide assistance in their implementation. The second goal is to advise on the gender implications of its new work programmes. It is made up of a voluntary board made up of nine members from Brazil, Egypt, India, the Netherlands, Pakistan, Romania, Sudan, the UK and the US.

Source: CSTD, 2007.

S&T gender & national policy

Thus, while scientific and technological development potentially offer an instrument of social progress and cultural enrichment, actually ensuring that the benefits are equitably distributed depends on well-constructed public policy, itself based on accurate data and pertinent statistical tools.

The democratization of science implies increasing the participation of all people in S&T in a gender-equitable way, and facilitating access to science as a central aspect of culture and education. Open and accessible participation in R&D activities, preparation and debates in the fields of science, technology, ethics and political decision-making are vital elements of the democratization process. Government policies and initiatives that explicitly address gender issues and encourage broad social participation in S&T can have a marked impact on a country's socioeconomic development.

S&T policy represents a national commitment, or a national project, to promote science, technology and innovation. Both the public and the private sectors must be included, and policy should specifically address mechanisms of change and funding instruments. Because the participation of women in science is a key concern in addressing inequalities and improving socioeconomic growth, it is imperative to incorporate a gender perspective into S&T policy.

Because women's participation in science is a key concern in addressing inequalities and improving socio-economic growth, it is imperative to incorporate a gender perspective into S&T policy.

In addition to national policies, supporting policies and processes – for instance, regulations regarding consultation and participatory processes – also play a crucial role. These might include:

- **S&T for policy**: effective mechanisms to incorporate S&T inputs into top political and economic decision-making.

- **Generation and dissemination of knowledge**: procedures to achieve broad public participation in critical S&T issues and to communicate S&T knowledge. Popularization activities aim to ensure that S&T becomes a central component of culture, social conscience and collective intelligence.
- **S&T statistics and indicators:** strengthening, developing and utilizing systematic statistics, indicators and interpretative models to understand the multiple factors and interrelationships in the generation of S&T knowledge and innovation processes.
- **Evaluation of R&D programmes and projects**: consistent, multi-criteria evaluation methods to assess the efficacy and impact of the use of resources, activities and results with regard to pre-established objectives. Evaluation must be supported by diverse data, information sources and agents, and explicitly incorporated into the decision-making process.
- **Prospective studies**: these studies strengthen institutional capacity to predict future trends regarding science, technology, innovation and gender. They seek to enable true freedom of decision and action by outlining and analyzing a certain number of possible futures ('futuribles' are possible lines of evolution of a given situation, phenomenon or problem). Prospective studies are placed within a historic process and, supported by a retrospective analysis, approach the future as an occurrence. They do not produce forecasts, but rather *conjectures* that support decision-making; nor do they attempt to reduce the unlimited variety of possible futures to a handful of alternatives, but instead seek to clarify and render explicit the dangers and opportunities that may take shape in the long term.

It is imperative that the socioeconomic benefits of integrating an S&T perspective into decision-making structures be recognized and promoted by the public and the private sectors alike. By assuring a gender balance in their internal structures and decision-making processes, and incorporating an STG perspective into all actions (in national governments and ministries, as well as in local governments), higher education institutions (especially faculties of science or engineering), R&D centres and major companies can improve social awareness of STG and encourage the development of relevant policy instruments. Relevant bodies include:

- STG coordinating networks, committees and national bodies
- scientific associations, societies and academies (including associations promoting traditional knowledge)
- United Nations agencies and other international and regional inter-governmental organizations
- non-governmental organizations
- international, regional and sub-regional development banks
- parliaments
- multilateral and bilateral development-assistance organizations
- foundations
- the media.

Nonetheless, the advantages offered by new products and technologies cannot be used to their fullest if they do not complement the existing skills and knowledge of their intended beneficiaries – men *and* women. To this end, innovation networks that identify S&T priorities are expanding beyond industry and research institutions to include a larger range of technology users, grassroots organizations, science and engineering organizations, and

The advantages offered by new products and technologies cannot be used to their fullest potential if they do not complement the existing skills and knowledge of their intended beneficiaries – men *and* women.

The scarce availability of key statistics remains a significant obstacle to gender analysis or the development and evidence-based policies in science and technology.

other members of civil society. Moreover, initiatives to educate the public on S&T issues (popularization) and to promote scientific literacy in schools and in non-formal education are also increasing throughout the world. S&T education with a gender perspective is becoming a central component of education at all levels.

Intersectoral, interdisciplinary R&D, and transnational mobility, have become the hallmarks of a researcher's career, and research policies are beginning in turn to focus on career development and the working conditions of contemporary researchers. The European Charter for Researchers, issued by the European Commission (DG Research), outlines good practice for researchers and employers or funders of researchers. It articulates the essential rights and duties of researchers and their funding institutions. The charter is published together with the 'Code of Conduct for the Recruitment of Researchers', which outlines principles for hiring and appointing researchers.[1]

This said, the scarce availability of key statistics in this field remains a significant obstacle to STG analysis or the development of evidence-based policies in science and technology. Access to research findings and to sex-disaggregated data are key to establishing successful monitoring strategies and accountability systems (see **Chapter 5**). The European Union's online publication *She Figures* (2006) and the US National Science Foundation's *Women, Minorities and Persons with Disabilities in Science and Engineering* (2004) are collations of key indicators that can inform policy, decision-making and action.

1. Both are available at http://ec.europa.eu.

Box 1.2: The European Union's Science and Society Action Plan

In recent years, the European Union has focused on improving and enhancing the relationship between science and society by initiating various funding programmes that aim to improve the public's ability to become more involved in science. One of the benefits of this approach has been the establishment of specific initiatives and actions plans that aim to promote research by, for and about women in science and technology.

The first of these efforts began with the Helsinki Group, established in 1999 as a working group of national representatives and gender experts from the fifteen EU Member States and fifteen Associated Members. Its mandate is to promote the participation and equality of women in the sciences and provides a forum for dialogue about national policies. The group grew out of the recognition that women's talents were underutilized in the European science system and that women were significantly absent from science policy-making and advisory bodies in Europe (European Commission, 2000). Using a similar model, the Gender Advisory Board of the UN Commission on Science and Technology for Development has promoted the establishment of 'National Committees on Gender, Science and Technology' made up of a range of national stakeholders, including policy-makers, researchers and NGOs, to assess the gender dimensions of national S&T-related policies and promote strategies to more fully incorporate the concerns and abilities of women.

In response to the 2000 Lisbon Strategy, the EU Science and Society Action Plan (SASAP) was adopted by the European Commission in 2001. This ten-year iniative seeks to contribute to and enhance the participation and role of women in research, while also addressing other issues such as governance, ethics, youth and education. Below is a outline of the series of actions specifically targeted at 'producing gender equality in science'.

Initiative	Action
Establishing a European platform of women scientists	A European platform will be set up to bring together networks of women scientists and organizations committed to gender equality.
Monitoring progress towards gender equality in science	A set of gender indicators will be produced in cooperation with the statistical coorespondants of the Helsinki Group on Women and Science to measure progress towards gender equality in European research.

Mobilizing women scientists in the private sector	An expert group will examine the role and place of women in research carried out in the private sector, identifying career patterns and examples of best practice, and will formulate recommendations to increase gender equality.
Promoting gender equality in science throughout Europe	A group of experts will examine the situation facing women scientists in Central and Eastern Europe and the Baltic States, amd make recommendations for further work, in particular through the Helsinki Group on women and science and links with other appropriate policies.

Sources: European Commission (2002), Science and Society Action Plan (EC, p. 18). See also www.europa.eu.int/comm/research/science-society/women-science/women-science_en.html.

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Chapter 2
Gender and S&T Education

2

It is an undisputed fact that education lies at the core of sustainable human development and enhanced quality of life. It is equally undisputed that in most regions of the world women are more likely than men to be uneducated or undereducated, especially with regard to science and technology (S&T). 'Education for All' is a priority strategy for promoting women's equal participation in the knowledge society[1]:

> Educational attainment is, without doubt, the most fundamental prerequisite for empowering women in all spheres of society, for without education of comparable quality and content to that given to boys and men, and relevant to existing knowledge and real needs, women are unable to access well-paid, formal sector jobs, advance with them, participate in, and be represented in government and gain political influence (Lopez-Claros and Zahidi, 2005, p. 5).

Secondary school chemistry laboratory, Sri Lanka.

Although worldwide female enrolment at all levels of education is increasing, girls and women still face barriers to education, and particularly to S&T-related education at all levels. Women do not

1. Knowledge society: see note 1 on page 27 and glossary.

enter S&T courses at the tertiary level at the same rate as men, and do not have the same degree of access to the labour market.

The **Millennium Development Goals**[2] (see **Table 1**, page 37) recognize that gender equality is a core development issue. Educating women contributes to gender equality through increases in production and income, which lead in turn to increased school enrolment of children, decreased birth rates and increased agricultural productivity (UNESCO, 2003; World Bank, 2001, p. 1).

While total numbers of illiterate adults have declined over the last few years, women continue to make up two-thirds of illiterate adults and, of the 115 million children not enrolled in primary education, girls represent 53 percent.

Gender disparity can vary from country to country. Even though the norm is most often in favour of boys, in many countries in the Caribbean and Latin America, gender disparities can favour women and girls.[3] However, while total numbers of illiterate adults have declined over the last few years, women continue to make up two-thirds of illiterate adults and 53 percent of the 115 million children not enrolled in primary education (UIS, 2005). Women and girls lag behind in educational enrolment at the primary and secondary levels in many countries in **sub-Saharan Africa**, **South and West Asia**, and the **Arab States**, while elsewhere such as in Latin America, female enrolment is at or close to parity with male enrolment, or even greater (World Bank, 2005).

At the tertiary level, women have made significant progress in enrolment rates in many regions of the globe. However, gender disparities are clear in the distribution across fields of education,

2. See www.un.org/mileniumgoals.

3. During the World Regional Forum (Dakar, April 2000) it was noted in the Regional Round-up for Latin America and the Caribbean that, 'In the Caribbean as a whole, girls' enrolment exceeds that of boys, and girl pupils are outperforming boys.' See www.unesco.org/education/efa/wef_2000/press_kit/latin.pdf.

with fewer girls and women in general enrolling in S&T subjects at all levels.

Non-formal S&T education is, however, expanding rapidly. ICTs (see Box 3) are invaluable in providing distance and e-learning, and S&T centres increasingly offer hands-on experience. Similarly, community-learning opportunities provide S&T education directly related to local situations. The content areas supported by the study of S&T through such non-formal channels – including topics such as health, energy and agriculture – are often directly aligned with enabling women in the roles they are expected to play within the family and the community.

Girls and science

Literacy and basic education

Access to education has improved in many countries, especially over the last decade or so. From 1998 to 2002, total worldwide enrolment in primary education increased from 655 million to 671 million. While this is slow progress, there have been some rapid increases in total enrolment levels in **sub-Saharan Africa**, **South and West Asia** and the **Arab States**, regions in which enrolment rates have been particularly low. Gender disparities have narrowed, although progress has been too slow to reach the MDG of gender parity in primary and secondary enrolment for 2005. Serious barriers remain that especially limit access to education for girls and women, as well as their ability to complete school courses (UNESCO, 2006*a*).

Box 2.1: Education for All

As a key contributor to the MDGs, especially MDG2 on universal primary education and MDG3 on gender equality in education (see Table 1, page 37), the Education for All (EFA) programme represents a global commitment to provide quality basic education for all children, youth and adults.[1] EFA was introduced at the World Conference on Education for All in 1990 during which six ambitious goals were set out to meet basic learning needs by the year 2000. These fundamental goals include:

- **Universal access to learning.**
- **A focus on equity.**
- **Emphasis on learning outcomes.**
- **Broadening the means and the scope of basic education.**
- **Enhancing the environment for learning.**
- **Strengthening partnerships by 2000.**

By 2000, ten years after the initial commitment to the MDGs, it was clear that the rate of progress in many countries was insufficient to reach the 2000 target. In response, another meeting was called – (The World Education Forum, Dakar, Senegal, 2000) – in which the international community once again declared its commitment to EFA and identified six new goals to be met by the year 2015[2]:

- **Expand early childhood care and education.**
- **Provide free and compulsory primary education for all.**
- **Promote learning and life skills for young people and adults.**
- **Increase adult literacy by 50 percent.**
- **Achieve gender parity by 2005, gender equality by 2015.**
- **Improve the quality of education.**

Women make up 64 percent of illiterate adults worldwide, a percentage unchanged since 1990, although men make up the majority of illiterates in some countries, such as Botswana, Jamaica, Lesotho, and the United Arab Emirates. For more information on literacy and Education for All, see *Education For All: Global Monitoring Report* (UNESCO, 2006a).

1. portal.unesco.org/education/en/ev.php-URL_ID=47044&URL_DO=DO_TOPIC&URL_SECTION=201.html.
2. The Education for All goals were adopted by representatives from 164 countries at the World Education Forum in Dakar in 2000. See www.unesco.org/education/efa.

Enrolment ratios by gender have noticeably progressed. By 2002, forty-nine countries had achieved gender parity in both primary and secondary enrolment.[4]

In some regions of the world (e.g. the **Caribbean**), participation in education has favoured girls over boys. A study commissioned by the Ministry of Education and Culture in Jamaica to investigate gender differences in academic achievement, participation and learning opportunities pointed out that 'for a number of years, girls' academic achievement has surpassed that of boys in nearly every subject and curricular' (Evens, 2002). Nevertheless the gender dimension of participation in education still warrants specifically targeted research, policy responses and intervention.

Major gender disparities affecting girls are concentrated in the **Arab States**, in certain countries in **South and West Asia**, and in **sub-Saharan Africa**, although this situation has slightly improved in recent years and dramatic progress was achieved in many countries in these regions between 1998 and 2002 – notably in **Côte d'Ivoire, Ethiopia, Guinea, Lebanon, Mali, Mozambique** and **Yemen** (UNESCO, 2003, 2006).

It is currently estimated that there are 771 million illiterate adults globally, which has dropped by 100 million since 1990 (UNESCO, 2006*b*, p. 30). However, this global rise in literacy is

4. These countries are: Albania, Anguilla, Armenia, Australia, Azerbaijan, the Bahamas, Barbados, Belarus, Bulgaria, Canada, Chile, China, Croatia, Cyprus, the Czech Republic, Ecuador, France, Georgia, Germany, Greece, Hungary, Indonesia, Israel, Italy, Jamaica, Japan, Jordon, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Malta, Mauritius, the Netherlands, Norway, Oman, Republic of Korea, Republic of Moldova, Romania, the Russian Federation, Serbia and Montenegro, Seychelles, Slovakia, Slovenia, TFYR Macedonia, Ukraine, United Arab Emirates, United States, Uzbekistan. See UNESCO, Education for All Literacy for Life Summary (2005), Table 1.4.

To combat global illiteracy, we need to target regions of the world where progress in girls' education is slow.

mostly due to increased literacy rates in China. To combat global illiteracy, we need to target regions of the world where progress in girls' education is slow, notably in the Arab States, South and West Asia and sub-Saharan Africa, where high population-growth is bringing down overall literacy rates even as the numbers of children enrolled in schools overall increases. In fact, despite impressive increases of 30 percent or more in some countries, 40 percent of countries in sub-Saharan Africa still have gross intake rates of below 95 percent, with access to schools continuing to be an issue, particularly for girls in rural areas. Crises in the region exacerbate the situation: by 2010, it is expected that 10 percent of children in sub-Saharan Africa will be orphaned by HIV/AIDS and other diseases, or by armed conflict.

While the gender gap in enrolment is narrowing in many countries, it is not expected to be eliminated in the short term, or by 2015 – the target date of the MDGs. Although 60 percent of the 159 countries with available data had achieved gender parity in primary education intake by 2002, when we look at total numbers of children, global education rates for girls at the primary level remain lower than those for boys: 53 percent of the 115 million children in the world who do not attend primary school are girls. A six-year-old girl in South Asia is expected to spend six years in school, compared with nine years for a boy. Living in the countryside widens the gap; a girl living in a rural area is three times more likely to drop out of school than a boy in the city (UNESCO, 2003, 2005).

In general, the following three conclusions can be drawn regarding gender and primary enrolment:

1. **The lower a country's rate of primary school enrolment, the greater the inequality between the enrolment levels of boys and of girls.**

Where enrolments are low, boys are given preference in most countries and regions. Exceptions include Iran, Niger, Tanzania and Zambia – countries with net enrolments far below 100 percent, but which have virtually achieved gender parity.

2. **Poverty contributes to under-enrolment.**
   Data show that enrolment rates at primary school level rise with per capita income, although there is considerable variability in this, especially for countries where the average income is less than US$1,000 per year.

3. **Inequality in the enrolment rates of boys and of girls reduces as per capita income increases.**
   Although there is substantial variation among countries at lower income levels, inequality in enrolment rates is consistently redeemed **only when average** incomes are quite high (above US$3,500 per capita annually). While overall access to primary education increased from 1990 to 2000 in most countries,[5] enrolment levels increased more rapidly for girls than for boys. **Sub-Saharan Africa** saw the highest relative increase in girl's enrolment (38 percent), while **South and West Asia** and the **Arab States** had lower rates of increase (19 percent and 17 percent: UNESCO, 2003).

Secondary school

As at the primary level, gender disparities in enrolment levels favouring boys (greater than 10 percent) are seen at secondary-

5. The exceptions are Chad, Benin, Burkina Faso, Guinea-Bissau, Mali, Niger and Pakistan. Poverty is a major factor affecting school enrolment in these seven countries, all of which also have a high level of gender disparity in school enrolments.

school level almost exclusively in low-income countries, which often have undeveloped school systems. Although enrolment rates for girls at the secondary level have increased in all developing regions since 1990, discrepancies continue in some countries, especially in those that have very low enrolments rates for girls at the primary level.

When access is not limited by resource constraints, we see more girls enrolled than boys, particularly at the upper levels of secondary education. Boys tend to enrol in shorter, less academic programmes that do not lead to tertiary education, and leave secondary education earlier.

In a large range of countries, with different levels of GNP per capita, gender disparities at secondary-school level favour girls. Overall, secondary enrolment levels average around 30 percent of youth in **sub-Saharan Africa** and 70 percent in **Latin America** and the **Arab States**, while **OECD and Central and Eastern European countries** are at or close to universal secondary enrolment. When access is not limited by resource constraints, we see more girls enrolled than boys, particularly at the upper levels of secondary education. Boys tend to enrol in shorter, less academic programmes that do not lead to tertiary education, and leave secondary education earlier. For these reasons, the overall increase in secondary enrolment worldwide has been an important factor in gender parity in education (UNESCO, 2003, 2006).

It can be expected that, as more girls graduate from primary school, their attendance at secondary levels will increase. However, other issues also play a role: while admission rates are usually lower for girls, survival rates are more often equal or higher. Once girls are in school, they usually perform as well as boys if not better, with boys being more likely to have to repeat school years. This is generally true in all regions except **sub-Saharan Africa** and **Central Asia**, and is particularly apparent in **Latin America** and the **Caribbean**, where girls are in the majority at secondary and tertiary levels.

In **OECD countries** and the **Caribbean**, concern is growing about the decreases in the enrolments and performance of boys in schools at all levels. In the Caribbean, for example, girls start school earlier, attend more regularly, drop out less frequently, stay in school longer, and achieve higher levels. Ramifications of this situation for the increasing alienation of boys and men from Caribbean society are of concern (UNESCO, 2003). In the **United Kingdom**, too, a great deal of attention has been paid to the declining performance of boys on school examinations, indicating that girls are making better progress than boys in reading, mathematics, and verbal and non-verbal reasoning (Arnot and Phipps, 2003).

Box 2.2: Factors affecting the lower enrolment of girls

- **Girls are often kept at home to help with domestic chores.**
- **Girls can be thought not to need education because they are not expected to take up paid employment outside of the home.**
- **Early marriage and motherhood: in Nepal, 40 percent of girls are married before the age of fifteen.**
- **A lack of acceptable or appropriate sanitation facilities at schools (toilets, clean water).**
- **Armed conflict: girls are more vulnerable to rape, sexual violence and exploitation than boys. It is estimated that approximately 100,000 girls directly participated in conflicts in at least thirty countries in the 1990s as fighters, cooks, porters, spies, servants or sex slaves.**
- **Poverty: girls and women are usually responsible for addressing the basic needs of the household.**
- **Economic and natural shocks including diseases, HIV/AIDS and poor health.**
- **Violence and sexual harassment in schools (this is more pervasive than is often recognized).**

Sources: UNESCO, Education for All, Global Monitoring Report, 2003/4, p. 13.

Choice of subjects

Despite higher enrolment rates for girls overall, and better learning achievements, clear gender disparities in subject choices in secondary education persist.

Girls at secondary level tend not to enrol in scientific and technical subjects as much as boys. Even within technical programmes of study, girls tend to select less-technical subjects than boys: for example, in **Chile**, of students enrolled in secondary-level technical courses, 82.2 percent of the girls chose a commercial specialization, while 58.5 percent of the boys (and 13.1 percent of the girls) chose an industrial specialization. These numbers are echoed in other parts of the world. Even though girls consistently perform better than boys in science at secondary level, in **France**, for example, they make up less than half (44.2 percent) of the students taking science at final (*baccalaureate*) level. In the **United States**, while gaps between girls and boys in math and sciences courses are diminishing – likely a result of more attention paid to gender-equity[6] issues in science and math courses – more boys continue to take advanced courses. They also enrol in more math and sciences courses overall and achieve higher scores in the National Assessment of Education Progress testing (UNESCO, 2003; AAUW, 1998).

Reasons for why girls are less interested in scientific and technological subjects vary. Sociocultural attitudes about what is considered appropriate for girls and women are frequently passed

6. Gender equity involves being fair and impartial to men and women regardless of their gender. Measures must often be put in place to compensate for the historical and social disadvantages suffered by women (equity is a means, equality is the result).

on from parents to their daughters.[7] A study in **Mali** found that almost one-third of households surveyed differentiated enrolment choices for girls and boys because boys were considered to be more intelligent. Similar attitudes prevail in developed countries: a study in the **United States** found that parents consider their sons to have greater math abilities than their daughters, despite the lack of gender differences in grades or test scores (Jacobs and Eccles, 1992); while in another study, mothers' estimates of their sixth-grade child's (average age of eleven years) likelihood of success in mathematics predicted the career choice of that child at the age of twenty-five. Parents' attitudes are also important in girls' decisions to study scientific subjects. Women scientists tend to have parents (either fathers or mothers) who are scientists in greater proportion than their male colleagues.

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Performance

International studies indicate that, overall, the performance of girls and boys is roughly equal in mathematics, with small discrepancies in other S&T-related subjects. The *TIMSS 2003 International Science Report* found essentially no difference in achievement between boys and girls at fourth-grade (average age of nine years) or eighth-grade (average age of thirteen years) levels, although gender differences exist between countries and in different S&T subject areas (IEA, 2005; Martin, 2004). Boys achieved better results in physics and earth science subjects in eighth grade, while girls tended to have higher achievements in the life sciences. In a

7. Studies show that women scientists are more likely than their male colleagues to have at least one parent who is a scientist (see Rathgeber, 2002; CWSE, 2001).

majority of countries, girls in eighth grade attained significantly higher scores in measures of reasoning and knowledge, while boys had better results in application.

These findings have been echoed by studies at the regional level. The Latin American Laboratory for Assessment of Quality in Education found that girls achieve higher grades in languages and slightly lower grades in mathematics (Casassus et al., 2002, p. 13). The Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) compared test scores of girls and boys in reading and mathematics in member countries. Girls had higher mean scores in mathematics in five countries (**Botswana**, **Lesotho**, **Mauritius**, **Seychelles** and **South Africa**), and lower mean scores by only ten points or less in **Malawi**, **Namibia**, **Zambia, Swaziland** and **Uganda**.[8] Similarly, the OECD's Programme for International Student Assessment (PISA) studied student performance in mathematics, problem-solving, science and reading in **OECD countries** and found that, while girls outperform boys in reading in all countries, gender differences in mathematics are slight – they tend to be larger within schools than overall (OECD, 2003*a*).

Studies suggest that sex differences in performance are more linked to home and school environments than dependent on innate differences.

Girls nonetheless consistently report lower interest in and enjoyment of mathematics, lower levels of confidence in their mathematical aptitude and higher levels of anxiety relating to mathematics (Schmader, 2005; OECD, 2003*a*). And while girls are more likely to select the higher-rated, academically oriented tracks and schools, within these they often perform significantly below boys.

These and other studies suggest that sex differences in performance are less dependent on innate differences and more linked to home and school environments, as well as to social and

8. See SAQMEC website, www.sacmeq.org/indicate.htm.

cultural values regarding the usefulness of math and science in everyday life. These contextual factors can result in lower confidence, lower self-esteem, lower test scores and less interest in graduate school on the part of women science students. The PISA Plus study concluded that the wide variation in gender gaps among countries suggests that differences in achievement between males and females are not 'inevitable' or inherent, but can be influenced by effective policies and programmes that address differences in interests, learning styles and capacities (OECD, 2003*a*).

Box 2.3: Progress towards achieving the Millennium Development Goals

Despite improvements in education enrolments and increasing numbers of both girls and boys in school, gender disparities (for both sexes) remain the rule worldwide, and present trends are insufficient to meet the MDGs.

Only twenty countries are likely to achieve the goal of universal primary education by 2015, with forty-five making recognizable progress towards that goal. In twenty countries, primary school enrolments are actually decreasing.

In 2002, forty-nine countries had achieved gender parity, with forty-three countries achieving parity in primary-school enrolments but not at secondary level. Twenty-four countries with gender disparities in favour of boys and unlikely to achieve parity are characterized by underdeveloped school systems. Of the one hundred countries without gender parity in primary and secondary levels, six are likely to reach both by 2005; eight are likely to reach both by 2015, and eighty-six are at risk of not achieving parity in either primary or secondary levels, or both.

Source: UNESCO, 2006b.

Quality of education

Access and progress are crude measures of equity in education. The process of education itself and how inequalities in the treatment of boys and girls have an impact on school achievement are elements that affect the potential success of children at school and can discourage parents from sending their children to school altogether.

Access and progress are crude measures of equity in education. The process of education itself and how inequalities in the treatment of boys and girls have an impact on school achievement are elements that affect the potential success of children at school.

Studies show that teachers tend to answer boys more often than girls in math and science classes (in both the developed and the developing world) and pay more attention to girls in non-science classes, practices that send clear messages about how perceptions of capacities are culturally embedded (Margolis and Fisher, 2002). Too often, teaching materials, textbooks and lectures still depict S&T as a male domain, depriving girls of role models. These findings are supported by gender analysis[9] of similarities and differences in math and science abilities among students in the **United States** aged from five to twenty-five years. One study found that, although gender differences in math performance are practically non-existent when averaged over all samples of the general population, differences between boys' and girls' problem-solving and spatial ability emerge in the high-school years (Hyde, 2005).

Studies have found that girls are often especially interested in understanding how S&T fits into a larger social, environmental or work context – and that they can often be alienated by a narrowly focused pedagogical approach (AAUW, 2000; Bissell et al., 2003;

9. Gender analysis is the collection and analysis of gender/sex-disaggregated information, in order to explore and examine the different roles, experiences and needs of women and men. See glossary.

Margolis and Fisher, 2002; Kelly, 1985). Curricula and methods that take account of these gendered differences in approach, perspective and relation the world have been demonstrated to increase girls' interest in science subjects. Other research suggests that girls can benefit from S&T teaching curricula that emphasize hands-on activities and application to everyday life and the environment, and that such an approach in the physical sciences might improve the achievement of girls and help to close the gender gap. An experimental programme that trained first-year engineering students in spatial skills improved the retention rate of women engineering students from 47 to 77 percent (Hyde, 2005). Studies have also found that making math and science subjects compulsory for students through their high-school years increases enrolments at tertiary levels.

In assessing the quality of science curricula and teaching approaches, in relation to gender disparity, the following questions are critical (Malcom, 2003):

Box 2.4: The World Declaration on Education for All and the Dakar Framework for Action

In 1990, the World Declaration on Education for All identified the improvment of the quality of education as a 'prerequisite for achieving the fundamental goal of equity' (UNESCO, 2005, p. 29). The Dakar Framework for Action defined quality education as including healthy, motivated students, competent teachers, active pedagogies, relevant curricula, and good governance and equitable resource allocation. This definition has particular relevance to science teaching, which remains outdated in many countries in both the developed and the developing world, irrelevant to children's (and especially girls') interests, and characterized by outdated pedagogical practices and approaches.

- Is science a prominent component of basic education?
- Who teaches science and how well prepared are these teachers?
- Were teachers taught using modern methods? Are opportunities for professional development available to teachers to learn science and mathematics content and teaching methods?
- Does the curriculum incorporate themes relevant to communities and sustainable development?
- Are tests interactive and do they include hands-on models?
- Do all pupils have equal access to quality basic education in science and mathematics?

Box 2.5: International and National Declarations and Initiatives

Two international declarations that focus on providing access to basic education for all are already in place: the 1997 United Nations Resolution on Education for All and the Decade of Education for Sustainable Development (2005–15). These initiatives recognize that science needs to be included as a specific component of basic education.

National initiatives that work with communities to promote the education of girls are another important strategy. The Kenya Alliance for Advancement of Children (KCAAR) works with members of community stakeholder groups – teachers, women's organizations, parents and religious leaders, and local and national government representatives – to generate support for the education of girls (FAWE, 2001).

National education strategies

As discussed throughout this Report, the international community is committed to eliminating gender disparities in primary and secondary schooling by 2005, and to achieving gender equality by

2015. There is also a powerful developmental case for achieving gender equality: it is clearly of both private and social interest to eliminate gender inequalities in education wherever they exist. A wide range of international experience points to breakthroughs that have facilitated girls' access to schooling and improved performance (UNESCO, 2004). But sustainable advances regarding gender-related inequities, especially in S&T, require sound national education strategies and policies and reforms that can make a significant contribution to achieving equality goals. And in those strategies, the removal of gender gaps should have first priority in all programmes of school expansion and quality improvements; the state has a fundamental role in making good-quality basic education a right and a reality for every citizen.

Sustainable advances regarding gender-related inequities, especially in S&T, require sound national education strategies and policies and reforms that can make a significant contribution to achieving equality goals.

The overwhelming incidence of gender-related inequities in education, especially in S&T, still favours males over females. And where families must choose which children to support in their education, the choice is often in favour of the boys. The role of policy in advancing gender equity[10] can be seen from the example of **Uganda**, where up to four children are provided educational support, two boys and two girls. Such requirements reduce the negative effects of parental choice by removing the bias in favour of either sex.

By recognizing gender-differentiated socioeconomic outcomes, policy-makers can more readily develop national actions to achieve the education MDGs. In industrialized and transition countries, as well as in those countries where achieving gender parity is the greatest challenge, such policies rely on key

10. Gender equity: see note 6 on page 66 and glossary.

strategies to address gender-related inequalities of access, participation and learning.

Several factors for national policy and action have been identified as key to achieving progress towards meeting the education MDGs (UNESCO, 2005; Boyle et al., 2002):

- School fees have been found to have a negative effect on school enrolment levels (reduction of private costs).
- Good governance and an effective legal-institutional framework are crucial, especially regarding gender-sensitive actions that are participatory, consensus-oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive.
- Quality and relevance of education are taken into consideration.
- Suitable facilities and infrastructure are made available.
- Engagement with civil society in the provision and monitoring of education quality is proposed.
- Better management of education through decentralization is effected.

In particular, school fees and community involvement in education have strong gender dimensions. Reducing school fees has been shown to be one of the most effective ways to encourage girls enrolment in school. In the 1990s, education cost-sharing and cost-recovery strategies were seen as a way of helping governments to generate financing for education and to ensure community and parental ownership of education. A synthesis report commissioned by the Department of International Development in 2002, entitled *Reaching the Poor: The 'Costs' of Sending Children to School*[11], has

11. Reaching the poor – Synthesis report: www.dfid.gov.uk/pubs/files/reachingthepoor-edpaper47.pdf.

shown that the effect of these strategies is to keep enrolment levels low, particularly for girls. Direct and indirect school costs – uniforms, books, writing utensils, game fees, school guards, and exam costs – in addition to tuition fees can affect the ability of poor families to sustain basic livelihoods. A six-country study of **Bangladesh**, **Kenya**, **Nepal**, **Sri Lanka**, **Uganda** and **Zambia** concluded that the costs of education are the predominant reason that some children never attended school, in both poor and better-off households. Increasing a household's wealth index by one unit enhances a boy's chances of attending school by 16 percent, in contrast to 41 percent for girls (UNESCO, 2005, 2003).

Women and science – Higher education

Governments throughout the world are increasingly recognizing the importance of supporting the study of S&T at tertiary levels. This includes vocational and technical training, as well as under-graduate and graduate education of women and men whose interests, talents and capabilities lie in S&T fields.

Governments throughout the world are increasingly recog-nizing the importance of supporting the study of S&T at tertiary levels.

Divergent paths through higher education and towards research

Analysis of the breakdown by sex of students and researchers in S&T fields raises questions concerning future trends. The current stock of researchers is the result of the flow of enrolments and graduates at each tertiary level combined with variations in the labour market over the last four decades.

If we consider the careers of S&T students in terms of the participation of women across the different academic stages –

from undergraduate to doctoral student and on to career success and promotion as researchers – the gender gap widens following a scissor-shaped pattern, as shown in **Figures 2.1 and 2.2**. A 2003 analysis of data from twenty-five EU countries[12] shows that the gender gap at the highest stages of academic study is beginning to close, though very slowly. While the total number of women full professors increased by 23 percent from 1999 to 2003 (compared to a 13 percent increase in the number of men), the proportion of female professors in 2003 was still only 15 percent, compared to 13 percent four years earlier (**Figure 2.1a**). As an example from the developing world, **Figure 2.1b** shows that in **Argentina** the fact that women researchers outnumber men does not imply a lack of vertical segregation. More statistics and a wider application of such classifications are needed to produce comparable data with other countries and regions of the world.

A 'scissors diagram' is also a valid representation of how the gender gap evolves through the various levels of higher education and on to professional research (**Figure 2.2**). However, when analyzing S&E fields specifically, the gaps are so wide at every level that this pattern fades altogether.

A cautionary note should be made about the explicatory power of some of the analysis presented here: data are not yet available for many countries. There is a significant need to improve the production of higher-education and S&T statistics at the country level, particularly in Africa, and to develop sustainable

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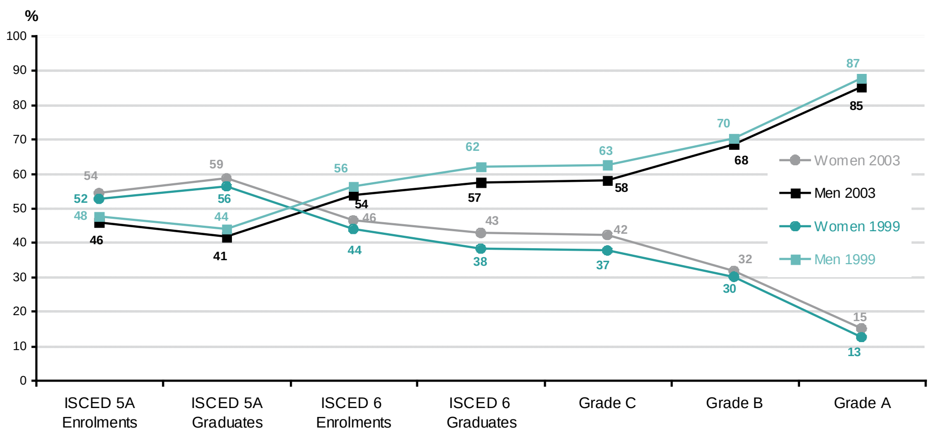
12. Austria, Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and the United Kingdom. Key facts and figures about Europe and the Europeans are available from the European Commission at http://ec.europa.eu/publications/booklets/eu_glance/51/en.pdf.

S&T statistical systems that can provide sound measures for the comparision of information on gender and other key variables across countries.

Indeed, indicators on science, technology and gender (STG) can be drawn from a variety of sources worldwide. Nevertheless, it is not easy to obtain cross-nationally comparable data, though international availability has been rising steadily in the last few years. The statistical overview and figures presented here make use of data available at international organizations (of which UNESCO is the lead agency for S&T data in the UN system), and regional organizations and groupings. STG data are more frequently available for developed countries, particularly Europe, than for the developing world. We hope that the analysis presented in this Report, while necessarily restricted by the limited data available, will help to encourage countries to produce more sex-disaggregated S&T statistics (see **Table 2.1** on page 93).

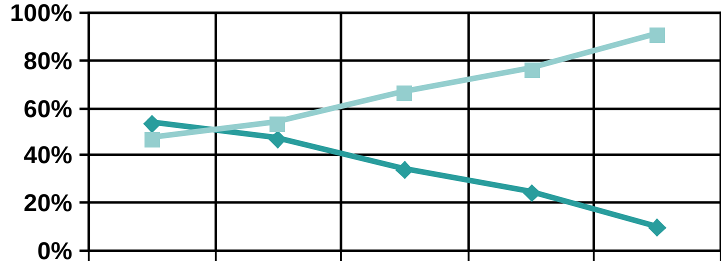
Figure 2.1: Proportions of men and women in various stages of a typical academic career

Figure 2.1a: EU-25, 1999 and 2003



Source: European Commission: Eurostat–WiS database, 2003. Countries include: Austria, Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

Figure 2.1b: Argentina, 1998



	Level 1: Asist.	Level 2: Adj.	Level 3: Ind.	Level 4: Ppal.	Level 5: Sup.
Women	54%	47%	34%	24%	10%
Men	47%	53%	66%	76%	90%

Source: CONICET, RAGCyT, 1998.

Figure 2.2: Percentage of countries with gender parity or disparities by level of education, 2003

Figure 2.2a: All fields of study

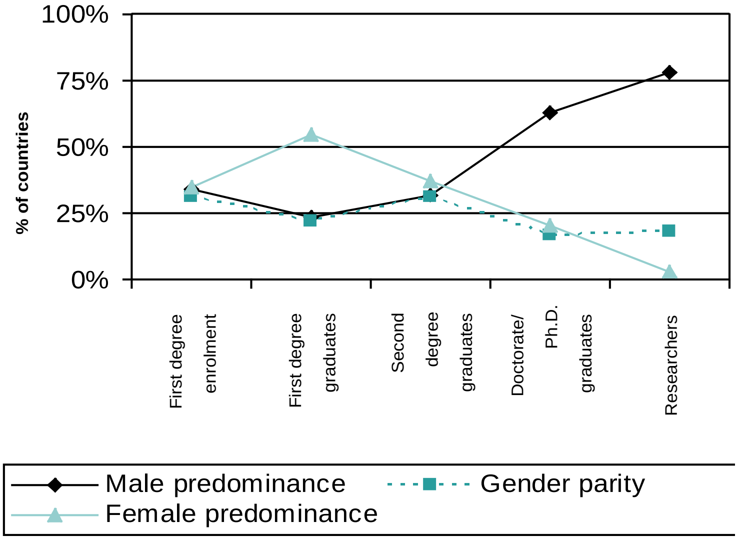
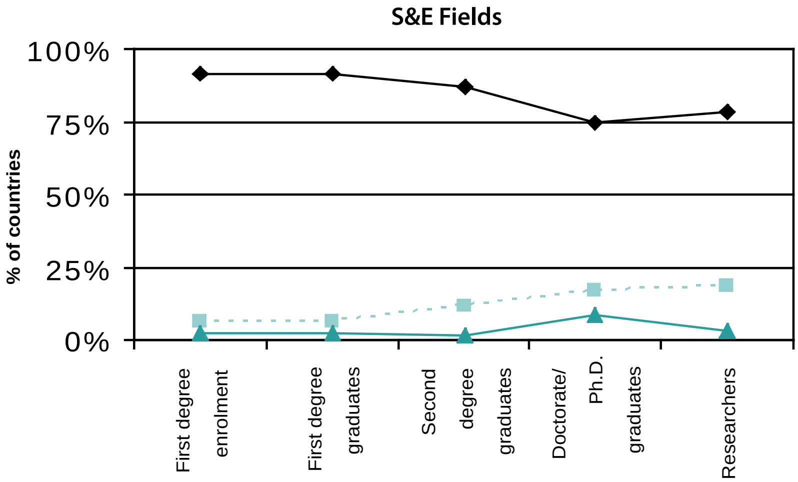


Figure 2.2b: Science, technology and engineering fields



Source: UIS, 2005.

Academic career – Graduate and postgraduate levels

Globally, enrolment of women at the tertiary level has increased steadily over the past few decades, with women now approaching 50 percent of the total number of tertiary students worldwide. The greatest gains in absolute terms have been made in developing countries.[13] However, there are wide variations at the country and region levels.

13. Argentina, Australia, Austria, Belarus, Belgium, Canada, Denmark, Estonia, France, Greece, Iceland, Ireland, Israel, Italy, Japan, Latvia, Libyan A.J., Lithuania, Macao (China), the Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Korea, the Russian Federation, Slovenia, Spain, Sweden, the United Kingdom and the United States. See the GMR Report: Table 2.18 Tertiary education: Grouping of countries according to gross enrolment ration, by region, 2000; http://portal.unesco.org/education/en/file_download.php/d5c87db2bbae2a278b5df5f91d7e03detable2.18.pdf.

Although gross enrolment rates (GERs) at the tertiary level stand at 45 percent in **OECD** and **Central and Eastern European countries**, in the great majority of developing countries, the percentage is under 30 percent. Of those countries that gather sex-disaggregated data relating to academic participation, women make up the majority of students at this level in most **European countries** and in **North America, Latin America** and the **Caribbean**, but are poorly represented in **sub-Saharan Africa** (with the exception of **South Africa**), with rates of enrolment for women varying greatly in the **Arab States**. In several countries in **Asia** and **the Pacific**, female enrolment is less than two-thirds of male enrolment. Nevertheless, gender disparities favouring girls are more frequent at tertiary than at the secondary levels, so that in general the expansion of tertiary education between 1998 and 2002 has benefited women (UNESCO, 2003, 2006).

The International Standard Classification of Education (ISCED) is a tool with which to compile internationally comparable statistics on education systems.

The International Standard Classification of Education (ISCED) is a tool with which to compile internationally comparable statistics on education systems. ISCED classifies educational programmers by field of education and by level. The system was revised and updated in 1997 (ISCED 97).

ISCED 5A programmes are tertiary programmes, largely theoretically based, intended to provide sufficient qualifications for gaining entry into advanced research programmes and professions with high skills requirements. ISCED 5A programmes must satisfy a number of the following criteria:

- a minimum cumulative theoretical duration (at tertiary level) of three full years or equivalent
- faculty with advanced research credentials
- the completion of a research project or thesis

- the level of education required for entry into a profession with high skills requirements (theoretically based/research preparatory, such as history, philosophy, mathematics, etc.) or access to professions with high skills requirements, (e.g. medicine, dentistry, architecture, etc.) or an advanced research programme. This level includes first-degree programmes such as Bachelor degrees, and second and further degrees and research programmes that are not part of a doctorate, such as Master's degrees or the equivalent.

Box 2.6: A classification of the seniority of researchers

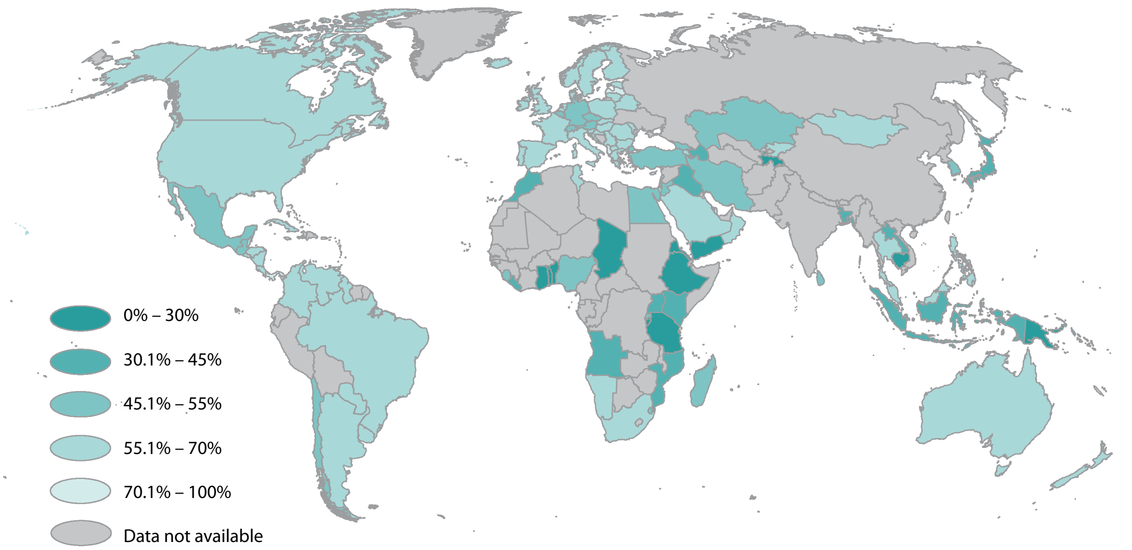
The Statistical Correspondents of the Helsinki Group on Women and Science, an expert group of the European Commission, has developed a four-tier grading system for use in measuring indicators that incorporate hierarchical positions in academic and research careers. Already in use in the European Union, this classification provides an interesting starting point for the debate. Its inclusion into the Eurostat statistics system is currently being discussed, and would provide important additional information.

A: The single highest grade/post at which research is normally conducted
B: Researchers working in intermediate positions, senior to newly qualified Ph.D. holders (C)
C: The first grade/post into which a newly qualified Ph.D. graduate would normally be recruited
D: Postgraduate students engaged as researchers (not yet holding a doctoral degree), or researchers working in posts that do not normally require a Ph.D.

Source: Helsenki Group on Women and Science, 2002.

Gender parity in enrolment at ISCED 5A first-degree level is met in only one-third of countries for which gender-disaggregated data is available (see **Table 2.1**, on page 93). The remaining countries are split almost evenly between female and male prevalence in enrolment at this level (**Figure 2.3**).[14]

Figure 2.3: Percentage of female enrolment, ISCED 5A (1st degree) all fields of education, 2004



Source: UIS, March 2007.

Gender parity of *graduates* at the ISCED 5A first-degree level, however, has been reached or exceeded (from the point of view of female participation) in 76 percent of the countries presenting such data (**Figure 2.4**). In addition, in more than 56 percent of these countries, women represent over 55 percent of total graduates at the first-degree level. Only in certain parts of **Africa** and

14. This section is based on data from the UNESCO Institute for Statistics for 2005 or the last available year.

Asia do men constitute a clear majority of graduates at this level. Comparing these data on graduates with the more balanced enrolment figures suggests that female students have a higher success rate at this level, and, generally speaking, drop out less often than their male colleagues.

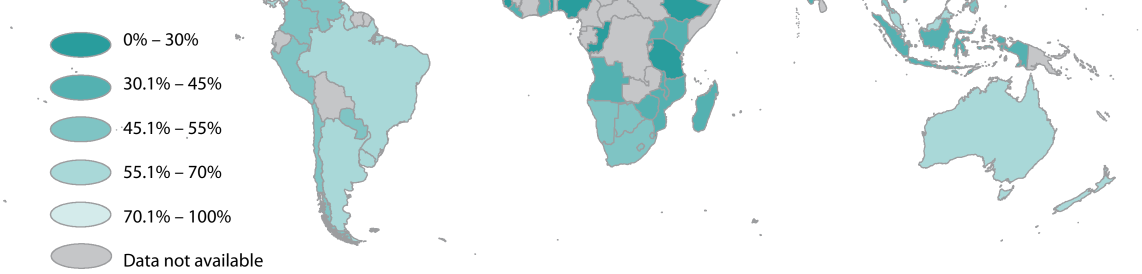
When limiting the analysis to S&E fields, however, the situation differs significantly (**Figure 2.5**) in relation to the pattern presented by the total set of graduates. Female graduation rates in S&E areas retain the same patterns for enrolment in the same fields. In 85 percent of these countries, gender parity has not been achieved, with women representing less than 45 percent of university graduates in S&E fields. The female graduation rate is significantly higher than the male graduation rate in S&E fields in only 4 percent of countries presenting data.

Moving up through the university system, a quarter of these countries record overall gender parity at second-degree level (ISCED 5A: i.e. Masters). The rest are divided between female and male prevalence, with slightly more countries recording a higher percentage of female than male graduates at the Masters level (**Figure 2.6**). Data on ISCED 5A second-degree level must be analyzed carefully, taking into account that Masters programmes are not available in all countries, or may have been established only recently or only in certain parts of the country. The pattern presented for graduates at this first postgraduate level, however, is similar to that of first-degree enrolments, with the percentage of women graduating at this level dropping in relation to the percentage of women first-degree graduates.

ISCED 5A second-degree graduates in S&E fields present patterns that are similar to first-degree graduates in these fields, which indicates a more homogeneous continuity between the two graduate degrees (**Figure 2.7**).

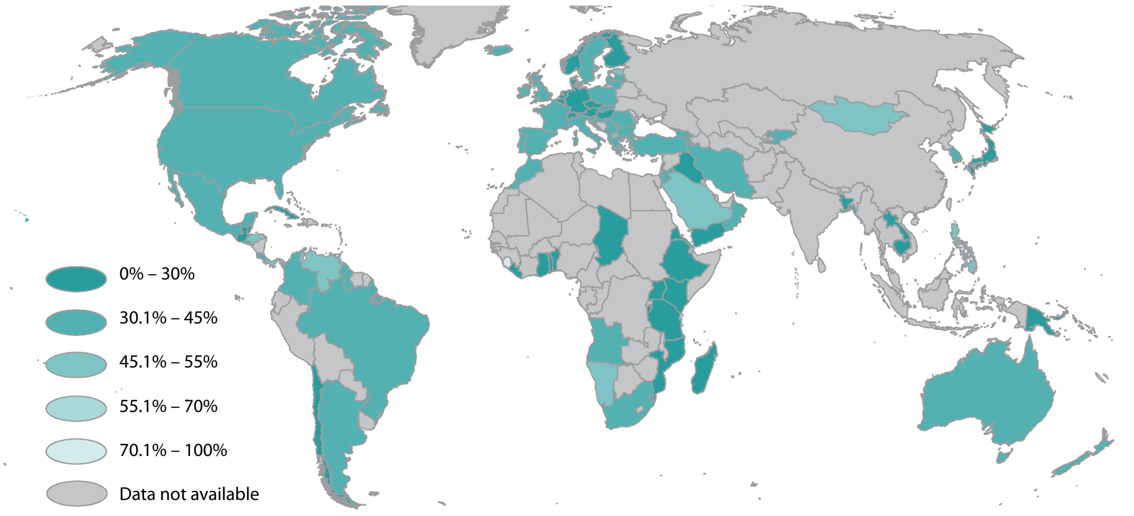
At the ISCED 6 graduate level (programmes leading to the award of an advanced research qualification, devoted to advanced study and original research not solely based on course-work, typically requiring the submission of a thesis or dissertation of publishable quality that represents a significant contribution to knowledge), male prominence is evident. Only 14 percent of the countries produce significantly more female than male doctorates (**Figure 2.8**). This share goes down to 3 percent when looking at S&E fields (**Figure 2.9**). Only 25 percent of countries have reached gender parity at this level, with only 15 percent for S&E disciplines. ISCED 6 level programmes usually prepare graduates for faculty posts in institutions offering ISCED 5A programmes, as well as research posts in government, industry, etc.

Figure 2.4: Percentage of female graduates, ISCED 5A (1st degree), all fields of education, 2004



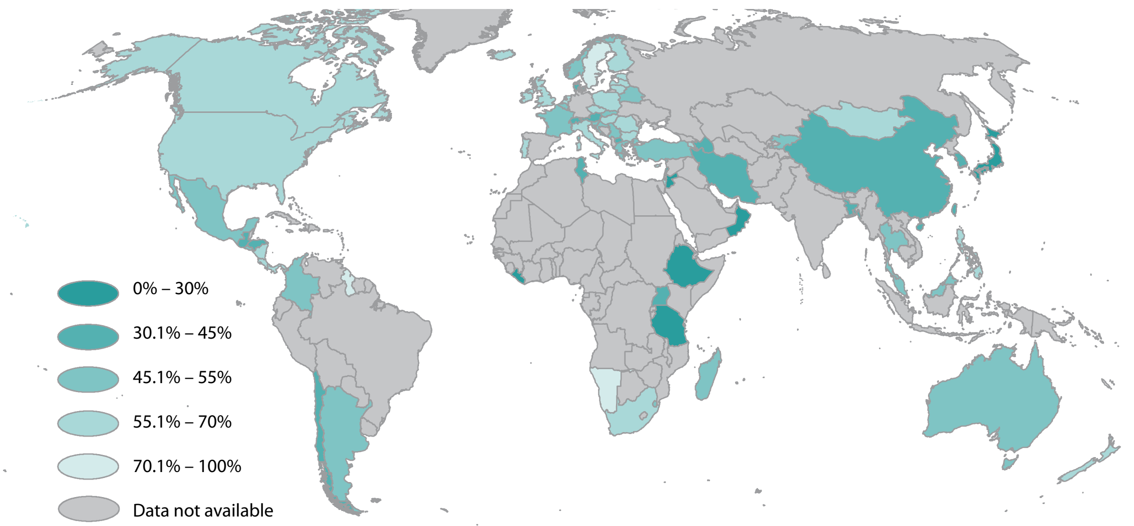
Source: UIS, Education Statistics, March 2007.

Figure 2.5: Percentage of female graduates, ISCED 5A (1st degree), science and engineering fields, 2004



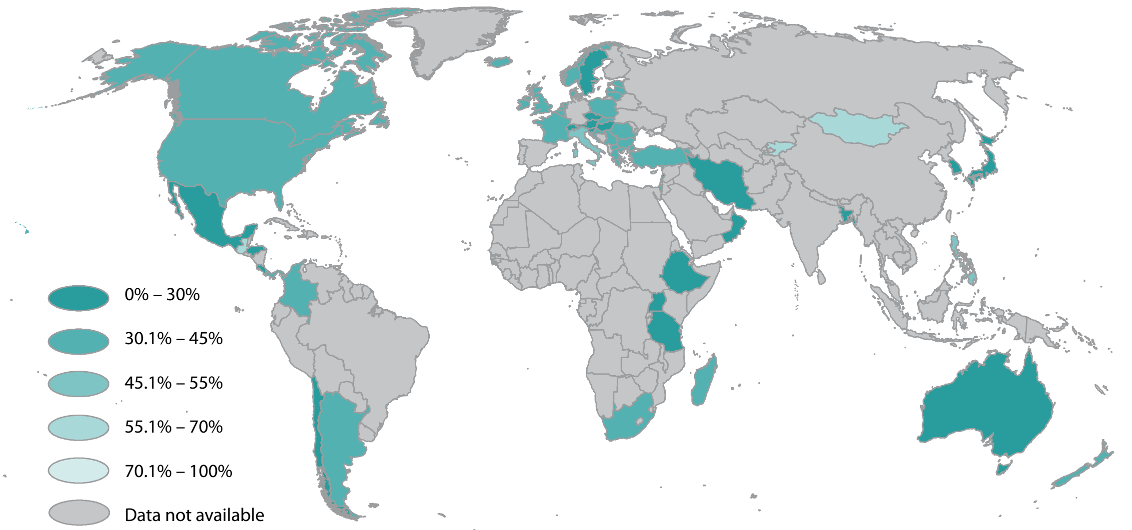
Source: UIS, Education Statistics Database, March 2007.

Figure 2.6: Percentage of female graduates, ISCED 5A (2nd degree), all fields, 2004



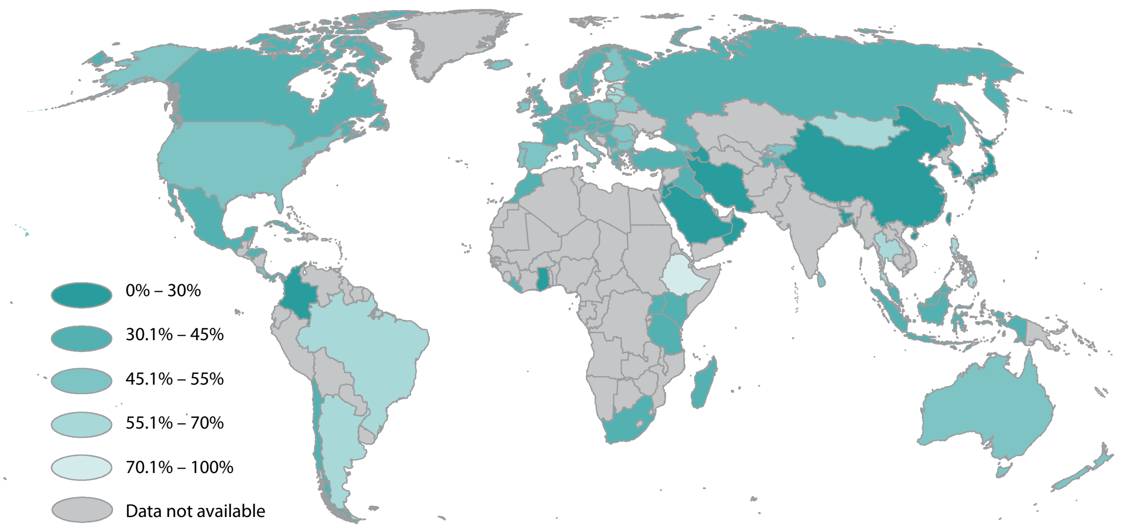
Source: UIS, Education Statistics Database, March 2007.

Figure 2.7: Percentage of female graduates, ISCED 5A (2nd degree), S&E fields, 2004



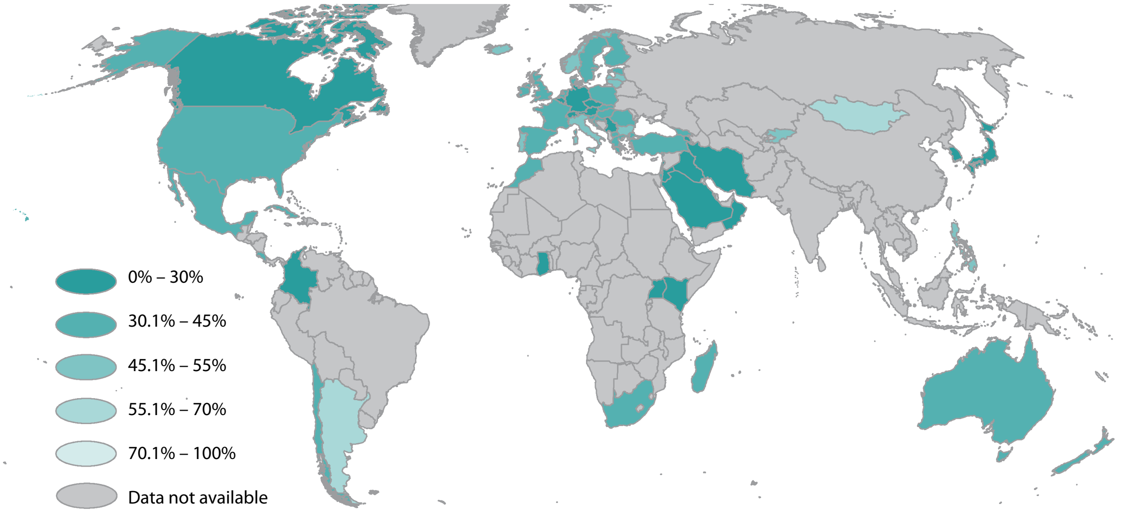
Source: UIS, Education Statistics Database, March 2007.

Figure 2.8: Percentage of female graduates, ISCED 6, all fields, 2004



Source: UIS, Education Statistics, March 2007.

Figure 2.9: Percentage of female graduates, ISCED 6, S&E fields, 2004



Source: UIS, Education Statistics Database, March 2007.

A concentration of women in specific S&T fields?

Experience shows that getting enough women 'into' science, or attaining critical mass (said to be about 30 percent), does not assure that parity will naturally follow. Although this has been the pattern in biology and chemistry in much of the world, other fields of science, for example, computer science and information technology, have seen decreases in female enrolment since the 1980s. The structural gender and social inequalities in systems of education, recruitment, retention and decision-making need to be assessed and understood for real change to occur.

In many regions, women's participation in bio and life sciences has increased and continues to increase, so that we see, for example, the 'feminization' of the biosciences in Europe, where women make up over 50 percent. In the **United States**, primatology is dominated by women,

The structural gender and social inequalities in systems of education, recruitment, retention and decision-making need to be assessed and understood in order for real change to occur.

who receive over 80 percent of Ph.D.s awarded in the discipline (Schiebinger, 1999). At the same time, women's level of representation in 'harder' sciences such as physics and engineering is persistently low around the world. While women earn more than half the undergraduate degrees awarded in the biosciences in the **United States**, they earn only 21 percent of undergraduate degrees in physics. Although women's participation in engineering and the 'hard' sciences is increasing gradually (Gotzfried, 2004), these numbers are echoed elsewhere: in **OECD countries**, women make up just 30 percent of university graduates in math and computer sciences overall, with women graduates in these subjects accounting for only 9 to 25 percent in nine OECD countries (She Figures, 2006).[15]

Dependable sex-disaggregated data is not available for all countries. However, a review of women's enrolment at universities in the **Arab region** found that percentages of women students in science courses varied from 82 percent in the **United Arab Emirates** to 8 percent in **Djibouti**, with **Saudi Arabia**, **Yemen** and **Syria** at around 44 percent. Enrolments of women in engineering in these countries is somewhat lower, ranging from 65 percent in the **United Arab Emirates** to 45 percent in **Egypt** and in the range of 30–35 percent in **Yemen**, **Syria** and **Saudi Arabia**.[16]

According to the American Institute of Physics, women in **Turkey** earn 39 percent of the bachelor's degrees awarded in physics, while in **Poland**, **Greece** and **South Korea**, they earn, 36, 34

15. Austria, Belgium, Germany, Hungary, Iceland, the Netherlands, Norway, the Slovak Republic and Switzerland. www.transworldeducation.com/articles/oecd_education_levels.htm.

16. However, these numbers do not translate into the Arab science workforce, where career opportunities for female science graduates in universities, research institutes and scientific organizations are considerably more limited than those for men, particularly in senior positions (Hassan, 2000).

and 30 percent respectively. This percentage drops to 20 percent in **Taiwan** and to 18 percent in **Mexico**. Numbers for Ph.D.s are somewhat lower: in **Turkey**, women earn 28 percent of Ph.D.s in physics, and just 10 percent do so in **South Korea** and **Taiwan**.[17]

In **South Africa**, women are over-represented in the health and social sciences, and under-represented in the natural sciences and engineering. The majority of female doctoral enrolments (47 percent) were in the health sciences, predominantly nursing and occupational therapy. Two-thirds (69 percent) of both enrolments and graduations in natural sciences and engineering were men (Department of Science and Technology, South Africa, 2004).

We can compare the number of women graduating in selected fields of education at first-degree level by calculating **Field Relative Parity Indices** (FRPIs; see **Box 2.7**). These indices reflect the relationship between the proportion of female graduates in a specific field and the average proportion of female graduates at

Box 2.7: Field Relative Parity Indices

Field Relative Parity Index (FRPI) for field X = *Share (percent) of female graduates in field X*

Share (percent) of female graduates in all fields

FRPI > 1 field X has a higher proportion of female graduates than the total for all fields (field is feminized)

FRPI < 1 field X has a lower proportion of female graduates than the total for all fields (field is masculinized)

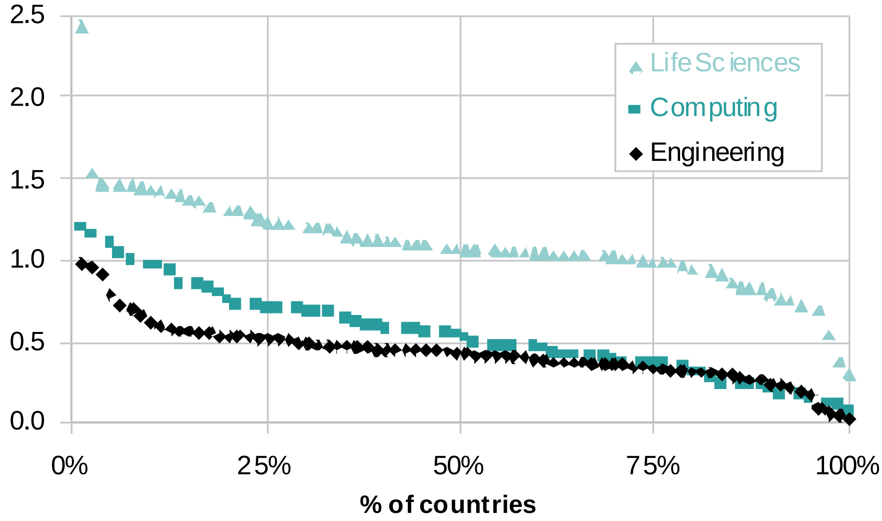
FRPI ~= 1 field X has a similar proportion of female graduates to the total for all fields (field is neutral).

Source: UIS bulletin, Issue No. 3, Nov. 2006.

17. American Institute of Physics, Statistical Research Center, www.aip.org.

first-degree level in that country. FRPIs show the extent to which female participation in the specific field is above or below average in that country.

Figure 2.10: Field Relative Parity Indices – ISCED 5A, (1st degree) graduates in engineering, computing and the life sciences, 2003



Source: UIS, Education Statistics Database, 2004.

Figure 2.10 compares FRPIs for all available countries for first-degree graduates in engineering, computing and the life sciences. The FRPIs for engineering bring no surprises: graduates of engineering schools are overwhelmingly men. All countries with available data present FRPIs of less than 1 for female engineering graduates, with an average as low as 0.44. The proportion of women graduating with engineering degrees is on average less than half the overall proportion of women graduates in all fields at first-degree level.

In the case of computer science graduates, it is fair to say that universities are still 'manning' the information society. FRPIs for female computer science graduates are above or equal to 1 in only 8 percent of the countries that presented data, and in 18 percent of these countries they are lower than 0.25. The average FRPI of 0.55 is slightly higher than that of female engineering graduates, but still indicates a high predominance of men in this field.

The life sciences, however, present a different picture. FRPIs for female first-degree graduates in these fields are equal to or greater than 1 in 73 percent of cases, with an average of 1.1. Women clearly predominate among graduates in this area, which includes medicine and other life sciences.

Lifelong learning enables individuals and communities to keep up with socioeconomic, political, scientific and technological change.

Technology and non-formal education

Non-formal education is an important educational strategy in much of the world. It is a general term used to designate education that takes place outside the classroom. It encompasses lifelong learning, adult education, e-learning, open and distance learning, skills training, and much technical and vocational training. Basic education includes formal and non-formal education, often incorporating programmes in areas such as basic health, nutrition, family planning, literacy, agriculture and other life and vocational skills.

Non-formal and lifelong learning are especially important for women and girls, considering their lower levels of literacy and education. Lifelong learning enables individuals and communities to keep up with socioeconomic, political, scientific and technological change. It can be provided by government or local institutions, or by NGOs or the private sector. Activities can be organized in

ICTs and distance learning can promote education for women and girls at all levels. The flexibility of access and study times and the potential to reach women in rural areas can make this a very positive educational approach for women and girls, for whom cultural and social expectations and situations can hinder opportunities to travel or to attend school.

diverse ways, drawing on a range of media, including the Internet, radio, television, video and newspapers.

Technical and vocational education and training is of particular relevance to S&T education. Technical education refers to formal training in a technological area, while vocational training is less academic and prepares learners for careers centered on manual or practical activities. Very often, women and girls cannot access the technical and skills training required to move into the technical workforce. Women remain concentrated in low or unskilled jobs, missing out on the more highly skilled jobs offered by the information society. For example, 42 percent of women in **sub-Saharan Africa** participate in the labour force, but few have access to skills development – illiteracy rates for women in many countries in the region exceed 30 percent, and women make up only 15–35 percent of students attending formal training programmes (Johanson, 2002).

ICTs and distance learning can promote education for women and girls at all levels, in both formal and non-formal learning settings. The flexibility of access and study times and the potential to reach women in rural areas can make this a very positive educational approach for women and girls, for whom cultural and social expectations and situations can hinder opportunities to travel to attend school: for reasons of time, the cost of transportation, safety considerations or perceptions of the appropriateness of travelling on their own (Kramarae, 2001; Maroba, 2003; Huyer, 2006). In addition, ICTs and distance learning can also facilitate access to technical and vocational training support in building and managing IT-based and small and medium-scale enterprises (SMEs).

Table 2.1 Women in S&T education and research

Country or territory	Share of women in total enrolment: ISCED 5A 1st degree (Total)		Share of women in total enrolment: ISCED 5A 1st degree (S&E)		Share of women in total number of graduates: ISCED 5A 1st degree (Total)		ISCED 5A 1st degree (S&E)		ISCED 5A 2nd degree (Total)		ISCED 5A 2nd degree (S&E)		ISCED 6 (Total)		ISCED 6 (S&E)		Share of women in total number of researchers	
Albania	...		...		72%	3	44%	3	...		...		...		...		...	
Algeria	…		…		…		…		…		…		…		…		35%	5
Andorra	60%		36%		33%		...		...		...		...		...		...	
Angola	40%	2	30%	9	41%	2	41%	2	...		...		...		...		...	
Argentina	56%	3	...		59%	3	41%	3	46%	3	39%	3	59%	3	61%	3	51%	
Armenia	...		...		57%	2	30%	2	57%	2	36%	2	32%		24%		46%	5
Aruba	79%		...		81%		...		67%		...		...		...		...	
Australia	57%		...		59%	3	34%	3	51%	3	27%	3	46%	3	36%	3	...	
Austria	52%		...		51%		26%		36%		14%		40%		27%		24%	
Azerbaijan	47%		...		41%		...		43%		...		28%		...		52%	5
Bahrain	65%	3	55%	3	75%	3	62%	3	58%	3	50%	3	...		...		...	
Bangladesh	34%	3	22%	3	34%	3	24%	3	32%	3	23%	3	27%	3	...		14%	U,7
Barbados	67%	1	...		68%	1	...		61%	1	...		…		...		...	
Belarus	...		...		59%		...		49%		...		45%		...		43%	5
Belgium	51%		...		51%	2	27%	2	54%	2	38%		34%		28%		28%	3
Belize	70%		...		65%		22%		...		...		...		...		...	
Benin	...		...		17%	9, t	8%	9, t	...		...		...		...		...	
Bolivia	...		...		...		...		...		...		...		...		40%	1
Botswana	45%		24%	2	...		...		...		...		...		...		31%	5
Brazil	57%	3	...		63%	2	37%	2	...		...		56%	3	...		47%	
Brunei Darussalam	68%		59%		66%		52%		...		...		...		...		27%	3
Bulgaria	52%		...		57%		41%		59%		45%		51%		48%		46%	
Burkina Faso	...		...		...		...		...		...		...		...		19%	F,7
Burundi	...		...		26%		14%		...		...		…		...		...	
Cambodia	31%		13%		29%		12%		...		...		…		...		21%	2
Canada	59%	2	...		61%	2	38%	2	55%	2	35%	2	43%	2	25%	2	...	
Cape Verde	53%		...		...		...		...		...		...		...		52%	2
Chad	...		...		10%	0	4%	0	...		...		...		...		...	
Chile	50%		...		53%		27%		42%	3	25%	3	34%		32%		30%	
China	...		...		...		...		34%	0	...		20%	0	...		...	
Colombia	53%		36%	2	57%	2	39%	2	53%		37%	2	30%		24%	2	37%	
Comoros	39%	3	25%	3	38%	9	36%	9	...		...		...		...		...	
Congo	13%	1	14%	1	...		...		...		...		...		...		13%	F,0
Costa Rica	...		...		62%		31%		62%		27%		50%		32%	0	41%	
Croatia	55%	2	35%	2	59%	2	40%	2	50%	3	42%	2	48%	3	44%	3	41%	
Cuba	64%		34%	3	64%		29%		…		...		40%		40%		...	
Cyprus	78%		...		80%		63%		62%		57%	9	62%		...		32%	
Czech Republic	50%		...		54%		29%		65%		27%		36%		28%		29%	5
Denmark	64%	2	...		67%	3	28%	3	42%		33%		48%		43%		28%	3
Djibouti	42%		22%		…		...		...		...		...		...		...	
Ecuador	...		...		...		...		...		...		...		...		29%	3
Egypt	46%		...		49%	3	...		...		...		...		...		...	
El Salvador	54%	3	32%	3	57%	3	35%	3	49%	3	...		...		...		31%	
Eritrea	12%		9%		14%		8%		...		...		...		...		...	

Country or territory	Share of women in total enrolment				Share of women in total number of graduates														Share of women in total number of researchers	
	ISCED 5A 1st degree (Total)		ISCED 5A 1st degree (S&E)		ISCED 5A 1st degree (Total)		ISCED 5A 1st degree (S&E)		ISCED 5A 2nd degree (Total)		ISCED 5A 2nd degree (S&E)		ISCED 6 (Total)		ISCED 6 (S&E)			
Estonia	...		...		70%		46%		69%		40%		62%		42%		42%	
Ethiopia	25%		17%		30%		15%		7%		5%		100%		...		6%	U,5
Fiji	52%		...		...		...		...		...		...		...		...	
Finland	...		...		63%	2	28%	2	59%	3	...		49%	3	33%	2	29%	
France	55%		...		58%	3	35%	3	53%		37%	3	42%		36%	3	28%	
Gabon	...		...		...		...		...		...		...		...		31%	
Gambia	19%		14%		14%		9%		...		...		...		...		...	
Georgia	...		...		53%	t	38%	t	...		...		53%		41%		53%	5
Germany	47%		...		50%		29%		...		...		38%	3	25%	3	19%	3
Ghana	33%		24%		27%	1	20%	1	...		...		8%	1	7%	1	...	
Greece	53%		...		64%		44%		52%		42%		38%		31%		37%	3
Greenland (Denmark)	…		…		…		…		…		…		…		…		27%	
Guatemala	42%	2	21%	2	46%	2	29%	2	41%	2	63%	2	...		...		...	
Guinea	...		...		...		...		...		...		...		...		6%	0
Guyana	61%		39%		58%		30%		74%		...		...		...		...	
Holy See	28%	9	...		31%	9	...		42%	9	...		11%	9	...		...	
Honduras	58%	3	35%	3	60%	3	49%	3	32%	3	13%	3	33%	3	...		27%	3
Hong Kong (China), SAR	53%		28%		54%		31%		50%		24%		41%		32%		...	
Hungary	57%		...		60%	0	23%	0	65%		28%		43%		33%		34%	5
Iceland	66%		...		68%		38%		57%		44%		50%		50%		39%	3
India	38%		35%		...		...		...		...		...		...		12%	F,9
Indonesia	42%	3	...		44%		...		...		...		38%		...		...	
Iran, Islamic Republic of	56%		42%		50%		34%		33%		22%		24%		12%		20%	
Iraq	39%		37%		39%		28%		...		...		32%		27%		...	
Ireland	57%	2	...		59%		35%		62%		35%		46%		40%		30%	
Israel	57%		...		60%		32%		59%		41%		50%		41%		...	
Italy	56%		...		56%	2	34%	2	59%		52%	2	51%		46%	2	30%	
Japan	41%		...		42%		14%		28%		13%		25%		14%		12%	
Jordan	50%		...		48%		40%		30%	3	...		29%		11%		21%	3
Kazakhstan	...		...		55%	3	...		...		...		...		...		50%	5
Kenya	39%		19%	1	35%	0	20%	0	...		...		32%	0	16%	0	...	
Kuwait	...		...		...		...		...		...		...		...		21%	5
Kyrgyzstan	...		...		55%		45%		47%		58%		55%		54%		45%	5
Lao P.D.R.	40%		18%		40%		22%		...		...		...		...		...	
Latvia	64%		...		71%		34%		68%		36%		58%		46%		52%	5
Lebanon	54%		35%		58%		44%		35%		26%		37%		25%		...	
Lesotho	54%	3	30%	3	...		...		...		...		...		...		76%	U,2
Liberia	35%	0	13%	0	42%	0	21%	0	28%	0	...		40%	0	...		...	
Liechtenstein	27%		...		25%	3	36%	3	19%		50%		11%		...		...	
Lithuania	59%		...		64%		36%		62%		41%		57%		48%		49%	5
Luxembourg	54%	3	...		...		...		...		...		...		...		17%	3
Macao, China	33%	2	...		56%	0	...		28%	0	...		...		...		22%	5
Madagascar	44%	2	27%	2	48%	2	29%	2	47%	2	36%	2	43%	2	42%	2	31%	5

Country or territory	Share of women in total enrolment				Share of women in total number of graduates												Share of women in total number of researchers	
	ISCED 5A 1st degree (Total)		ISCED 5A 1st degree (S&E)		ISCED 5A 1st degree (Total)		ISCED 5A 1st degree (S&E)		ISCED 5A 2nd degree (Total)		ISCED 5A 2nd degree (S&E)		ISCED 6 (Total)		ISCED 6 (S&E)			
Malawi	35%		17%	9	...		...		...		...		...		...		...	
Malaysia	59%	3	...		62%	3	...		52%	3	...		36%	3	...		36%	
Malta	56%		...		58%		29%		56%		52%		38%	3	50%	0	26%	5
Mauritania	22%	3	14%	3	...		...		...		...		...		...		...	
Mauritius	48%		39%		50%		40%		32%	3	...		9%	3	33%	3	20%	7
Mexico	51%		...		53%	3	35%	3	48%		30%	3	38%		31%	3	32%	3
Mongolia	62%		45%		65%		51%		68%		62%		58%		65%		47%	5
Morocco	46%		35%		44%		32%		...		...		33%		35%		26%	5
Mozambique	31%		15%		35%		23%		...		...		...		...		...	
Myanmar	...		...		...		...		...		...		...		...		85%	U,2
Namibia	54%	3	39%	3	56%	3	52%	3	74%	3	...		...		...		...	
Nepal	...		...		...		...		...		...		...		...		15%	2
Netherlands	51%		...		56%		17%		59%		31%		39%		31%		17%	3
Netherlands Antilles	44%	2	11%	1	54%	0	10%	0	...		...		...		...		...	
New Zealand	59%		...		62%		39%		60%		40%		49%		41%		39%	1
Nicaragua	52%	2	41%	2	60%	2	...		62%	2	...		...		...		42%	2
Nigeria	29%		29%		49%	9	...		...		...		...		...		17%	5
Norway	61%		...		63%		23%		49%		33%		40%		50%		29%	3
Oman	57%		33%		63%		39%		17%		8%		13%		0%		...	
Pakistan	38%		...		...		...		...		...		...		...		23%	5
Palestinian A.T.	50%		43%		54%		48%		41%		38%		...		...		...	
Panama	63%		36%		72%		46%		65%		43%		43%		...		41%	
Papua New Guinea	...		...		27%	8	19%	8	...		...		...		...		...	
Paraguay	55%	3	...		60%	1	...		...		...		...		...		51%	
Peru	45%		...		...		...		...		...		...		...		...	
Philippines	55%		...		61%	3	48%	3	62%		51%	3	61%		47%	3	53%	3
Poland	55%		...		63%		32%		69%		38%		47%		38%		39%	
Portugal	...		...		69%		44%	t	65%		...		55%		46%		44%	3
Qatar	73%	3	58%	3	76%		67%		...		...		...		...		...	
Republic of Korea	37%		...		48%		31%		36%		24%		24%		17%		13%	5
Republic of Moldova	...		...		57%	t	...		...		...		58%		...		30%	2
Romania	55%		...		57%		40%		56%		41%		49%		32%		43%	
Russian Federation	...		...		...		...		...		...		42%	3	...		42%	5
Rwanda	37%	3	...		47%		...		...		...		...		...		...	
Saint Helena (U.K)	...		...		...		...		...		...		...		...		25%	F,9
Saint Lucia	79%		...		69%		...		...		...		...		...		33%	U,9
Samoa	40%	0	...		42%	0	0%	0	40%	9	...		...		...		...	
San Marino	59%	0	0%	0	...		...		...		...		...		...		...	
Saudi Arabia	66%		58%		61%		50%		...		...		29%		19%		17%	2
Serbia and Montenegro*	56%	1	36%	1	59%	1	42%	1	50%	1	42%	1	37%	0	26%	0	44%	
Sierra Leone	16%	1	20%	1	55%	0	70%	0	...		...		...		...		...	
Singapore	...		...		...		...		...		...		...		...		26%	5
Slovakia	52%	2	...		56%		34%		53%		40%		45%		39%		41%	5
Slovenia	61%		...		64%		34%		54%		25%		41%		34%		33%	

Country or territory	Share of women in total enrolment				Share of women in total number of graduates														Share of women in total number of researchers	
	ISCED 5A 1st degree (Total)		ISCED 5A 1st degree (S&E)		ISCED 5A 1st degree (Total)		ISCED 5A 1st degree (S&E)		ISCED 5A 2nd degree (Total)		ISCED 5A 2nd degree (S&E)		ISCED 6 (Total)		ISCED 6 (S&E)			
South Africa	52%	3	36%	3	56%	3	36%	3	55%	3	37%	3	38%	3	35%	3	38%	
Spain	54%		...		60%		36%		...		...		47%		44%		36%	
Sri Lanka	...		...		50%	8	...		...		...		46%	8	...		35%	
Sudan	...		...		...		...		...		...		...		...		30%	
Swaziland	53%		25%		54%		43%		50%		...		...		...		...	
Sweden	61%	3	...		63%		35%		83%		27%		43%		32%		35%	3
Switzerland	47%		...		47%		20%		34%		24%		37%		29%		27%	
Tajikistan	...		...		21%	t	...		...		...		38%		...		26%	
Thailand	54%		...		60%		...		53%		...		55%		...		46%	3
The F.Y. R. of Macedonia	58%		41%		65%		47%		40%		42%		48%		38%		50%	
Togo	17%	0	7%	0	15%	0	6%	0	...		...		...		...		...	
Trinidad and Tobago	60%		38%		62%		42%		64%	3	44%	1	60%		44%		39%	
Tunisia	...		...		57%		...		39%	2	...		...		...		45%	5
Turkey	43%		...		46%		34%		47%		40%		38%		36%		36%	
U.S. Virgin Islands	...		...		...		...		...		...		...		...		17%	2
Uganda	41%		27%		43%		28%		32%	1	21%	1	34%		19%		38%	5
Ukraine	...		...		...		...		...		...		...		...		44%	5
United Kingdom	55%		...		56%		32%		55%		32%		43%		33%		...	
United Rep. of Tanzania	30%		17%		27%	1	10%	1	28%	1	17%	9	38%	9	...		...	
United States	56%		...		57%		35%		58%		31%		48%		30%		...	
Uruguay	60%	2	...		60%	3	...		...		...		...		...		47%	2
Venezuela	47%	2	40%	2	61%	2	45%	2	...		...		...		...		46%	
Viet Nam	52%	3	...		...		...		...		...		...		...		43%	2
Yemen	...		...		25%	9	13%	9	...		...		...		...		...	
Zambia	...		...		...		...		...		...		...		...		27%	U,5
Zimbabwe	33%	3	...		...		...		...		...		...		...		...	

Source: UIS, Education Database and Science and Technology Database, February 2007.

Notes*:*

S&E: Science and Engineering ISCED 97 fields of education: Sciences includes the life sciences, physical sciences, computing, and mathematics and statistics; engineering includes engineering and engineering trades, manufacturing and processing, architecture and building.

The reference year is 2004 unless otherwise specified as follows: 5=2005, 3=2003, 2=2002, 1=2001, 0=2000, 9=1999, 8=1998, 7=1997

. . . : Data not available

t: including second degree

F: Fulltime equivalent (FTE) instead of headcounts

U: UIS estimation

**: Serbia and Montenegro data were gathered through UIS surveys conducted during or before 2006, at which time Serbia and Montenegro was a single Member State of UNESCO.*

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Chapter 3
Employment and Careers in S&T

3

While many women enjoy successful and rewarding careers in various areas of science and technology (S&T), much more progress needs to be made. Girls are less likely to obtain the education required to take up an S&T career, and less likely to receive appropriate career information to guide them into S&T. Women in the field are often paid less than equally qualified men, are less likely to be promoted, and are consistently clustered at the lower ranking levels of the science system. In the **United Kingdom**, the main activity for men with scientific qualifications is management; for women it is teaching and non-professional activities not requiring a university degree (such as technicians). These findings are supported by studies in the **United States** and some developing countries (Rathgeber, 2002).

There is no one single obstacle that leads to women in S&T being few in number and overwhelmingly concentrated at the lower levels; there is no one solution.

Pr. Ligia Gargallo – Laureate of the L'ORÉAL/UNESCO Awards for Women in Science 2007
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Options, access and trajectories

Opportunities for girls and women to participate in science and engineering employment vary considerably from country to country, and between different subgroups within countries. Girls and women in many countries face greater restrictions than boys and men in how their lives are organized. In addition to their often extensive household responsibilities (which can begin at a very young age), there may be cultural and even legal restrictions on their options for employment. Within the same local culture there are often class differences about what is considered appropriate and practical for women to do.

In addition to their employment and income-generation activities, women generally bear most of the responsibility for childcare, elder care and household work. These responsibilities affect the time that women have available for employment, as well as their geographic and career mobility. Women are also more likely than men to be employed part-time.

The roles of a woman as the 'binding force within a family' and as a 'direct contributor to society' are not just symbiotic, but necessary if our communities and countries are to grow and prosper.
(International Organization of Pakistani Women Engineers, 2004)

Some women choose not to work outside the home, but for most this is not a freely chosen option. A woman's ability to take part in formal employment is hugely affected by her family responsibilities. Of science and engineering doctorate holders surveyed in the **United States** in 2004, 35.3 percent of women doctorates who were unemployed or out of the labour force cited family responsibilities as the reason, compared with 2.4 percent of men.[1]

Women's employment options are often restricted by rules and laws, many of which were constructed to protect them. Employer or worker association regulations or other legislation can keep women out of S&T jobs– particularly in engineering – by setting inappropriate physical requirements for jobs that do not actually require heavy lifting. Restrictions on working at night can keep women out of well-paid shift work. The International Labour Organization (ILO), which is devoted to advancing opportunities for

1. Figures from SESTAT database (see **Box 5.4**, page 144), National Science Foundation, 2004: www.nsf.gov/statistics/wmpd/2004/pdf/tabh-12.pdf.

women and men to obtain decent and productive work in conditions of freedom, equity, security and human dignity',[2] shifted its stance on night-shift work for women in the 1990 Convention on Night Work (No. 171). It called upon its Member States to adopt gender-sensitive night work regulations and to eliminate all restrictions prohibiting women from night shift work; nevertheless, such restrictions still remain in force in some countries.

Some employers simply refuse to employ women in professional S&T roles. Women can also be made to feel very unwelcome in certain working environments. This may be deliberate, or it may be an unintended effect of a 'macho' culture within the organization. Sexual harassment affects the working life of many women, even though it is hard to quantify. To benefit from more women in the S&T workforce, it is essential to address any aspect of company culture that allows such abuse.

Career development

The fact that more women are working to obtain S&T degrees overall (Handelsman et al., 2004) does not necessarily correlate with an increase in women participating in the S&T labour market (see Wallon, 2002; Unit of Gender Studies, University of Tartu, Estonia, 2005). In the **United Kingdom**, only one quarter of women graduates with degrees in S&T are working in the key jobs of science, engineering or technology, although others are working in related jobs, such as sales and marketing in the sector.[3] This trend is reflected in the **United States** and in **Australia**.

2. For further information, see the International Labour Organization: www.ilo.org/global/About_the_ILO/lang--en/index.htm.

3. UK Labour Force Survey, www.statistics.gov.uk.

Much talent is being wasted as girls turn away from S&T careers, and as women in S&T become discouraged by discriminatory treatment.

Many factors affect the development of a career in S&T. Women's and men's paths tend to diverge as women are promoted more slowly and as they abandon S&T work for other fields. This is true even for women who have no children and few household responsibilities. Suitably qualified girls may not receive appropriate information on S&T courses and careers and may be steered into other fields. Many girls and their advisers are influenced by stereotypes that tell them that certain jobs are for men only. Managers may believe that only a man is appropriate for certain jobs. Much talent is being wasted as girls turn away from S&T careers, and as women in S&T become discouraged by discriminatory treatment (see, for example, Equal Opportunities Commission, 2004).

In the workplace, a woman's place in a team may be determined by preconceived ideas rather than her actual knowledge and abilities (Faulkner, 2006; Symonds et al., 2006). Unfortunately, stereotypes still exist. This inefficiency in managing teamwork is often compounded by different ways of communicating. Women can feel that pushing their ideas strongly is culturally unacceptable. With these disadvantages, it can be difficult for women to play the key roles that lead in turn to promotion opportunities.

Cultural norms can also prevent women from mixing freely with men. Where their access to social networks at work is restricted, women may find that they do not hear about funding or other opportunities and thus be at a disadvantage when compared with their male peers. Work-related social events frequently take place outside office hours, at times when many women have to be home to ensure family responsibilities. Lack of access to strategic information is often cited as a major reason for women promoted at a slower rate than equally qualified men (National Centre for Social Research, 2002).

To obtain promotion, women usually need to achieve more on all scores than do men (Handelsman et al., 2004; Symonds et al., 2006). Women's achievements are frequently underrated, and where women have noticeably different working methods, their abilities may be totally overlooked. But since results in S&T can be easier to quantify than in other sectors, women may in fact obtain fairer treatment in S&T than in other fields. Still, there are too many stories like those of the United Kingdom's Rosalind Franklin and Jocelyn Bell, who received no formal credit for their parts in Nobel Prize-winning scientific work.[4]

Career paths in S&T are often associated with the gaining of varied experience, in particular experience in foreign countries (Wood, 2004). Women's careers and opportunities for promotion are often adversely affected when they are not free to travel to take up a new post. Undoubtedly, varied experience is important, and efforts must be made to develop women's skills through opportunities that fit their circumstances, such as a programme of short visits instead of a longer posting or assignment to international teams in their home country. A woman's career development may be affected by her taking time out of employment when her children are young and it can difficult to return to a position comparable to those held by others who have not taken time off and have been steadily advancing in their careers; this is especially true in the world of scientific research, where publishing is a key component of career advancement.

Lack of access to strategic information is often cited as a major reason for women promoted at a slower rate than equally qualified men.

4. For more on these women, see Osman (2003).

The use of rigid age limits can exclude women from various schemes appropriate to their level of experience. Similarly, it may be difficult for them to comply with rules to complete the requirements for a qualification within a fixed number of years from the commencement date.

Gender segregation can be either horizontal or vertical, though often both forms occur together. Horizontal segregation refers to an uneven gender distribution between disciplines and between sectors of the economy (public and private), thus to concentration rates in certain occupational sectors or disciplines. Vertical segregation concerns the position of women and men within the hierarchies of science; such segregation is manifested as an uneven gender distribution over levels of seniority.

Gender segregation can be either horizontal or vertical, though often both forms occur together.

Trends of horizontal and vertical segregation are mostly consistent across industry, academia and government work worldwide. Exceptional women may reach high positions, but the statistics show that there is considerable discrimination (see **Figure 2.1** on page 77). There are some bright spots where a few countries have a higher proportion of women in senior academic positions in S&T – such as in **Turkey**, where in 2006, 25 percent of senior academic SET positions were held by women (European Commission, 2006). These are certainly beacons showing that women can perform well in these positions, but the underlying cause seems to be that these are countries where academic work is poorly paid and so men are less likely to compete for the positions. Across the world, government work usually attracts more women than does the private sector, probably in part because government employment conditions are generally more open and better regulated.

Remuneration structure

'Equal pay for equal work' is widely agreed to be a basic human right. Unfortunately there is no nation on earth where it is currently fully implemented. Women typically receive less pay than men for the same work even in high-skilled occupations.

Women working in S&T may receive more equal treatment than women in other employment sectors. This is not universally true, however, particularly for women at lower levels. True equality in remuneration would require regulating not just pay levels but also extra allowances and rewards. The tendency is for these to accrue to men in a way that undermines many equal pay schemes. This can happen through an unfair award process (controlled by senior people, who are more likely to be men), or through rules that attach extra value to additional responsibilities normally given to men while ignoring equally valuable contributions made by women. For instance, many S&T educational establishments ask women to take on time-consuming responsibilities for student welfare without renumeration, but are willing to pay extra allowances for more technical responsibilities often given to men (who have more time available to carry them out).

There is another aspect to 'equal pay for equal work'. Work that is traditionally done by women tends to attract lower pay rates than work traditionally done by men. The knowledge and skills required for 'women's work' are consistently rated as having less value. One of the implications of this is that attracting women into S&T may be easier because the remuneration in this 'masculine' career sector is much better than in traditionally 'feminine' sectors. However, it is important that these divides be permitted to arise within the S&T sector. In particular, undervaluing the skills involved in effective delivery of scientific and technical education can lead to a damaging loss of good scientists of both sexes to other career paths.

'Equal pay for equal work' (Universal declaration of human rights, 1948) is widely agreed to be a basic human right. Unfortunately there is no nation on earth where it is currently fully implemented. Women typically receive less pay than men for the same work even in high-skilled occupations.

Work–life balance

Good work–life balance policies also give workers more choice and control over their working lives by offering less rigid working arrangements . . . employers who find a way to offer some choices report measurable gains in productivity and improved retention of experienced staff.

The Universal Declaration of Human Rights says: ‘Everyone has the right to rest and leisure, including reasonable limitation of working hours and periodic holidays with pay.’ This is often particularly important to women, who frequently perform paid work alongside heavy family responsibilities (Holtzman and Glass, 1999). Experience has shown that employees also place a high value on being able to work hours that have some flexibility. Again, everyone benefits, but particularly women with caring responsibilities.

Good work–life balance policies also give workers more choice and control over their working lives by offering less rigid working arrangements. The details of the arrangements vary with the practicalities of different work situations, but employers who find a way to offer some choices report measurable gains in productivity and improved retention of experienced staff (Holtzman, 1999). Even permitting small variations in working hours can be useful. Similarly, modern technology means that many knowledge workers can function effectively from home. Unfortunately, this facility is not usually available to the junior grades of workers, where most women are to be found.

Rigid employment practices and a lack of opportunities for retraining can lead to skilled professionals leaving S&T careers permanently. This affects both men and women, but women are more likely to have gaps in employment and opt for unpaid leave due to the demands of caring for children and for elderly relatives (Australian Bureau of Statistics, 2004). Many women are forced to give up work or change to a part-time job (and there are few of those within S&T) unless a way can be found to combine their caring responsibilities with their current job. The number of hours involved is often less important than availability at critical events, so flexible working is key here.

The provision of adequate maternity leave is an important factor in retaining qualified women in S&T work when they have children. Studies show that maternity leave provision actually increases the number of women returning to work (Whitehouse et al., 2006). But many women feel that their job will be adversely affected if they take their full entitlement to maternity leave. Moreover, those women who feel that they should remain home with their children longer than the statutory provision, or change to part-time work, can lose their jobs and have to construct a new lifestyle – from which they may never return to the same professional work. This problem grows greater further up the scale and in less-structured employment.

It can be especially difficult to return to S&T after a lengthy career break, such as a few years spent caring for small children. While core skills gained over a long period of education and experience are not lost, some updating may be required. This problem is widely recognized and many small-scale schemes exist that testify to the benefits of good practice. Many women in academia believe that the research system needs to be changed in order to explicitly accommodate motherhood.

To retain women in the S&T workforce, they must be given equal opportunity to be successful and to advance. A supportive workplace climate is vital: one that is safe and free of discrimination, where clear policies are in place to support the work–family balance of all, and where opportunities exist for professional growth and advancement.

Governments and social partners can help to alleviate this work-family divide by engaging in social policies that recog-

A supportive workplace climate is vital: one that is safe and free of discrimination, where clear policies are in place to support everyone's work–family balance and where opportunities exist for professional growth and advancement.

nize family responsibilities in the work place. Even though much progress still has to be made, some measures and initiatives on the international, national and employer levels in various countries that address reducing the work–family inequalities.

For example, at the international level, in 1981 the International Labour Organization (ILO) adopted recommendations aimed at enabling persons with family responsibilities to engage in employment without being subject to discrimination (Workers with Family Responsibilities Convention, 1981 [No. 156], and the Workers with Family Responsibilities Recommendation, 1981 [No. 165]: both focus on creating effective equality of opportunities and treatment for men and women). Other international conventions include the Maternity Protection Convention, 1919 (No. 3), Hours of Work Convention, 1919 (No. 1) and the Holidays with Pay Convention (Revised), 1970 (No. 132).

At the national level, labour legislation, social security benefits and policy developments aim to ensure basic rights to decent

Box 3.1: Gender equality objectives in Sweden

In Sweden, a gender equality perspective is to pervade all areas of government policy. The Equal Opportunities Ombudsperson is a government authority responsible for supervising the enforcement of equality legislation in working life and at universities. The overall aim of the Swedish Government is for women and men to have the same opportunities, rights and obligations in the most important walks of life. Thus, objectives incorporate issues related to work–famliy reconciliation and include:

- **equal conditions and opportunities regarding jobs, terms of employments and advancement**
- **the same chance of achieving economic independence**
- **shared responsibility for children and the home.**

Sources: Hein, 2005, p. 37; Sweden, Ministry of Industry, Employment and Communications, 1999.

working conditions. Social benefits that focus on family friendly policies (such as subsidized child and elderly care, paid maternity leave, healthcare and pension funds) can both positively benefit women's labour force participation and equality of opportunity and also keep women in the workforce.

However, many nations still view family responsibilities as a private matter and fear that intervention could have cost implications for employers. And when it comes to employers, traditionally the family and work are two separate spheres and typically one should not interfere with the other. Catherine Hein refers to this outlook as 'family blind' (Hein, 2005). This type of social disengagement can have very negative impacts, such as increased turnover, absenteeism, stress, employee burn-outs, or negative working environments. However more and more, employers are realizing that work-family measures stand to benefit not only their employees but also their business.

Many nations still view family responsibilities as a private matter and fear that intervention could have cost implications for employers.

Table 3.1 provides one example of categorization of work-family issues and the measures that can be taken to alleviate the burden of family responsibilities. These and like issues can be addressed by all levels of government and all types of employers.

Box 3.2: The 'high road' to increased productivity

A study in the United Kingdom has found that family-friendly working conditions in the private sector are associated with company productivity and improvement in employee commitment. Flexitime working, job-share arrangements, assistance with childcare and possibilities to work from home were all associated with lower staff turnover. Nine out of ten companies offering flexible working arrangements said there were cost-effective. These findings strongly challenge the belief that longer hours, more intensive working and the cutting back of wage costs hold the key to business success.

Sources: Hein, 2005, p. 27; Judge Institute of Management, 2002.

Table 3.1: Measures facilitating reconciliation of work with family responsibilities, by type of problem

Types of measures	Types of problems in reconciling work and family		
	Establishing workable routines (daily, weekly, yearly)	Coping with major family events/needs	Coping with emergencies
Leave entitlements	At least 3 working weeks' annual leave entitlement as per Holiday with Pay Convention, 1970 (No. 132) Ability of worker to choose when to take annual leave	Maternity leave (mothers) Paternity leave (fathers) Parental leave (both) Long carer's leave (men and women) Programmes for re-integration	Annual leave Sick leave that can be used for family emergencies Emergency/ compassionate leave Parental days
Work schedules	Avoiding long hours and overtime Predictability of work schedule (particularly for those working overtime, shift work, asocial hours) Part-time hours Flexitime Working during school term-time	Ability to reduce working hours temporarily	Flexitime or time banking schemes where workers have some control over their hours
Place of work	Working from home Partial teleworking	Working from home Partial teleworking	Ability to work from home in emergency Partial teleworking
Care facilities	Access to affordable, appropriate care for young children and elderly School canteens for lunch Out-of-school hours supervision	Breastfeeding facilities at work	Access to emergency care when main arrangement not available Ability to bring child to work in emergency Possibility of using workplace phone
Lightening the burden of family and domestic tasks	School hours that coincide with working hours Opening hours of government services, medical services, stores Transport facilities and spatial planning Labour-saving techno-logy or services for cooking, cleaning, laundry Family planning		

Source: Hein, 2005, p. 34.

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Chapter 4
Women in Scientific and Technological Research

4

The UNESCO Institute for Statistics (UIS) estimates that women constitute only slightly more than one-quarter of the world's researchers, although there are many countries for which data is not internationally comparable (including countries with a significant number of researchers, such as **Australia**, **Canada**, **China**, the **United Kingdom** and the **United States**) because many developing countries calculate data by using full-time equivalencies (FTE)[1] instead of headcounts.[2] In more than 80 percent of countries, less than 45 percent of researchers are women (see **Table 2.1** on page 93), while in over 40 percent of countries this figure falls to less than 30 percent. Gender parity, defined here as a percentage of participation of between 45 and 55 for both sexes, is at this stage reached by only 17 percent of countries (**Figure 4.1**).

Pr. Mildred Dresselhaus – Laureate of the L'ORÉAL/ UNESCO Awards for Women in Science 2007
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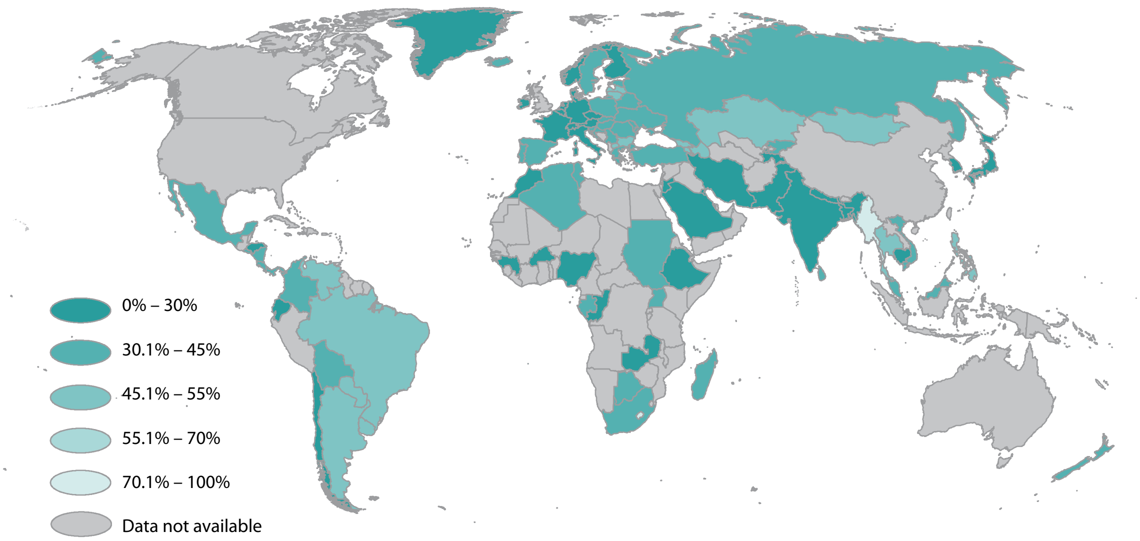
1. FTE is calculated by the total number of regular straight-time hours worked by employees and dividing it by the number of compensable hours applicable to each fiscal year.

2. See UNESCO's *World of Science*, 5 (2), April-June 2007: www.unesco.org/science/doc/E21_23.pdf.

Figure 4.1: Women as a share of the total number of researchers (headcount), 2005



Source: UIS, March 2007.

In **Latin America** and the **Caribbean**, 43 percent of researchers are women, exceeding the world average. Only five of the eighteen countries in this region that collect gender-disaggregated data have achieved gender parity (representing 28 percent). However, these five countries include **Argentina**, **Brazil** and **Venezuela**, which are among the most populous in the region and have the largest numbers of researchers, as well as the remaining **Mercosur countries**. One-half of the countries in this region that do provide such data present moderate male predominance (30 percent to 45 percent of researchers are women), while men account for more than 70 percent of researchers in **Chile, Ecuador**, **Honduras** and the **U.S. Virgin Islands** – countries with significantly smaller research communities.

In **Asia**, on the other hand, women constitute only 17 percent of researchers. While 26 percent of countries achieved gender parity in 2005, a markedly heterogeneous picture emerges across the continent. Fewer than 30 percent of researchers are female in all countries with available data in **Southwest Asia**, as well as **Japan** and the **Republic of Korea**. **South Asia** in particular has a rate of 16 percent, mostly due to **India**, where only 12 percent of researchers are women. In contrast, five out of seven **Central Asian countries** with data (71 percent) report gender parity. In this region, 50 percent of researchers are women, which is well above the global average. In **South East Asia**, the total share is 41 percent, ranging from 21 percent in **Cambodia** to 53 percent in the **Philippines** and 85 percent in **Myanmar**, which has the world's highest proportion of women researchers.[3]

Gender parity in **Europe** has been reached in only four countries (**Latvia**, the Former Yugoslav Republic of **Macedonia**, **Lithuania** and **Bulgaria**), highlighting a trend found in many former communist states. In fifteen of the twenty-eight countries (54 percent) of the European Union and the European Free Trade Area countries with data, more than 70 percent of researchers are male. A more balanced situation is found in the southeastern and eastern European countries, where women account for 42 percent of researchers.

3. No data are available for China. This section is based on data from the UIS for 2005 on the last available year. Worldwide and regional totals are UIS estimates. See www.uis.unesco.org.

An increasing body of research examining the nature of the scientific endeavour from the perspective of race, class and gender reveals the pitfalls of an academic career system that is based on a traditional 'male model' of labour market participation.

In the **Commonwealth of Independent States** (CIS), women's participation in research is significantly higher (43 percent) than the world average.[4]

In **Africa**, it is estimated that about 31 percent of researchers are women. In almost one-half of countries with available data, however, women represent less than 30 percent of researchers. **Cape Verde** is the only country in the region to report gender parity. **Lesotho** has the second-highest share (76 percent) of female researchers in the world.

A wide range of factors may explain the lower number of women in senior R&D positions, including work–life balance, gendered patterns and approaches to productivity, and performance measurement and promotion criteria. An increasing body of research examining the nature of the scientific endeavour from the perspective of race, class and gender reveals the pitfalls of an academic career system that is based on a traditional 'male model' of labour market participation. This includes long working hours, limited allowance for personal life and responsibilities, emphasis on early achievements, and exclusive identification with science and the workplace. Scholarly review processes rarely take into account gendered patterns of productivity and careers, domestic and child-bearing responsibilities, or publication patterns.

Many countries are already working to substantially increase the participation of women in research and development. But although sex discrimination does play a role in women's lower participation in science, in general the problem is larger, having to

4. The Commonwealth of Independent States consists of eleven former Soviet Republics: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan. See www.cis.minsk.by.

do with how the system is constructed. It tends to be those who fit the traditional male model set by those already in powerful positions who are assessed as better scientists (European Commission, 2004). For example, in the **United States**, having children significantly reduces the chances of promotions for women, but not for men (Olson, 1999).[5] Increasing women and girls' access to educa-

Box 4.1: South Africa Reference Group on Women in Science and Technology

The South Africa Reference Group (SARG) on Women in Science and Technology is coordinated by the Department of Science, Technology, Arts and Culture (now the Department of Science and Technology) of South Africa. Its objectives are to:

- **assist the National Advisory Council on Innovation (NACI) to promote a research agenda, including influencing funding that will improve womens quality of learning**
- **assist NACI to promote innovation that will allow women to make a greater contribution to wealth generation in South Africa**
- **provide advice on developing mechanisms that will increase the participation and contribution of women in S&T**
- **highlight role models that promote women's entry and advancement in S&T.**
- **monitor the institutional impact of these actions.**

Gender mainstreaming is SARG's ultimate goal: to achieve the acceptance and equal valuation of the differences between women and men and the diverse roles they play in society. Gender mainstreaming aims to achieve greater equality between women and men by bringing a gender-aware perspective into everyday policy-making (into the mainstream), to complement legislation and positive action.

Source: www.sarg.org.za.

5. See also other papers that discuss this topic: Gunther and Shulawit, 2006; and Goulden and Mason, 2002.

One of the prime factors restricting women's participation in the scientific endeavour is that existing systems of defining and evaluating scientific excellence are not as gender neutral as they are claimed to be.

tion and careers in S&T increases the likelihood that women will join men as full participants in R&D activities.

Measuring performance and scientific excellence

One of the prime factors restricting women's participation in the scientific endeavour is that 'existing systems of defining and evaluating scientific excellence are not as gender neutral[6] as they are claimed to be'. Bias occurs in the definition of scientific excellence and assessment criteria, choice of explicit and implicit indicators to measure excellence, differing application of measurement criteria to men and women, and the failure to integrate women in scientific networks and assessment frameworks. The key question posed here is the following: Are women's and men's achievements assessed on the same basis and from the same level of opportunity and inclusion? (European Commission, 2005, pp. 4-12).

More broadly, questions are being raised about how to measure scientific excellence or merit in general: how can original, innovative research, that is not immediately recognized as such, be fairly measured and evaluated? The current system is based on the presupposed disinterestedness and objectivity of peers and colleagues. The challenge is to 'develop metrics that better capture the dynamics of scientific discovery' (European Commission, 2004, p. 18), metrics that include an assessment of the societal objectives of public policy and research funding, in addition to the more 'purely' scientific imperative.

6. Gender neutral are those interventions with predetermined objectives that do not seek to change the existing division of resources and responsibilities along gender lines.

A number of researchers have emphasized the biased nature of science, pointing out that it is a human activity heavily influenced by prevailing social, political and economic factors (Rosser, 1988). Related questions concern how other social and life situations – such as race, geography, disability, socioeconomic status, age, marital status and sexual orientation – affect not only the practice of science, but perceptions of scientific merit (Harding, 1993; Malcom, 2006).

For women, current measurements of performance and productivity work to their disadvantage. A United States National Science Foundation (NSF) review of gendered career patterns found that women faculty earn less than their male colleagues; they are promoted less frequently, and they publish less frequently. These results emerged even when studies are controlled for factors such as age/experience, academic rank and family characteristics. As a result, women participate less in senior societies, committees and prestigious activities (NSF, 2003).

A number of researchers have emphasized the biased nature of science, pointing out that it is a human activity heavily influenced by prevailing social, political and economic factors.

'Count-based' and publication-focused measurements of employment experience and publication record also tend to penalize women by not properly reflecting the quality of their contributions. Many studies show that women prefer to focus on teaching and interaction with students (NSF, 2003). Others argue that 'years of employment' is not a good indicator of experience, and that the concept of 'academic age' is a more accurate measurement (Glover, 2001).

Scientific productivity

The analysis of scientific and technological productivity by sex has, up to now, only been conducted through specific studies on patents, bibliometrics or citations. No systematic international

Box 4.2: The US National Science Board Task Force on Merit Review

The US National Science Board (NSB), the policy-making body of the United States National Science Foundation (NSF), has reviewed its criteria for proposal awards by the NSF as part of a larger strategic planning effort. A 1996 Task Force on Merit Review made up of NSB members and NSF senior staff presented a report advising the adoption of two criteria in award of proposals by the NSF: the intellectual merit and quality of the proposed activity and its broader impacts. In so doing, the NSB went beyond questions of technical merit that tended to dominate discussions of funding decisions (e.g. research competence and institutional capacity) to consideration of broader impact (effect on output of diverse students, relevance in addressing a social issue). Expanding and elaborating on what is meant by 'merit' has prompted much discussion, and some unhappiness among traditional gatekeeper communities (Malcom, 2006).

data collection yet exists in this area that includes gender breakdown. This area needs further development in the future in order to provide sound data and indicators.

Studies on citation rates and patterns have revealed interesting (and often gender-biased) trends. While straight index counts generally indicate lower production by women, use of a quality-weighted index that takes into account the number of times an article is cited will demonstrate a higher level of scholarly production by women. A study by Sonnert and Holton (1995) of 699 scientists in the United States found that women tended to produce work that was more comprehensive and succinct, so that while they had fewer numbers of publications, these publications tended to be more widely cited. In biochemistry, J. Scott Long (1992) found that the average paper by a woman was cited 1.5 times more often than that of a man. It is well known that women tend to be more cautious, thorough and attentive to detail in preparing work for publication. This is partly due to a sense of insecurity about the quality of their work, as well as a sense (often based in reality) that their work is not rated as highly as that of their male colleagues. The result is that women's work often has to be seamless to be valued at its worth (Schiebinger, 1999; Rathgeber, 2002; Margolis and Fisher, 2002).

Although women are as likely as men to collaborate on research projects, they tend to belong to smaller teams that publish less, so that their rate of return on collaboration is lower than for men. Research indicates that women co-author less often than men, which is a disadvantage in ranking because single and co-authored publications are weighted equally. Men also tend to publish a higher number of shorter papers from their research (Sonnert and Holton, 1995). Reasons given for the differing collaboration patterns vary, with some suggesting that since both women and men tend to collaborate with researchers of the same sex, the lower number of women in S&T fields restricts women's opportunities for collaboration (NSF, 2003). It has also been suggested that women collaborate closely with co-workers, perhaps more so than men, but their definition of collaboration extends beyond co-authorship to include all joint research projects and activities (Campion and Shrum, 2004).

Studies on citation rates and patterns have revealed interesting (and often gender-biased) trends. While straight index counts generally indicate lower production by women, use of a quality-weighted index that takes into account the number of times an article is cited will demonstrate a higher level of scholarly production by women.

Funding and grants

Other indicators that give clues about the achievements of women in scientific careers could be funding success rates by gender or the proportion of women on scientific boards. The European Commission's WiS database[7] shows that in most EU countries

7. The European Commission's WIS database: http://epp.eurostat.ec.europa.eu.

Studies of grant awards indicate that structural and social inequalities exist in the award evaluation and selection process.

men have higher success rates in obtaining research funding than women, although the differences are small and for the most part not statistically significant. The proportion of women on scientific boards would give some indications on female participation in the process of setting the scientific agenda. In the EU, women are under-represented on scientific boards in most countries with data, except for the Nordic ones. The application of these indicators in a broader context would require clear definitions and methodologies in order to obtain comparable data outside Europe.

Studies of grant awards indicate that structural and social inequalities exist in the award evaluation and selection process. One study found that male applicants to Sweden's Medical Research Council (MRC) and researchers with an affiliation with one of the evaluators were more successful (Wenneras and Wold, 1997). Competence was one factor in the final decision, but women had to demonstrate much higher credentials than men to obtain the same grants. The gender of the applicants, and affiliation with one of the members of the evaluation committee, also affected award decisions to the advantage of men.

University/Research Chair holders – prestigious research professorships in universities – are nominated by their colleagues and peers, a factor that may help to explain the low numbers of women recipients.[8] Many science awards favour men over women (Carnes et al., 2005; Malcom, 2006). A recent experiment shows prevalent double standards: curriculum vitae were ranked more highly by both male and female assessors when assigned male names (Steinpreis et al., 1999). In another study, both men and women were given a research article by an author identified vari-

8. Canada Research Chairs, www.chairs.gc.ca/web/media/statistics_e.asp.

ously as John T. McKay, Joan T. McKay, J. T. McKay (sex-neutral), Chris T. McKay (ambiguous with respect to sex) and Anonymous. When identified as written by a male author – John – the article received the highest reviews; next in ranking was the article identified as written by 'J. T.', and third was 'Joan'. When readers thought the initials 'J. T.' indicated a woman trying to hide her identity, the article was ranked lower (Paludi and Bauer, 1983).

Box 4.3: The L'ORÉAL/UNESCO Awards for Women in Science

Launched in 1998, the L'ORÉAL/UNESCO Women in Science programme is a public–private-sector partnership that promotes international recognition of the achievements of women scientists: it is among the world's leading international awards programmes.

L'Oréal Group's international initiative, developed in partnership with UNESCO, stems from the desire to both improve the position of women in science and to create new career opportunities for women scientists worldwide – objectives that echo MDG3, 'to promote gender equality and empower women'.

The programme's two main components encourage women already helping the world to move forward through their scientific work, as well as the female students who will be following in their footsteps: The L'ORÉAL/UNESCO Awards, worth $100,000 each, distinguish the achievements of five outstanding women research scientists each year, representing five continents – Africa, Asia-Pacific, Europe, Latin America and North America. In addition to the awards, three young women scientists from each region receive L'ORÉAL/UNESCO Fellowships. These fifteen Fellowships are each worth up to $40,000 toward doctoral or post-doctoral research projects.

Since its creation, more than 350 women researchers worldwide have benefited from this unique programme.

Source: For more details, see *www.loreal.com.*

Women scientists: Different perspectives and research interests?

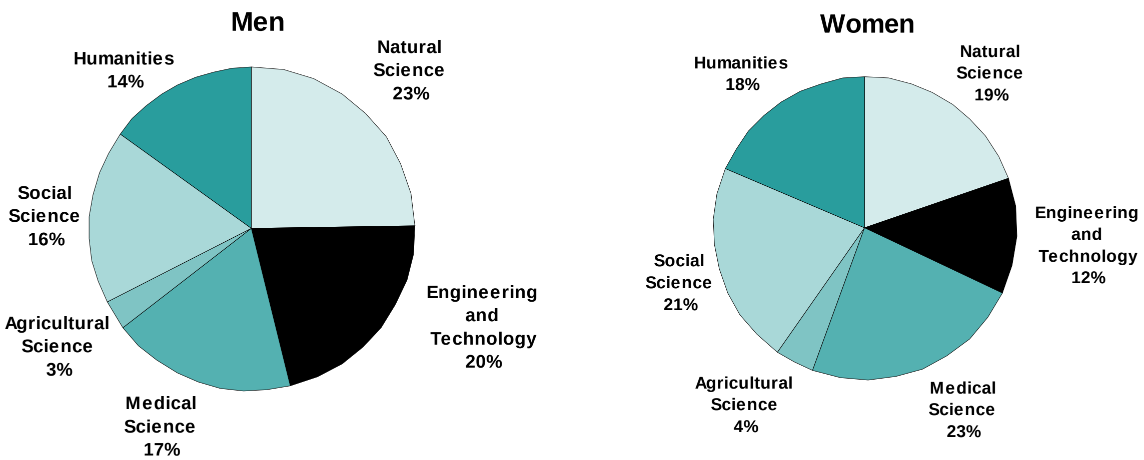
What do we know about the kind of science that women do, or the kinds of research undertaken by them? We do know that there are gendered trends in scientific disciplines, trends that, despite regional variations, might have some commonalities. As we have seen above, women tend to congregate in the bio- and life sciences, where they make up 50 percent or more of undergraduates in many regions. They are also less-well represented in computer science and the 'harder' sciences such as physics and engineering. We also know that the absence of women in science has affected research priorities: the first pacemakers were developed to fit the male chest, and were too large for women; women tended to be left out of the very clinical studies that were used to diagnose and treat them. The role of females in primate groups was overlooked until more women entered primatology and began to pay attention to the wider range of social interactions in groups (Schiebinger, 1999).

The number and proportion of women researchers varies widely not only between countries but also between sectors and fields (see **Figure 2.10**). Statistics from the sixteen European Union (EU) countries that collected sex-disaggregated data in 2003 show that 28 percent of researchers in the natural sciences and 22 percent in engineering and technology in these countries were women.[9] The proportion of men performing research in engineering or technology-related areas in these countries was

9. Data collected in: Austria, Cyprus, the Czech Republic, Denmark, Estonia, Germany, Hungary, Ireland, Lithuania, Luxembourg, Malta, Portugal, Slovakia, Slovenia, Spain and Sweden.

nearly twice as high as that of women, although the gender gap narrowed in the natural sciences (**Figure 4.2**).

Figure 4.2: Distribution of researchers in the EU by main scientific fields and sex, higher education sector, 2003, by headcount



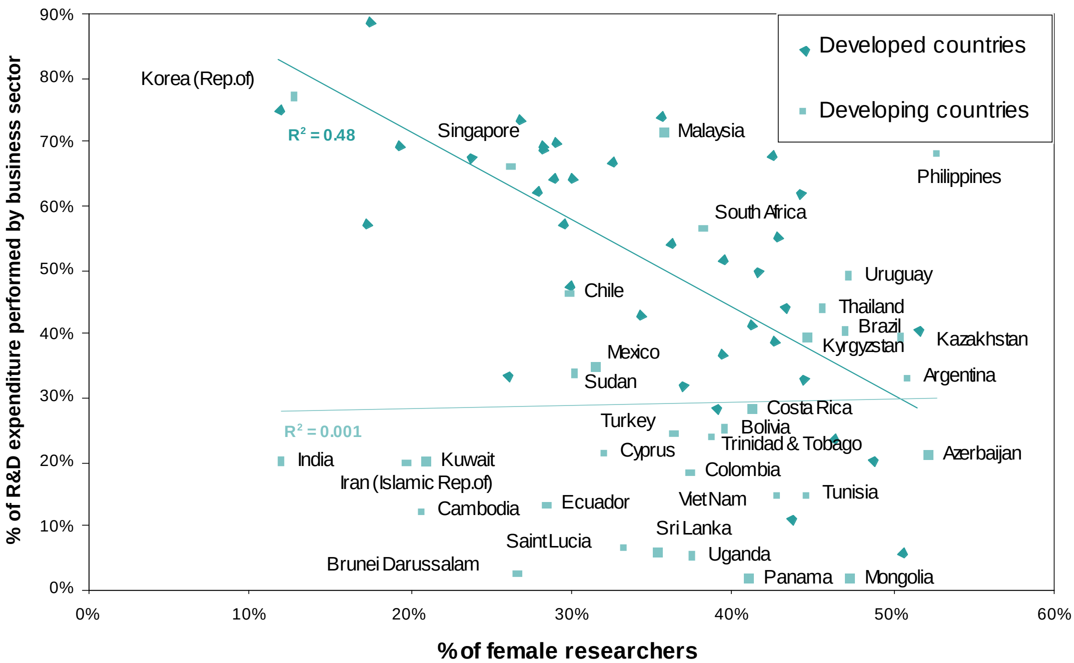
Source: EU, DG Research.

Sectorial patterns

Overall, 29 percent of researchers in the **EU-25** countries that collected sex-disaggregated data in 2003 (Austria, Cyprus, the Czech Republic, Denmark, Estonia, Germany, Hungary, Ireland, Lithuania, Luxembourg, Malta, Portugal, Slovakia, Slovenia, Spain and Sweden) were women. But in the public sectors of government and higher education, this proportion reached 34 percent, nearly double the participation of women in industrial research (18 percent). Growth rates during the period 1999–2003 were, however, generally higher for women than for men throughout the EU, particularly in industrial research.

The increasing weight of industrial research – frequently considered more likely to be undertaken by men – in total R&D might be considered as one explanation for the low percentage of women researchers worldwide. **Figure 4.3**, however, shows that while this seems to be accurate for developed countries, developing countries present a more scattered pattern, in which female participation and weight of industrial research do not correlate well. While the quality and availability of data in developing countries varies greatly and limits the accuracy of current measurements, this pattern is worth a closer look. Updated and more detailed data are needed to better understand this situation.

Figure 4.3: Relationship between percent of female researchers and industry-funded R&D expenditure (as a percentage of total R&D expenditure), 2005



Source: UIS, 2007.

Other experimental indicators

The 'Honeypot' indicator[10] is an innovative proposal by the European Commission that measures the 'triangular relationship' between:

- R&D expenditure
- concentrations of researchers in particular sectors or scientific fields of R&D
- sex composition of researchers in sectors or fields.

The Honeypot is based upon the relationship between two values of R&D expenditure per capita for women: an expected value and an observed value. The expected value is calculated by applying the overall proportion of women to the overall amount of R&D expenditure. The observed value is calculated by applying the proportion of women in each sector or field of science to the amount of R&D expenditure in each sector or field of science and then summing these amounts. The Honeypot measures the extent to which women are more likely to congregate in high- or low-expenditure areas.

By indicating the proportion of their per capita share of R&D that women are 'accessing' or 'missing out on', the Honeypot indicator is designed to standardize the relationship between gender, money and the work–life balance context of R&D. More research is needed to better interpret this indicator for the EU. The available statistics do not allow for the construction of the Honeypot indicator for most of the world.

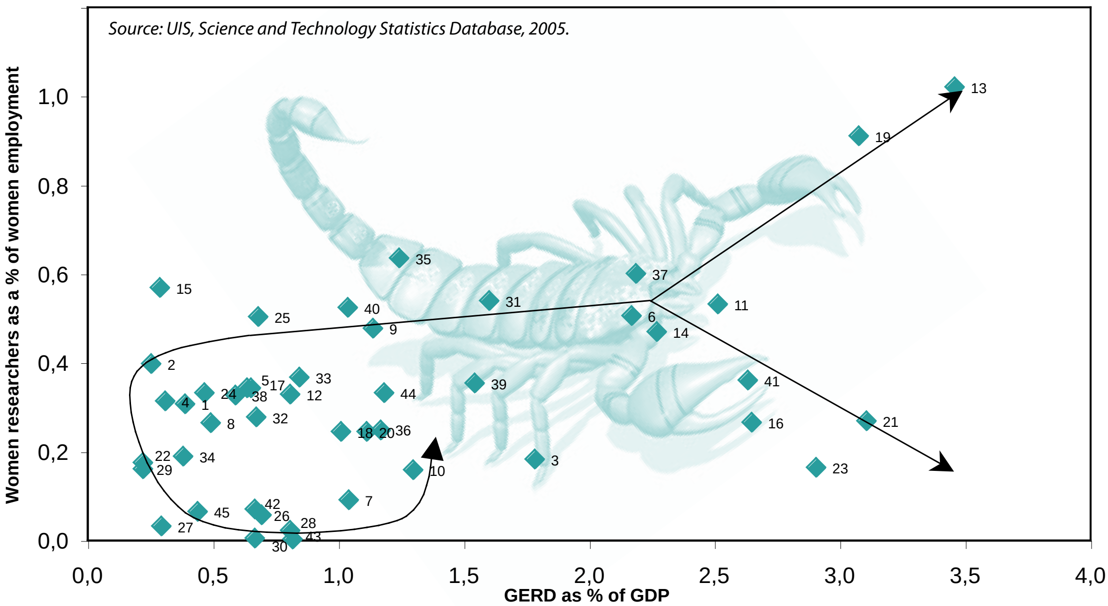
10. Developed by Enwise (Enlarge Women and Science to East) Expert Group. See, European Commission, 2003.

1 **Argentina**
2 **Armenia**
3 **Austria**
4 **Azerbaijan**
5 **Belarus**
6 **Belgium**
7 **Brazil**
8 **Bulgaria**
9 **Croatia**
10 **Czech Rep.**
11 **Denmark**
12 **Estonia**
13 **Finland**
14 **France**
15 **Georgia**
16 **Germany**
17 **Greece**
18 **Hungary**
19 **Iceland**
20 **Italy**
21 **Japan**
22 **Kazakhstan**
23 **Korea, Rep.**
24 **Latvia**
25 **Lithuania**
26 **Malaysia**
27 **Mauritius**
28 **Moldova**
29 **Mongolia**
30 **Nepal**
31 **Norway**
32 **Poland**
33 **Portugal**
34 **Romania**
35 **Russia**
36 **Serbia and Montenegro**
37 **Singapore**
38 **Slovak Rep.**
39 **Slovenia**
40 **Spain**
41 **Switzerland**
42 **Turkey**
43 **Uganda**
44 **Ukraine**
45 **Venezuela**

The '**Scorpion diagram'** illustrates the relationship between R&D intensity and the density of researchers in the female labour force (defined as the number of women researchers as a percentage of the total number of women in employment). These show moderate correlation (R^2 = 0.41). However, after reaching around 2.5 percent of the GERD/GDP ratio, countries start to differentiate regarding the density of researchers in the employed female population. The resulting 'Scorpion diagram' shows that, while in **Finland** and **Iceland** researchers are around 1 percent of employed women, in **Switzerland**, **Germany**, **Japan** and **Korea** this density falls to between 0.2 percent and 0.4 percent, levels that are similar to those more frequently found in the 'tail' region of the 'scorpion'.

Figure 4.4: The 'Scorpion diagram', 2002

Values in the lower left-hand corner vary from 0.00 to 0.05 (X axis) and from 0.01 to 0.37 (Y axis) and include the following countries: Bolivia, Colombia,Cyprus, Ecuador, El Salvador, Honduras, Kuwait, Kyrgyz Republic, Pakistan, Panama, Paraguay, Sri Lanka, Thailand, Trinidad and Tobago, Uruguay, Zambia.



Source: UIS, Science and Technology Statistics Database, 2005.

Research agendas and policies

The presence of fewer women at the highest levels of science decision-making means that they have less opportunity to shape research questions and priorities. Science agendas have on the whole been dominated by white men, and they consequently reflect male views of what is important and relevant. Women have not been present for long enough, or in numbers great enough, for us to know if science would be 'different' if it were directed equally by women and men.

Not enough data or research exist for this question to be definitively resolved. Currently, there are three main approaches:

1. The **difference model** suggests that women 'do' science differently, because of their different perspective on the world and different approach to problem solving.
2. The **equity approach** argues for gender parity on the basis that women should have equal opportunity to contribute to and benefit from S&T (an argument that could in itself be considered a sufficient basis for reforming the science system).
3. **Structural change analysis** points out that women (and other under-represented groups) may have different research interests and priorities – the result of differences in positions, traditions and roles – and suggests that integrating women into a structure that has for hundred of years actively rejected women and their concerns will require 'deep structural changes in the culture, methods, and content of science' (Schiebinger, 1999, p. 11).

Women scientists continue to be absent in top managerial positions from educational and research institutions, and also at the

Science agendas have on the whole been dominated by white men, and they consequently reflect male views of what is important and relevant. Women have not been present for long enough, or in numbers great enough, for us to know if science would be 'different' if it were directed equally by women and men.

ministerial level. Inevitably, this excludes female voices from being heard – and in equal partnership – in decisive decisions on the current and future orientation of S&T (Rathgeber, 2002; Campion and Shrum, 2004).

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European Commission (DG Research), European Charter for Researchers and Code of Conduct for the Recruitment of Researchers: http://ec.europa.eu.

UNESCO Institute for Statistics (UIS): www.uis.unesco.org.

Chapter 5 Information on STG: Data, Statistics and Indicators

5

If the development of science and technology (S&T) continues to maintain the growth rate of the last fifty years, it will be necessary to significantly increase the numbers of people, both men and women, dedicated to research. S&T policy is therefore undergoing a critical period in most countries and regions of the world. As such, it is particularly urgent to study closely the situation of women in science, and it is vital to establish a wide-ranging S&T information system to provide substance for analysis and input to evidence-based policies (**Box 5.1**). Such an information system must include databases and indicators that can accurately describe the conditions under which women are participating in the S&T system in different countries and regions and monitor whether the state of affairs is improving and gender policy is on track. What future avenues need to be pursued?

Science course in secondary school, pupil and teacher, Malay © UNESCO / Jack Ling

Gender statistics

Gender statistics is a relatively new field that cuts across all traditional statistical fields: it describes social progress from the perspective of gender equality. By examining gender concerns and goals in society and identifying appropriate statistics and

Box 5.1: Evidence-based policy

Evidence-based policy is an approach that 'helps people make well informed decisions about policies, programmes and projects by putting the best available evidence from research at the heart of policy development and implementation' (Davies, 1999). In a democratic context, evidence-based policy-making means that, wherever possible, public policy decisions should be reached through open debate, informed by careful and rigorous analysis, using sound and transparent data.

More specifically, evidence-based policy may be defined as the use of statistics to achieve issue recognition, inform programme design and policy choices, forecast the future, monitor policy implementation and evaluate policy impact (Scott, 2005).

indicators, policy-makers can address them with adequate policies and plans, and assess and monitor the related changes. The life conditions of all people, women and men, in society, at the workplace and in the family, must be taken into account in every decision-making process if true gender equity is to be achieved. And to accomplish this, all socioeconomic and educational statistics must be disaggregated by sex and reflect each society's gender-equality issues.

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Over the last three decades, much has been done to improve the production and dissemination of statistics that reflect the actual situation of women and men in society. Concepts, definitions, criteria for classification and survey methods have extensively been examined and often revised to improve the measurement of all aspects of women's and men's lives. Some data gaps have been filled and some measurement problems have been successfully addressed, but in many areas, including S&T, measurement problems remain and data are often inadequate. Data systems need to be established, or expanded to collect sex-disaggregated data, to determine progress and to target areas of intervention. The scattered availability of data on STG reflects a general lack of awareness of its many implications. Other areas, such as education, can draw on a much higher availability of international, sex-disaggregated statistics.

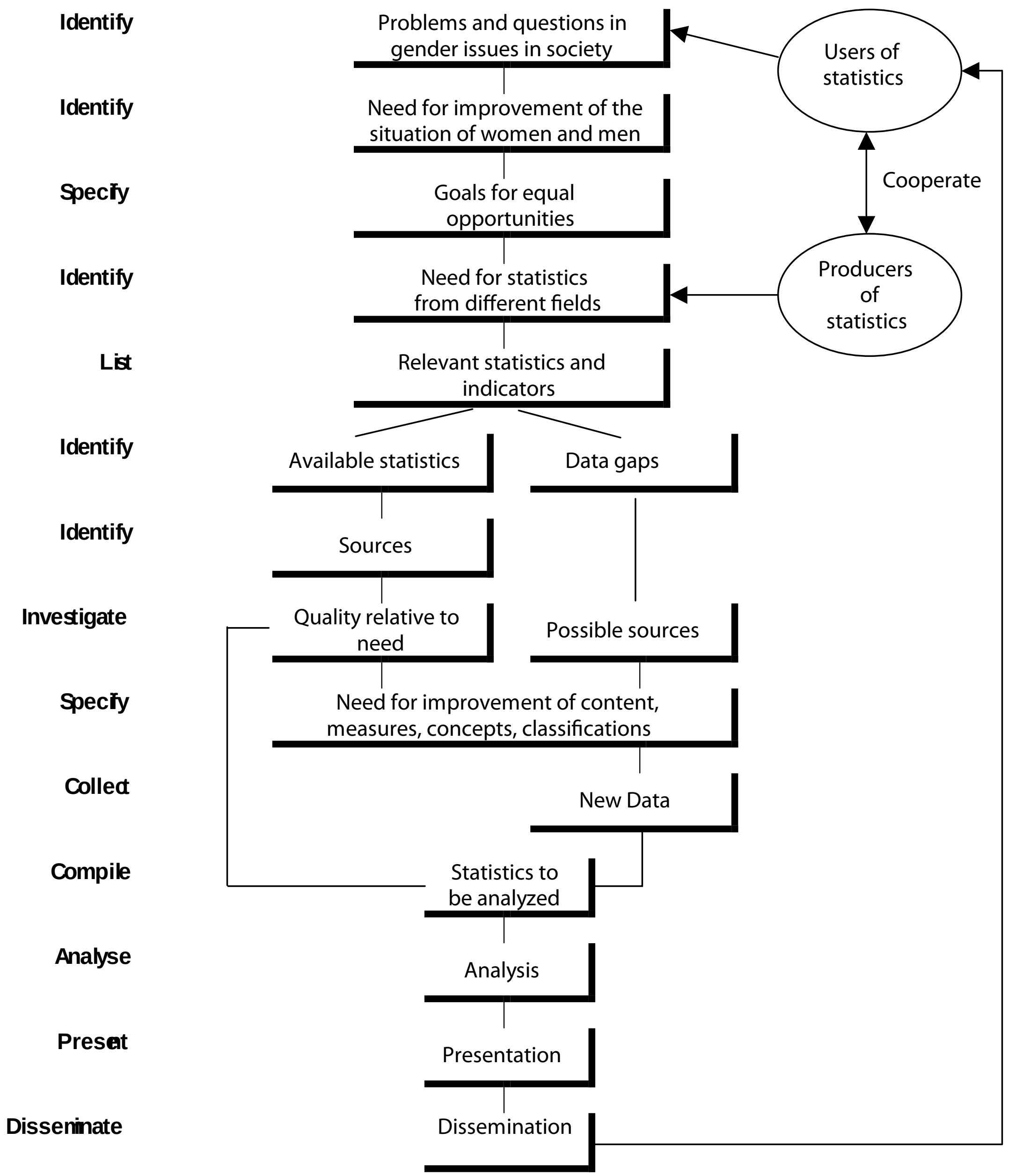
The scattered availability of data on STG reflects a general lack of awareness of its many implications.

One reason that education statistics have been consistently broken down by sex for decades may be that the focus in education policy is primarily on people, rather than on finances, whereas in R&D, expenditure is very often valued above other questions relating to human resources. However, the rapid pace of technological change and the enormous impact technology now has on socioeconomic growth have seen human resources in S&T become an important policy area in recent years. In this context, improving the gender balance is crucial to increase the total number of scientists in areas and places where there are shortages.

While in many areas – particularly in health and education – statistics are primarily used for the purposes of monitoring and evaluation, in the field of S&T statistics are also vital to put gender issues firmly onto policy-makers' agendas. By developing statistics and methodologies to collect STG data, and by encouraging countries to mainstream the gender dimension into data-collection instruments and procedures, international organizations can deactivate the vicious circle of a lack of policy priorities leading to a lack of statistics, leading to a lack of awareness, leading in turn back to a lack of policy priorities.

The production process of gender statistics is modelled in **Figure 5.1**.

Figure 5.1: The production process of gender statistics: flow diagram



Box 5.2: The United States National Science Foundation

The United States' Science and Engineering Equal Opportunity Act (1980) states that men and women must have equal opportunities in education, training and employment in scientific and technical fields. The US National Science Foundation (NSF) is authorized to support and undertake research, data collection and other activities to assess, measure and increase the participation of women in science, technology, engineering and mathematics, including:

- **Activities designed to increase the participation of women in courses of study leading to degrees in scientific and technical fields.**
- **Programmes in science and mathematics in elementary and secondary schools.**
- **Activities in continuing education in S&T to provide opportunities for women in the workforce, as well as women whose careers have been interrupted, to acquire new knowledge, techniques, and skills in such fields.**
- **Research designed to increase understanding of the potential contribution of women in S&T and facilitate the participation and advancement of women.**
- **National Research Opportunity Grants and fellowships to women scientists to conduct scientific research.**
- **Demonstration projects designed to encourage the employment and advancement of women in S&T.**
- **A comprehensive science- education programme to increase the participation of minorities in S&T.**

The NSF is also required to:

- **Prepare and submit to the United States Congress a report proposing a comprehensive policy and programme to promote minority participation in such fields.**
- **Prepare and transmit to the United States Congress a report concerning the participation and status of women in S&T, including an accounting and comparison by sex, race and ethnic group, and by discipline, of the participation of women and men in scientific and technical positions.**

Source: See www.nsf.gov, for more details.

Measuring science, technology and gender

A solid body of statistics and indicators is a basic component of a complete information system. There is still a lack of significant official data on science, technology and gender (STG), a situation that constrains efforts to design and implement policies directed at women in S&T, particularly policies seeking to provide equitable labour situations. In many countries, data and indicators are produced – by academics, NGOs and special interest groups – but they are poorly communicated, not well received or not taken into account by national decision-making bodies. Data collected by the different sectors need to be mainstreamed into analysis and policy design, thereby complementing official statistics in the field. At the international level, lack of official data constitutes a serious obstacle to the construction of cross-country comparable statistics and to the developement of further analysis and policy recommendations.

STG statistics

The demand for relevant, reliable statistics among policy-makers and the international community has increased tremendously in recent years. The availability and quality of data collected are critically dependent upon the statistical capacities of relevant government departments and agencies within countries. However, a large number of countries, particularly in the developing world, still suffer from weak statistical capacities and inadequate information to support policy-making and decision-making.

It is therefore a priority for the international community to help countries to improve their capacities for data collection, processing, quality control, analysis and dissemination. This needs to be done as cost-effectively as possible, with a view to creating robust and sustainable S&T information and statistics systems and encouraging cooperation between the different stakeholders involved, both governmental and non-governmental. There is a relative lack of S&T statistics broken down by sex in both developed and developing countries. While existing figures show that the situation of women in S&T is still far from ideal, it is essential to collect more and better data on women in S&T in order to undertake a full diagnosis in the first place and to further elaborate strategies to promote and value their contribution.

Because collaboration with government and civil society organizations is key to building awareness about the situation of women in science, capacity-building activities must be complemented by awareness-raising activities to help bring STG issues into the main policy agendas.

Box 5.3: Collecting data: South Africa – SET 4 Women

SET 4 Women, an advisory group to the Department of Science and Technology of South Africa, has organized systematic research and data collection procedures to guide policy recommendations to the government. In 2003, it commissioned an investigation into the status of women in science, engineering and technology (SET) in South Africa and the potential benefits of science for all women in South Africa. The research aimed specifically to:

- **develop a sex-disaggregated profile of the human resources for S&T in the public science system in South Africa**
- **explore the nature and extent of the contribution of research in the public domain to understanding the specific needs and problems of women in general.**

Source: SET 4 Women, 2004.

Box 5.4: Recommendations on collecting sex-disaggregated data: UNESCO, the OECD and the European Union

Recommendation concerning the International Standardization of Statistics on Science and Technology (UNESCO, 1978)

(Adopted by the UNESCO General Conference at its twentieth session, Paris, 27 November 1978)

13. The information furnished by the statistics of science and technology should be presented with the periodicity and level of detail shown below:

FIRST STAGE: SET (Scientists, Engineers and Technicians) by sex and age (biennial)

UNESCO Manual for Statistics on Scientific and Technological Activities (1984)

1.3 The personnel of S&T institutions should be classified in a number of ways, some of which concern only the most qualified staff: . . . sex; age.

5.2 Classifications by nationality, age and sex

A number of other specific characteristics of personnel may be analyzed with the purpose of gaining better knowledge of the human potential employed in S&T activities. All the personnel should be classified by sex.

OECD *Frascati Manual 1993: Proposed Standard Practice for Surveys on Research and Experimental Development*

332. In order to understand more about the R&D labour force and how it fits in the wider pattern of total scientific and technical personnel, it is also useful to collect the following types of data on a headcount basis:

. . . researchers (or holders of university-level degrees) by age, gender, national origin, length of service, etc.

OECD *Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development*

21. The recommendation to report data by gender and age (with a proposed classification by age) is new.

347. In order to understand more about the R&D labour force and how it fits in the wider pattern of total scientific and technical personnel, it is recommended to collect headcount data on researchers and, if possible, on other categories of R&D personnel, broken down by: sex; age.

Decision No 1608/2003/EC of the European Parliament and of the Council of 22 July 2003 concerning the production and development of Community statistics on science and technology

Article 1: **The objective of this Decision is to establish a Community statistical information system on science, technology and innovation to support and monitor Community policies.**

Article 2: The objective described in Article 1 shall be implemented by individual statistical actions as follows:

. . . Development of new statistical variables to be produced on a permanent basis that can provide more comprehensive information about science and technology . . .

The Community shall give priority, in particular, to the following domains: . . . gender-disaggregated statistics on science and technology . . .

Council of the European Union: Conclusions on reinforcing human resources in science and technology in the European Research Area, 19 April 2005

Invites member states to:

- **encourage the further development of sex-disaggregated data on the participation of women in research, including the collection of yearly recruitment statistics.**
- **formulate ambitious targets for the participation of women focussing on areas where women are seriously under-represented, and in particular increase significantly the number of women in leading positions, with the aim of reaching, as a first step, the goal of 25 percent in the public sector as an average in the EU, as well as boost their participation in industrial research and technology.**

UNESCO has recommended collecting data on R&D personnel disaggregated by sex from as early as 1978 (see **Box 5.4**). However, the lack of statistics on STG has been reinforced by the lack of attention paid to gender in the more widely used OECD *Frascati Manual* (only the most recent edition recommends this breakdown; see OECD, 2003). Recognizing the lack of sex-breakdown in R&D statistics from Eurostat and OECD, in 2001 the European Commission created a sub-group of 'Statistical Correspondents' within the Helsinki Group on Women and Science to collect sex-disaggregated data and to develop gender-sensitive S&T indicators for the twenty-five Member States of the European Union, plus seven associated countries. The Statistical Correspondents collect sex-disaggregated data annually and have developed a number of gender-sensitive indicators.

Eurostat introduced sex-breakdowns into its R&D survey in 2001 for candidate countries and in 2002 for member states. The OECD now also includes a breakdown by sex in its R&D survey, and the two organizations have recently harmonized their R&D data collections into one common survey.

While UNESCO is the leading agency in the UN system for the collection of international S&T statistics, other agencies or regional networks, such as the OECD, Eurostat and RICYT, have assumed a considerable and frequently pre-eminent roles in contributing to the global S&T statistics system. NGOs and scientific organizations also have a wealth of information available that might complement the official data available.

The UNESCO Institute for Statistics (UIS) database of S&T statistics includes the categories: 'Total R&D Personnel', 'Researchers' and 'Technicians' broken down by sex. Availability of sex-disaggregated data is still scarce, but the database covers more than two-thirds of those countries (and territories) that do collect data on total researchers by sex. Less data is available in developing than in developed countries, although the amount of sex-disaggregated data available even in developed countries varies greatly, with European Union countries generally collecting more sex-disaggregated data than do other developed nations.

The S&T statistics databases of the OECD, and more prominently Eurostat, incorporate additional sex-disaggregated variables in measuring R&D personnel by qualification, sector, field of science, age, citizenship, economic activity and size in the business enterprise sector. Data availability for the various indicators is disparate, with some at only a preliminary stage (particularly breakdown by citizenship and sex). A survey conducted by UIS in 2004, however, showed an increasing tendency to collect various gender-based statistics in R&D surveys in developing countries.

In addition to official R&D statistics, three other groups of statistics are particularly relevant to STG:

- **Human resources in science and technology (HRST) statistics:** These statistics are collected by several countries, from various sources including national censuses, work-force surveys, and S&T information systems such as the SESTAT system in the US (see **Box 5.3**).
- **Higher Education statistics:** These statistics are collected internationally by the UIS, consolidated and frequently more complete, though data availability for many countries is still low.
- **Statistics on the participation of women in S&T and on the conditions of their participation**, such as data on members of scientific boards, applicants and beneficiaries of research funds by sex. Some of these data are collected in Europe by the Directorate-General for Research of the European Commission, and in other regions and countries by various NGOs or academic groups. These statistics are scarcely available and are mostly based on national classifications.[1]

Eurostat's commitment to sex-disaggregated R&D statistics provides a model for other international organizations to follow. However, a significant effort is still needed to improve statistical data collection within the European countries so as to provide the comprehensive information requested.

1. See, for example, Canada Research Chairs, www.chairs.gc.ca/web/media/statistics_e.asp.

STG indicators

More national and international sex-disaggregated indicators are needed to establish baseline information and to monitor the progress of women in S&T education and careers.

An **indicator** is an individual or composite statistic that relates to a basic construct in S&T and is useful in a policy context (Shavelson et al., 1991). Each is

> designed to provide consistent information about some important area of performance of a system. Although indicators can show trends, confirm successes, and identify potential problems, they usually do not by themselves provide explanations or permit conclusions to be drawn about cause and effect. More comprehensive research is required to answer complex questions, identify sources of benefits or problems, propose solutions and design appropriate policy responses (Cleveland et al., 2003).

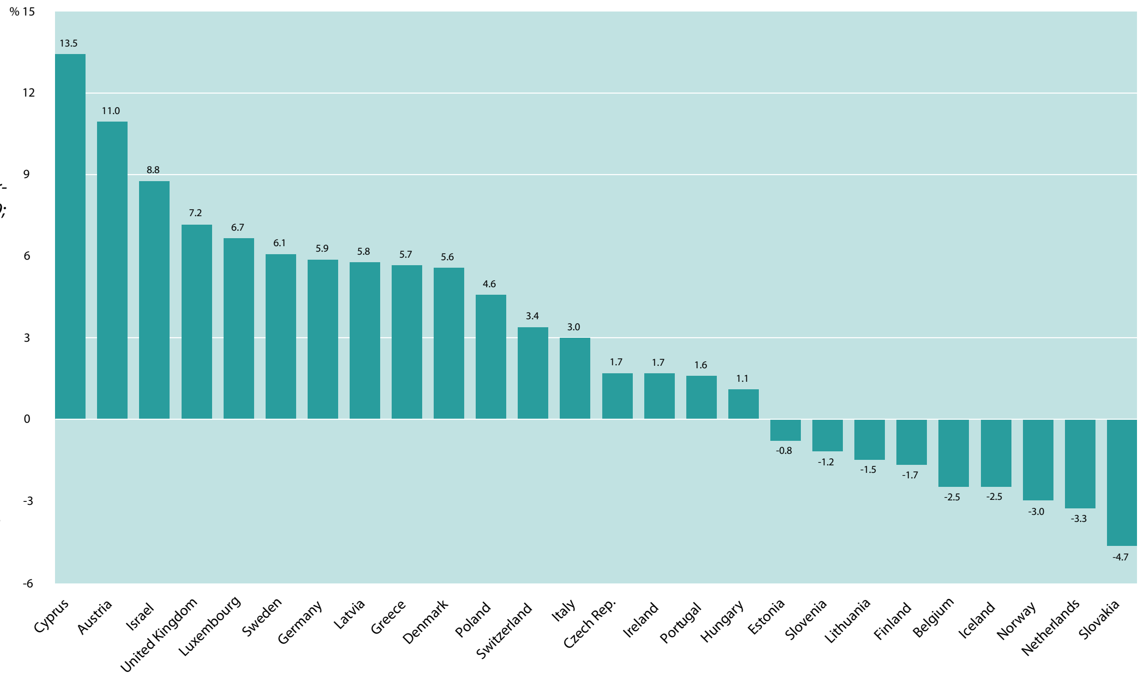
In recent years, statistics on STG have been mainstreamed in many different areas. New indicators have been developed to better understand the complex issues involved in obtaining gender parity in S&T. One noteworthy collation of key indicators on STG at the national level is the United States National Science Foundation's *Women, Minorities and Persons with Disabilities in Science and Engineering* (2004). But more national and international sex-disaggregated indicators are needed to establish baseline information and to monitor the progress of women in S&T education and careers. Data collected locally and regionally also needs to be incorporated into analysis and policy design at the national level.

Although STG data is lacking or limited in many countries, a number of STG indicators can be calculated based on the statistics currently collected at the international level – for example, the indicators developed in the European Commission's online publication *She Figures* (2006). Among existing STG statistics are idicators measuring:

- the number and proportion of women researchers (see **Figure 4.1** on page 118).
- the proportion of women in public research (academia and research institutions) and in business enterprise research (see **Figure 4.3** on page 130).
- various growth rates and time series (see **Figurse 2.1a and 2.1b** on page 79).
- the proportion of researchers in different fields of S&T (see **Figure 4.2** on page 129).
- the density of researchers in the population and the labour force by sex (see **Figure 4.3** on page 130).
- career paths of women in higher education and S&T, by graduation and promotion rates or by field of studies (see **Figures 2.1 – 2.9**, pages 77–87).
- the relationship between the density of women in research and the overall amount of R&D expenditure (see **Figure 4.4** on page 132).
- the 'Honeypot' indicator, measuring the triangular relationship between R&D expenditure and the concentrations of researchers in particular sectors or scientific fields of R&D and the sex composition of researchers in given sectors or fields.
- 'Field Relative Parity Indexes', which measure the relationship between the proportion of female graduates in a country at various tertiary levels in a specific field and the average proportion of female graduates in that country (see **Figure 2.10** on page 90).

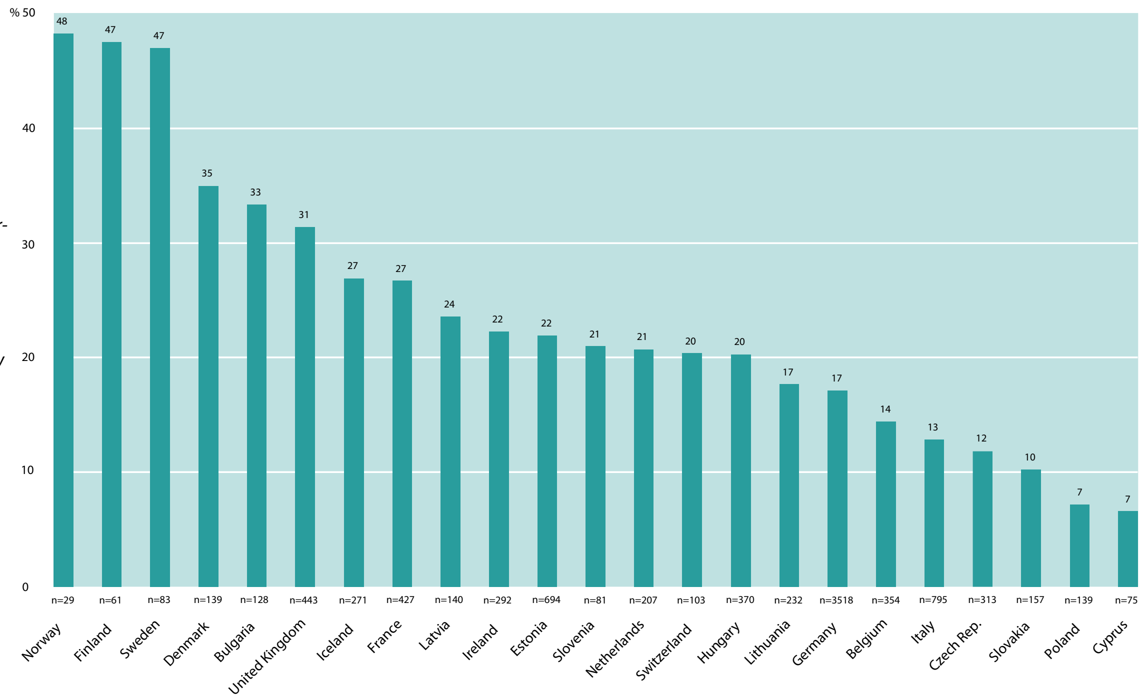
Data collected locally and regionally also needs to be incorporated into analysis and policy design at the national level.

Figure 5.2: Research funding success rate differences[1] between women and men, 2004



Source: WiS database DG Research. Exceptions to the reference year: AT, SE: 1999; IL: 2000; El, LU, NL, LT: 2002; IE, IT: 2003 Data unavailable: ES, FR, MT, BG, RO, TR. BE: Flemish community only. Data are not necessarily comparable between countries due to differences in coverage and definitions.
[1]Success rate men minus success rate for women.

Figure 5.3: Proportion of women on scientific boards, 2004



Source: WiS database DG Research. Exceptions to the reference year: FR, PL, SE: 2002; BG, IT, LV: 2003. Data unavailable: AT, EL, ES, LU, MT, PT, RO, TR, IL . BE: French community only. Data are not necessarily comparable between countries due to differences in coverage and definitions.

Beyond the foregoing, certain indicators based on national or regional standards are also available, particularly within European countries. Among these are indicators measuring:

- funding success rates by sex, as collected by the European Commission (*She Figures,* 2006, Page 70, Fig. 4.1).
- the proportion of women in scientific boards, an indicator closely related to the process of setting the scientific agenda, also collected by the European Commission (*She Figures,* 2006, page 71, Fig 4.2).
- indicators on researchers' careers by seniority (see **Figures 2.1a** and **2.1b** on pages 77 and 78) – the EC classification of academic grades is being used in European Union Member States and will potentially be included into the Eurostat statistics system.
- the proportion of women among employed scientists and engineers (see **Figure 4.3** on page 130).

Disseminating existing and sex-disaggregated national and regional indicators more broadly – particularly indicators measuring researchers by field of science, age, qualification and citizenship/nationality, and indicators of higher-education enrolment and graduates by field – would be invaluable in raising awareness of STG issues and the need for similar international statistics.

Among potentially useful international sex-disaggregated indicators that could greatly support the design of evidence-based policies in S&T would be:

- R&D output indicators, based on patents, bibliometrics, citations (journals and databases would have to register the sex of the author/s).

- 'Pay gap' and other S&T labour-market indicators.
- Indicators of researcher participation rates by gender and fields of science and seniority, especially concerning new appointments to the top level ('full professors' in the higher education sector).
- Indicators on decision-making positions at various levels, including evaluation structures and boards of editors at international journals. This would require a classification of decision-making levels within higher education institutions (along the lines of 'rectors, pro-rectors, senate, faculty' or 'dean, pro-dean senate, departments'), research institutions ('directors, members of boards & scientific boards, heads of departments, heads of research teams'), and in policy decision-making bodies in S&T ('parliamentary S&T committees, ministers and senior civil servants responsible for S&T, national S&T councils').
- Indicators measuring applications and success in scholarships and grant proposals (including the awarding of fellowships) by fields of science, by amount of funds (per project) and possibly by number of project members.
- Indicators on awards, honours or recognitions at international, national and university level (honorary doctorates), and awarded within an industrial sector or by private institutions (foundations, etc.).
- Participation in academies of science.

STG indicators must be embedded in information systems that collect data on women in general decision-making positions, information on labour-market conditions (such as rules for maternity leave, healthcare, childcare, working hours, social security

Box 5.5: Information systems for STG: SESTAT and the ScienTI Network

SESTAT is a comprehensive and integrated system of information about the employment, educational and demographic characteristics of scientists and engineers (S&E) in the United States. In concept it covers those with a bachelor's degree or higher who either work in or are educated in science or engineering, although some data on non-S&Es are also included. SESTAT was created by the National Science Foundation (NSF) to provide data for policy analysis and general research. SESTAT contains data from various NSF-sponsored demographic surveys, conducted in 1993, 1995, 1997 and 1999. These surveys provide data that have been integrated into a single system. The 1999 surveys include responses from about 87,000 individuals representing 13.1 million scientists and engineers, and covers labour force information, professional activities, education, family-related information and demographics (including sex). According to this database, 29 percent of S&Es in the United States who worked in R&D activities in 1999 were women.

ScienTI Network is a public network of sources of information and knowledge that aims to contribute to the management of scientific, technological and innovation activities. The network provides a public and cooperative space for stakeholders of national science, technology and innovation systems and communities of the member countries (Argentina, Brazil, Chile, Colombia, Cuba, Ecuador, Panama, Paraguay, Peru, Portugal, Venezuela) to interact. The sources of information include résumés (CVs), research groups, institutions and projects. All sources are standardized using international references in order to assure interoperability in the Internet. The network is designed to have an updated identification of skilled human resources, institutions and research projects for development and assessment of national policies and capacities in science, technology and industry, as well as to promote international cooperation programmes. The network is the expression of international cooperation among the National Science and Technology Organizations, International Science and Technology Cooperation Organizations (RICYT, SHARED, I-RESEARCH), R&D Groups in Information and Knowledge Systems, and Sponsoring Institutions, such as PAHO, BIREME, OAS and UNESCO.

Sources: SESTAT data are available at www.nsf.gov/statistics/sestat. For ScienTI, see www.scienti.bvsalud.org/ php/index.php?lang=en.

Quality statistics that respond to the demands of policy-makers and at the same time allow better cross-national comparability are crucial.

schemes) and various other labour-market statistics backing up the analysis of the situation of women in S&T. To better understand the figures, historical background and local social values need to be taken into account.

The information available is still widely insufficient, and sometimes provides only a partial or rather superficial picture. For example, many issues related to work conditions and problems such as work-family balance are still not reflected in existing statistics. Quality statistics that respond to the demands of policy-makers and at the same time allow better cross-national comparability are crucial.

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ANNEX 1

GLOSSARY*
SCIENCE, TECHNOLOGY AND GENDER

BRAIN DRAIN: Loss of human skills and talents, associated with emigration of skilled individuals from the state or lack of emphasis on research and development (R&D).

e-LEARNING: A broader concept than online learning, e-learning encompasses a wide set of applications and processes using all available electronic media (Internet, intranets, extranets, satellite broadcasting, audio/video, interactive TV and CD-ROM) for more flexible delivery of education and training.

EMPOWERMENT*: People – both women and men – taking control over their lives and daily activities, making decisions, developing self-reliance, solving problems, and building strength and self-confidence.

EVALUATION: Process seeking to determine the pertinence, efficacy and impact of the use of resources, activities and results as a function of pre-established objectives. Evaluation – 'ex-ante' or 'ex-post' – is a dynamic, technical, systematic, rigorous, trans-

* This glossary represents a contribution from some of the team leaders, and the terms and concepts do not necessarily represent the views of UNESCO or any of the institutions involved in the preparation of this report. Definitions with a star are partially drawn on UNESCO BSP/WGE baseline definitions of key concepts and terms.

parent, open and participative process, supported by diverse data, information, sources and agents and explicitly incorporated in the decision-making process. The evaluation unit (evaluator) should be independent from political instances and from those executing or involved in the process, and be credible and autonomous. Currently, multi-criteria evaluation methods (q.v.) are increasingly being used in very diverse situations, including project evaluation.

GENDER*: Related to the social and cultural differences between women and men, which are learned, changeable over time and very different both within and between cultures (while only women can give birth, biology does not determine who will raise the children-gendered behaviour). The roles and responsibilities of men and women are created in families, societies and cultures, as are the expectations held about the characteristics, aptitudes and likely behaviours of both women and men (femininity and masculinity).

GENDER ANALYSIS*: The collection and analysis of gender/sex-disaggregated information, which aims to explore and examine the differing roles, experiences and needs of women and men.

GENDER AWARENESS: The ability to identify problems arising from gender inequality and discrimination.

GENDER BLIND: A perspective that completely ignores the gender dimension, or differences between women and men. Gender blind policies often implicitly reproduce the male norm: interventions may appear neutral since they are expressed in abstract, generic categories, but are implicitly male biased.

GENDER DIMENSION: Giving differential treatment to individuals on the grounds of their gender.

GENDER DIVISION OF LABOUR: An overall societal pattern where women are allotted one set of gender roles, and men are allotted another set; a social division of work between women and men according to what is considered suitable or appropriate to each gender. Unequal gender division of labour refers to a situation in which there is an unequal gender division of reward.

GENDER EQUALITY*: A situation in which all human beings are equal and free to develop their personal abilities and make choices without limitations; the equal valuing by society of the similarities and the differences of men and women, and the roles they play. Both women and men have equal conditions for realizing their full human rights and for contributing to, and benefiting from, economic, social, cultural and political development. Structural gender inequality exists where gender discrimination is practiced by social institutions.

GENDER EQUITY*: The quality of being fair and impartial to men and women. Measures must often be put in place to compensate for the historical and social disadvantages (equity is a means, equality is the result).

GENDER IMPACT: The different outcomes of apparently neutral policies on women and men, reinforcing existing inequalities.

GENDER MAINSTREAMING*: A process aimed at integrating the gender dimension into existing institutions and practices in order to achieve gender equality and improve the relevance of development agendas; taking account of gender equality concerns in all policy, programme, administrative and financial activities, and in organizational procedures, bringing the outcome of socio-economic and policy analysis into all decision-making processes, and tracking the outcome.

> The process of assessing the implications for women and men of any planned action, including legislation, policies or programmes, in all areas and at all levels; a strategy for making women's as well

as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programmes in all political, economic and societal spheres so that women and men benefit equally and inequality is not perpetuated; the ultimate goal is to achieve gender equality (UN/ECOSOC).

GENDER NEUTRAL: Targeted interventions, appropriate to the realization of predetermined goals, without a change to the existing division of resources and responsibilities.

GENDER ROLES: The social (and not biological) constructs and responsibilities of men and women as created in families, societies and cultures, and the expectations held about the characteristics, aptitudes and likely behaviours of both women and men (femininity and masculinity). Gender roles and expectations are learned, can change over time, vary within and between cultures, and determine access to resources and opportunities.

GENDER SEGREGATION:

Horizontal: The uneven distribution between disciplines and between sectors of the economy, public and private. Horizontal segregation refers to concentration rates in certain occupational sectors or disciplines.

Vertical: The uneven distribution over levels of seniority. Vertical segregation concerns the position of women and men within the hierarchies of science.

GENDER SENSITIVITY: Policies and activities that take into account the particularities of the lives of both women and men, while aiming at eliminating inequalities and promoting an equal distribution of resources.

GENDER / SEX DATA/STATISTICS: Information divided by gender/sex; data that is collected and presented separately on men and women (in ‘sex counting’ gender is treated as a biological statistical variable only).

GLOBALIZATION: The continuous world expansion of capital to deeper and broader levels than any previous period, which conditions the processes of production of goods and services, international capital flows, and at the same time determines the nature, dynamics and the direction of technological change. The globalization of the economy increased in the 1980s as a result of two crucial changes: economic deregulation policies and the role of information and communications technologies (ICTs). Globalization involves a logic of homogenization and standardization of the economy, production, consumption, knowledge, education and culture, and forms part of a hegemonic discourse that hides the nature and specificity of development problems at the local, national, regional and worldwide levels.

Globalization does not emerge as a superior world harmony which forms a new international division of labour, but as the interrelationship of planetary chaotic flows (mainly financial), and works as a great social, political and cultural destructuring, segmentational and marginalizational phenomenon in the periphery (including little by little, the periphery in developed countries). ‘Techno-globalism’ represents the supposed globalization of scientific research and technological innovation activities, against the spatial reality of local and national systems.

INDICATOR: An aggregate and complex measurement that enables describing or evaluating a phenomenon, its nature, state and evolution; it articulates or correlates variables and its measurement unit is compound or relative. It is an individual or composite statistic that relates to a basic construct (in science and technology) and is useful in a policy context. The purpose of indicators is to characterize the nature of a system through its components; how they are related and how they change over time. This information can then be used to judge progress toward some goal or standard, against some past benchmark, or by comparison with data from some other institution or country.

Indicators generally present the following characteristics: generality, correlation between different variables or in different contexts, quantifiability, temporality, and the possibility of becoming basic components of theoretical developments. **Variables** are the elements that make up or characterize a phenomenon; usually they are measurable, have a measurement unit and are expressed in absolute values. **Statistics** are the tabulated results of measuring a variable (action, attribute, object), although in occasions they are used in a broad sense to designate the theoretical and methodological (operational) aspects of a measurement.

INNOVATION: The introduction of a new technique, product, production/distribution process, or service; a process that may often be followed by a spread process of diffusion. There are three types: product innovation, process innovation (method of production) and organizational innovation. It frequently implies moving from invention to commercial practical use; inventions that are introduced into the regular system of production or distribution of commodities and services are 'technical innovations'; although inventions are not the only source of innovation in the economy. Innovations are of two types: (i) incremental innovations (minor, continuous, cumulative), which bring about the improvement of the availability of products and processes; or (ii) major innovations (radical), that result in new technologies which lead to new products, processes or services. According to linear-sequential models, there are two kinds of innovation: 'discovery-push' (prior discoveries in science or technology) or 'demand-pull' (market demand, management's assessment of prospective needs).

KNOW-HOW: Non-divulgated, confidential, practical, unpatented, technical knowledge, professional experience and accumulated skills for the production and distribution of commodities and services.

KNOWLEDGE: Theoretical or practical understanding acquired on a natural or social phenomenon, or referred to thought, on the basis of information in a specific domain.

KNOWLEDGE ECONOMY: An idea about knowledge, science and technology replacing the traditional assets of land, labour or capital as the basis for wealth creation, competitiveness and economic development.

KNOWLEDGE SOCIETY: A society and economy organized around the learning, generation, adaptation, utilization and dissemination of knowledge. Generic idea about key changes in the role and importance of knowledge in society.

LIFELONG LEARNING: A continuous process for acquiring new knowledge throughout one's life (even after retirement), spreading to embrace all stages of life and all social groups (increasingly based on e-learning).

MENTORSHIP: A relationship in which a more experienced person contributes directly to the growth and development of the student; a formal, long-term relationship between a student and a professional role model who provides support and encouragement to the student.

MONITORING: The continuous collection and analysis of information in order to measure trends over time so as to determine whether interventions are having the desired result, or need to be changed; producing performance measures, and reporting and disseminating performance information.

MULTI-CRITERIA, DECISION/EVALUATION METHODS: Optimization involving various simultaneous objective functions and a single decision-taking agent; rationality and consistency of evaluation procedures. (Discrete) Multi-criteria Decision methods (MD) are used to carry out an evaluation and to make decisions concerning problems that, by their nature or design, are open to a finite number of alternative solutions. MD methods introduce a logic of analysis in order to apprehend the set of factors involved in reaching objectives, and to offer coherence to individual or group appreciations for obtaining valid conclusions. This logic is counterpoised to non-explicit, non-justified and intuitive thought and preferences underlying many of the evaluations and decisions related with complex programmes, projects and activities. Multi-criteria methods also respond to the need to supersede analysis or evaluation of the uni-criteria type (such as [Social] Cost-Benefit Analysis). The main multi-criteria methods are: multi-attribute utility, scoring, Analytic Hierarchy Process, and outranking (ÉLECTRE, PROMÉTHÉE).

NATIONAL (SOCIAL) SYSTEM OF INNOVATION: A network of institutions, resources, interactions and relations, political mechanisms and instruments, and scientific and technological activities (q.v.) that promote, articulate and materialize the technological innovation and diffusion processes in society (generation, import, adaptation and diffusion of technologies). National (social) systems of innovation (NSI) vary substantially both in their dimension as in their method of operation. The main dynamic elements are: (i) short and long-term technological prospective and strategic planning at governmental level; (ii) movement of financial and technological resources (government and companies); (iii) short and long-term strategic planning in companies; (iv) companies' R&D strategy integrated into the design and development of productive systems; (v) role and dimension of educational and training systems; (vi) role played by social innovations in the motivation, training and regulation of the work force; (vii) industrial structure favourable to long-term strategic investment in continuous training, innovation and marketing; (viii) technological organization and management of the company (continuous learning and innovation, continuous training, information flows and communication networks; (ix) company-university collaboration networks; and (x) user-producer-researcher interactions.

POSITIVE / AFFIRMATIVE ACTION: Agreed unequal treatment or incentive measure to compensate discrimination and improve gender equality.

PROJECT: An integrated set of activities geared to attain specific objectives, having defined resources (human, physical, equipment, material and information), a specific budget, responsible persons/institutions, and a given time frame.

PROSPECTIVE STUDIES: Outline and analysis of a certain number of possible futures ('futuribles'). Spatially and temporally (long-term) distant analysis of the possible evolution of a given situation, phenomenon or problem. Prospective studies are placed within a historical process and, supported by a retrospective analysis, approach the future as an occurrence. Prospective studies do not produce forecasts but conjectures supporting decision-making. Prospective studies do not attempt to reduce the unlimited variety of possible futures to a handful of alternatives, but rather to clarify and make explicit the dangers and opportunities taking shape in the long term. Prospective studies, through anticipation, seek to enable true freedom of decision and action. The main techniques are: scenarios (relevance trees), consensual methods (Delphi, expert panels, brainstorming), structural and morphological analysis, cross-impact analysis, input/output analysis, forecasting techniques, modelling, contextual mapping, decision trees, etc.

SCIENCE: (from the Sanskrit -'special wisdom', and its Latin derivation -'knowledge'): The term 'science' is used today to designate an Organized system of knowledge related to nature, society and thought. Science is knowledge-driven. Although, in the past, wide (free) access to scientific knowledge existed, currently a restrictive trend may be observed. Science may eventually be applied to the production or distribution of commodities and services, but only in an indirect and mediate manner. Science is, to some extent, universally valid. However, in its broader sense, science (and technology) is neither neutral, value -free nor non-normative, but, just like other ways of classifying reality and arranging data, it is generated in historical and social contexts that implant their values and social interests in its structure. Science reflects the social relations in the organizational forms of its existence, in its content (to a certain extent) and in the theoretical and cognitive forms of its development.

SCIENCE AND TECHNOLOGY (S&T): Historically, science (q.v.) and technology (q.v.) had been separate. The fact of science's increasing impact on technology has led to the mistaken idea that technology is just applied science. Science has its internal dynamics; similarly, new technology often grows out of old technology (not out of science). Science and technology came into close interaction during the nineteenth century. Prior to that, few inventions were based on science; they were based almost wholly on the empirical insights of craftsmen, with no discernible scientific input.

By the latter half of the nineteenth century, science stimulated many inventions, which in turn led to the growth of science-based technologies and industries, as in electricity and chemistry. During the Industrial Revolution (eighteenth and nineteenth centuries), the development of machinery that revolutionized production was mainly the result of empirical quests. In the twentieth century, the development of new machinery, processes and products has mainly been the (indirect) result of scientific research; the initial element with revolutionizing influence on production has not been machinery but science.

Thus, historically, the role that science has played in the development of productive forces comprises three periods: (i) the pre-scientific application of the laws of nature to technology and the productive forces; (ii) the first phase of conscious, large scale application of science, as such, to the productive forces (nineteenth century, early twentieth century); (iii) the close and 'institutionalized' relationship between science and production (the 'technological sciences', twentieth century).

Today, science and technology are extraordinarily interrelated (intermixed). On the one hand, there is an increasing 'scientification' of production. On the other hand, science itself (the natural sciences) is becoming somewhat 'technological', i.e. it increasingly rests on the technical basis of experiment, laboratory-based experimental-production, and factory-like organization (often, scientific knowledge requires technical solutions to its problems and the material embodiment of its discoveries). However, this does not mean the transformation of science into a so-called 'direct productive force'. The mutual penetration of science and technology does not erase functional distinctions between scientific and directly productive labour, nor the social distinctions between their subjects. It does not seem possible to explain the relations between science and technology on a simple causal basis; there is rather a dialectical relationship between the two.

SCIENCE AND TECHNOLOGY INSTITUTIONALIZATION: Establishment and maturity of institutions, mechanisms, instruments, resource flows and scientific and technological activities in society, which acquire organizational and practical methods that are acknowledged and included in the society's culture.

SCIENCE AND TECHNOLOGY PLANNING: Process of allocation and utilization of scarce resources; definition of criteria for the implementation of scientific and technological activities, and follow-up and evaluation of those actions, in order to achieve a set of goals, representing progress towards reaching long-term objectives of scientific and technological development, in a given period of time (usually within the context of national socio-economic development objectives).

SCIENCE AND TECHNOLOGY POLICY: Set of principles, declarations, guidelines, decisions, instruments and mechanisms oriented towards scientific and technological development in the medium and long term (usually within the framework of overall socio-economic development objectives). The term 'science policy' is sometimes used as an abbreviation of S&T policy, though on other occasions it has been employed as an equivalent of scientific and technological research policy (R&D promotion, financing and coordination). However, the expression 'technology policy' has been used in the sense of technological options for industry (which is closely linked to industrial policy). Recently the expression 'policies for industrial innovation' has come into use, which in fact represents the point of convergence (fusion) of S&T policy and industrial policy.

SCIENCE AND TECHNOLOGY POPULARIZATION: Scientific and technological knowledge communication and appropriation process directed at broad sectors of the population. The aim of S&T popularization activities is that they become a central component of culture, social conscience and collective intelligence, and they include: (i) S&T interactive centres (and exhibitions), (ii) S&T popularization multimedia programmes, (iii) mass media (television, radio, the press and Internet), and (iv) formal education: learning of sciences.

SCIENTIFIC AND TECHNOLOGICAL ACTIVITIES: Systematic actions directly and specifically relating to scientific and technological development, to the generation, dissemination, transmission and application of scientific and technological knowledge. These include: scientific research, technological research, transfer of technology, information services, consultancy, engineering and technical assistance services, metrology and standardization, S&T planning and management, and training of the scientific and technical personnel required for those activities.

SCIENTIFIC AND TECHNOLOGICAL SYSTEM: National system (q.v.) of institutions, resources, interactions and relationships, political mechanisms and instruments, and scientific and technological activities (q.v.) that in some (developed) countries reflect and are near to a complex reality, while in other countries (underdeveloped) reflect and are near to an analytic abstraction (embryonic reality).

SCIENTIFIC RESEARCH (traditionally called basic or fundamental research): Activity oriented towards creating new systematic (scientific) knowledge, innovations in the field of science and with no immediate practical application to production or distribution of commodities and services; it has no perceptible relevance to techniques (q.v.). However, it can have an explicit function as a generator of ideas and methodologies of immediate application. Eventually, it may result in a 'scientific discovery'.

STRATEGY: A way of relating to the environment; form (ways, modalities) of achieving the proposed objectives.

STRATEGIC PLANNING: Planning process at the level of an organization, involving the elaboration of an internal diagnostic and one of the external environment; formulation of missions and objectives; (external) analysis of opportunities and risks (position vis-à-vis the environment); (internal) analysis of strengths and weaknesses; formulation, selection and choice of a strategy (strategic definition, alternatives); activities, costs and time limits (implementation); and evaluation. Includes strategic, tactical and operational plans.

STEREOTYPING: The constant portrayal (media, images, culture) of women and men occupying social roles according to the traditional gender division of labour in a particular society; gender role stereotyping works to support and reinforce the traditional gender division of labour by portraying it as 'normal' and 'natural'.

SUSTAINABLE DEVELOPMENT: Development that meets the needs of the present without limiting the potential to meet the needs of future generations, where people are at the centre of the development process and advocate the protection of life opportunities for present and future generations while respecting the natural systems upon which all life depends.

TECHNIQUE: (from the Greek 'techné': art, skill, craft – the power or capacity, the habit or expertness, and the intellectual virtue of a man to make a product or an artefact): Knowledge, methods, procedures, skills for carrying out a specific production, distribution operation or activity whose objectives are defined. It is knowledge pertaining to the individual components of technology (as a system of knowledge), the means of utilization of technology (q.v.); it is knowledge embodied in a specific means of labour or labour force itself (inputs) or in production (or distribution) operations. Empirical techniques are skills, traditional crafts, practical knowledge and experience not grounded on science (q.v.).

TECHNOLOGICAL RESEARCH: (traditionally known as applied research and experimental development): Activity oriented towards the generation of new (technical) knowledge that can be directly applied to the production and distribution of commodities and services; it may lead to an invention, an innovation and an improvement (a minor application). Technological research is not the only source of changes in technology. Scientific and technological research seem to be more adequate terms, at least in the case of LDCs, than the traditional and rather ambiguous one of 'research and development (R&D).'

TECHNOLOGY: Often scientific knowledge, but also differently organized knowledge, systematically applied to the production and distribution of commodities and services. Technology is the sum of knowledge and methods for producing and distributing commodities and services, including those embodied in the means of labour, labour-force, processes, products and organization. Technology is need-driven, by the satisfaction of the needs of society, economy and business. There is a current trend towards privatizing and restricting access to technological knowledge. It is a system of technical knowledge, a systematic knowledge of the practical or industrial arts; it consists of a series of techniques (q.v.) (it is implemented through them). Technology comprises empirical techniques, traditional knowledge, craftsmanship, skills, procedures and experience not grounded on science (q.v.). Technology reflects and is determined by both technical and social relations of production (it is not 'neutral') within a given social formation; it is a concrete response to specific social economic conditions.

TECHNOLOGY ASSESSMENT: Process of systematic analysis, forecasting and evaluation of a wide range effects on society, the environment and the economy concerning the choice of techniques and technological change, with the purpose of identifying public policy, investment and production options. Evaluation of the social, environmental and economic costs of existing (civilian and military) technologies (q.v.), in the form of pollution, social disruptions, infrastructure costs, etc., anticipation of probable detrimental effects of new technologies; devising of methods of minimizing these costs; and evaluation of the possible benefits of new or alternative technologies in connection with social and economic needs. It tends to be, however, a relevance analysis and cost-benefit calculations (of a technocratic and economicist nature).

TECHNOLOGY MANAGEMENT: Utilization of management techniques to support technological innovation processes. It involves management methods (administration), evaluation, economics, engineering, computer sciences and applied mathematics. Technological needs and opportunities are identified in technology management and technological solutions are planned, designed, developed and implemented. It is a process whereby technological research activities are managed and the results are transferred to productive units. What is important for competitiveness (and productivity) is the capacity to place technological development (innovations, technical progress) within the framework of the enterprise's strategy.

TRANSFER OF TECHNOLOGY: Process of transmission of technology (technical knowledge) and its absorption, adaptation, diffusion and reproduction by a different productive apparatus from the one that has produced it. The transfer of technology is a much wider problem than the simple diffusion of technical innovations (q.v.), although such diffusion is an important vehicle for technology transfer. The transfer of technology seldom occurs in LDCs, as compared to the common process of commercialization of technology (search, bargaining and contracting of technical knowledge and its future use in the production and distribution of a given commodity or service).

Annex 2

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UN Millennium Development Goals: www.un.org/millenniumgoals.

US National Science Foundation: www.nsf.gov.

UK Labour Force Survey: www.statistics.gov.uk.

UNESCO Institute for Statistics (UIS): www.uis.unesco.org.

Women and girls around the world are excluded from participation in science and technology (S&T) by poverty, lack of education and aspects of their legal, institutional, political and cultural environments. *Science, Technology and Gender: An International Report* is designed to support efforts being made worldwide to analyze, discuss and change this situation.

Based on empirical research and data, this UNESCO report incorporates substantive inputs from institutions involved in science, technology, gender studies and policy. Marking the start of an ongoing initiative, it aims to spur serious discussion and action in national and international scientific and academic communities, especially regarding the pressing needs to increase women's participation in S&T careers and enable sex-disaggregated data collection and rigorous research development, along with increasing public awareness of gender issues.

With its goal of helping educators, policy-makers and the members of the scientific community to address the underlying causes of gender disparities in S&T, both in the public and private sectors, this report represents an important contribution to the political and institutional mainstreaming of the gender dimension in S&T.

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