Experts' Meeting on Gender, Science and Technology

Industrial Science and Technology Working Group

PROCEEDINGS OF THE APEC EXPERTS' MEETING ON GENDER, SCIENCE AND TECHNOLOGY

10 - 11 March, 1998
Manila, Republic of the Philippines

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REPORT OF THE ISTWG EXPERTS' MEETING ON GENDER, SCIENCE AND TECHNOLOGY

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MEETING OBJECTIVES

The APEC Experts' Meeting on Gender, Science and Technology was convened on 10 and 11 March, 1998 in Manila, Philippines. Falling under the auspices of the Industrial Science and Technology Working Group of APEC, the conference was co-sponsored by Canada, Indonesia, Korea, and the Philippines.

The meeting was attended by 42[1] experts from 13 APEC member economies (Australia; Brunei Darussalam; Canada; Hong Kong, China; Indonesia; Japan; Korea; Mexico; New Zealand; Philippines; Chinese Taipei; Thailand; United States). Also in attendance were guest experts from the United Nations Education, Scientific and Cultural Organization (UNESCO) and a consultant with expertise in the Organization of Economic Cooperation for Development (OECD)

The two day meeting focused on gender disaggregated data on science and technology. Special emphasis was placed on that data which is required for the formulation of policies and strategies to promote gender balance in scientific and technological education and careers. Specifically the objectives of the meeting were to:

- identify the critical data necessary to understand the underlying participation rates of women and men in scientific and technological education and careers;
- examine systematic approaches and coordination methods for ensuring the collection of comparable gender-disaggregated data on science and technology;
- discuss data analysis and policy actions that will help to remove barriers to women's participation in science, technology, and engineering education and careers.

ORGANIZATION

The meeting was co-chaired by Ms Monique Frize from Canada and Ms Aurora Perez from the Philippines. Mr William Padolina, the Secretary of the Department of Science and Technology in the Philippines, presented the formal welcome address to the meeting participants, while the key note address was given by the noted Ms Marilyn Waring of New Zealand.

The remainder of the meeting's presentations (12 papers and 3 discussant presentations) were organized around three thematic panels entitled:

[1] A list of participants with their contact addresses is presented at the end of this document.

- Existing Data
- Data Sources - Instruments in Use
- Statistics with a Purpose: Policy-Making within APEC Economies

These served to provide stimulus to the six workshop discussions, each of which derived specific recommendations for gender, science and technology. The six workshops each reflected one of six phases of S&T. These were: primary and secondary education; post-secondary education; research; workplace; associations; and coordination mechanisms

This report presents summaries[2] of the key note address, the panel presentations, as well as the salient points arising from subsequent discussions. It ends with a listing of the recommendations from the six discussion groups.

KEY NOTE ADDRESS

WHY IS GENDER AN IMPORTANT ISSUE IN APEC SCIENCE AND TECHNOLOGY?

Marilyn Waring

In this engaging presentation, Ms Marilyn Waring reminded listeners of the importance of looking at both the pros and cons of science and technology, thereby acknowledging the duality of gains and losses, which co-exist in S&T. This examination indeed calls into question the often assumed neutrality of technological tools, especially when gender in science and technology is considered.

On the debate about gender in S&T, Ms Waring argued that the critical questions to be asked are about power in S&T decision making. They centred around the contexts in which decisions are made, technical information is conveyed, and technological innovations are adopted. Four specific contexts can be identified for gender analysis purposes: the design or developmental stage, the user context, the environmental context and the cultural context. Of these, much more is known about the design and development stage than the other three contexts. The lack of knowledge about the environmental and cultural contexts in which women and men interact with S&T, combined with men's relative advantage in controlling resources and the media, contribute to the perpetuation of the myth that women and men benefit from S&T equitably.

In addressing strategies for improving gender equity in S&T, Ms Waring stressed the importance of engaging in actions which were not only inclusive (e.g. increasing the number of women in S&T decision-making), but also transformative. This would enable the challenging of some basic assumptions about gender, science and technology, and would begin to address the vast number of socially constructed exclusions embodied in such arenas as language, teaching methods, textbooks, curricula, and media stereotyping. This indicates

[2]The full texts of the presentations are contained in the second section of this publication.

that for each of the four contexts, there is a need for holistic frameworks in analysing gender equity in S&T.

Ms Waring further pointed out the importance of placing the usefulness of data requirements within the context of need. She noted that of the constraints which had been observed as barriers to women in S&T in APEC, some would not be assisted by data, requiring instead determined women's struggles. However, she did acknowledge that time use data could be useful in many ways, including in elaborating the inefficiencies in the use of human resources by unnecessary fragmentation of time, by providing measures of the interdependence of the activities of household members, and market and non-market activities. She also noted that in some situations, there were serious difficulties in the collection, coordination and reporting of statistical data.

While acknowledging the importance of sufficient quantities of good quality data, Ms Waring pointed out that a greater obstacle in achieving gender equity was that of affecting a paradigm shift. In conclusion, she emphasized the need for political will in achieving the desired transformation towards gender equity.

PANEL 1: EXISTING DATA

WOMEN IN SCIENCE, MATHEMATICS, ENGINEERING AND TECHNOLOGY IN THE U.S. THE CASE FOR DISAGGREGATED DATA

Shirley Malcom

Ms Shirley Malcom began her presentation with a description of the network of agencies involved in the collection of scientific and technological data in the United States. These included such institutions as the U.S. Department of Education, the National Science Foundation, the Census Bureau, the Department of Labour, and the National Centre for Education Statistics.

She noted that although gender disaggregated data on education was being collected as early as the 1920s, its profile was increased with the affirmative action requirements which arose in the 1970s. It was also in the 1970s that racially-disaggregated data on science and technology began to be collected and reported. Although organizations such as the American Association for the Advancement of Science (AAAS) work on the collection of gender-disaggregated S&T data, this data is still not abundant, and presents some challenges for collecting and reporting.

However, there are a number of documents and publications in the United States which report gender-disaggregated data for education, including S&T education. Some of these include the *Digest of Education Statistics*, *The Condition of Education*, which was federally mandated by the Educational Amendments of 1974, the *Science and Engineering Indicators*, and the *Women, Minorities and Persons with Disabilities in Science and Engineering*, another report which is mandated by the Equal Opportunities in Science and Engineering Act of 1980.

In addition to "head counting" it is important to also take into account more qualitative aspects of measurements. For example, in the United States, there have been remarkable improvements in gender balance in almost all science and technology fields. While it is easy to notice the gains in the increased numbers of women entering the fields, the associated changes in supportive policies, programs and culture which underpinned these advances are less apparent.

Likewise, it is important to get an insight into more qualitative aspects of data which reports the gender breakdown of participation in particular science and mathematical classes at all levels of education. These include, for example, the nature of science and mathematics classes, opportunities for engagement with S&T concepts both in and outside the classroom and the nature of class room practices.

Ms Malcom stressed the importance of being cognisant of the various objectives behind data collection, whether they be to attempt to influence policies, or to influence parent-focused intervention. She emphasised the need for the collection of data which was relevant in answering policy questions, and hence the need to communicate with policy-makers.

ARE GENDER DIFFERENCES IN THE ACADEMIC ACHIEVEMENTS OF HONG KONG SECONDARY SCHOOL STUDENTS DISAPPEARING?

Vivian Cheng

The second speaker on the first panel, Ms Cheng, presented research results which attempted to explain gender differences in the participation and performance of boys and girls in Hong Kong, China, high schools. The research sought to get an objective assessment of gender differences, using statistical techniques. An assessment of gender differences was made for participation and performance in the Hong Kong Certificate of Education Examination (HKCEE), which students undertake at a level equivalent to grade 11; and the Hong Kong Advanced Level Examination (HKALE), which is taken two years later.

The analysis was based on time-series data for the period 1980 to 1997. Using statistical methods, they found that at the HKCEE level, more boys participated in science subjects, while female students predominated in the classes of fashion and clothing, home economics and shorthand. It was found that girls scores in physics, chemistry, biology and additional mathematics were found to be higher than those for boys. The only subjects in which boys were found to score higher were mathematics and computer studies.

At the HKALE level, boys were found to out-score girls in mathematics and science subjects, even though the margin was slight. Girls out-scored boys in English and Chinese language classes, as they did at the HKCEE level. Ms Cheng pointed out that among those students who obtained the highest grades (A), the gender differences in scores were higher. Finally, trend analysis showed that gender differences for participation were declining, but that for participation varied among different subjects. At the Advanced level, gender differences in performance in science and mathematics courses were actually found to be increasing.

According to the results of this study, Ms Cheng urged Hong Kong, China decision-makers in education to consider further such issues as why gender differences persist in boys and girls scores in language courses, and why girls performance in mathematics and physics are not improving over time at the HKALE Level, while they are clearly improving at the HKCEE level?

DATA ON SCIENCE AND TECHNOLOGY IN THE WORK PLACE: THE KOREAN CASE

Young Ock Kim

The third panellist, examined gender differences in science and engineering (S&E) education, careers, research and development and decision-making agencies in Korea. In particular, the author noted that while Korea has almost achieved gender parity among natural science degree recipients (44.5% in 1996), women are still under-represented in engineering; only 8.3% of engineering bachelor's degrees were awarded to women in 1996.

Data shows that this gender gap is even larger in S&E careers, especially in science and engineering faculties and decision-making committees. The participation rate of women in science and engineering careers is less than the rate of women recipients of science and engineering degrees, indicating a “leaky pipeline” for women scientists. This finding is confirmed by the calculated “employment rate” for women graduates of S&E programs Ms Kim did note that even within S&E fields, the employment rates, as well as the gender gap in employment rates differ.

In examining gender-disaggregated data for science and engineering research and development personnel, Ms Kim pointed out that this had been collected since 1990. In this period, the number of women among S&T personnel has been rising at a faster rate than that of men. However, in 1995, only 8% of S&T research and development personnel were women; most of these were employed by public institutions, and the evidence suggest lower ratios of women in the higher ranks.

Ms Kim also analysed the share of women in S&T faculties. Only 2.8% of S&T professors were women, the largest share being found in biological sciences, 9.6 %, while less than 0.5 % of professors in material engineering, electric, electronic, mechanical and civil engineering were women. Finally, the presenter outlined the policy implications and recommendations related to the collection of gender-disaggregated S&T data. She pointed to the need for the increased availability of gender-disaggregated data in order to more accurately measure the participation of all potential scientists and engineers in Korea. In concluding she suggested ways in which this could be accomplished.

Discussant: ***Sjamsiah Achmad***

Ms Sjamsiah Achmad highlighted and discussed some of the key points from the presentations of the first panel. She noted the that Ms Malcom’s presentation focused on S&T data for education. She reminded the participants that although quite a lot of gender disaggregated data had been collected in the United States, it has not yet been fully utilised at all levels of policy and monitoring. Indeed, there is still a need for the increase collection, analysis and use of good quality data and indicators on gender, science and technology. Ms Achmad noted the importance of more personnel in the area of gender analysis in order to facilitate this.

Ms Vivian Cheng's presented the results of a study which evaluated gender differences in the participation and performance of high school students in Hong Kong. Ms Achmad pointed out how it was also important to look at opportunities for entry at higher levels of education. Other important statistics include student drop out rates, as well as comparisons of curricula for S&T programs. She noted that trend analysis was particularly useful. Ms Achmad pointed out the need to facilitate cross country comparisons of the results of evaluations.

Ms Young Ock Kim's presentation focused on the status of women in science and engineering in Korean education, research and development, and careers. One of the points emphasised was the loss which results from the movement of highly qualified women scientist and engineers out of scientific careers to work in more supportive environments.

On the question of different kinds of data requirements, Ms Achmad noted that the differences in institutional priorities presented a challenge in the manner of data collection and reporting if the data is to be used more fully. In general, data needs to be collected and utilised systematically, facilitating its use by the end-users. Related to this is the need for the development of guidelines for the use of statistical data by policy makers. Furthermore, in addition to education, research and development, and career data, it was important to study the gender-differentiated impact of science and technology.

In conclusion, Ms Achmad stressed the importance of sharing both data and experiences among APEC economies. In particular, there is a need to identify clearly the priorities which should be focused upon in gender and APEC S&T, and to assist women scientists in various exchanges.

PANEL 2: DATA SOURCES - INSTRUMENTS IN USE

GENDER STATISTICS IN SCIENCE AND TECHNOLOGY IN THE PHILIPPINES

Virginia Miralao

In her presentation, Ms Miralao discussed the data sets available at the Philippines' Department of Science and Technology (DOST) for assessing the involvement of women and men in science and technology. She grouped the available data into three clusters as follows:

- personnel data provided by science and technology agencies and institutions,
- data taken from other sources
- data from implementing agencies of S&T programs

The institution-based data indicates near parity levels for research and development (R&D) personnel in academe and public institutions, while men significantly outnumbered women in private industry R&D institutions. Interestingly, women also outnumbered men slightly (52.9%) among the highest personnel category. When segregated by fields of occupation, the data shows that women in R&D are concentrated in Medical Sciences, biotechnology, Natural Sciences and Social Sciences and Humanities, while men dominate in the fields of Agricultural Sciences, Engineering and Technology fields.

Data on membership in the National Research Council of the Philippines also show gender parity. 1994 data demonstrates again that there is a gender preference shown with women dominating the fields of pharmaceutical sciences, chemistry and the humanities, gender parity being more or less evident in the fields of biological sciences, social sciences, earth sciences, governmental, educational and international polices, medical sciences and mathematical sciences. The fields of agriculture and forestry, engineering and industrial research, and physics have a predominantly male membership, between 66% and 80% in 1994.

Ms Miralao notes that the data indicates some bias against women in the receipt of award and recognition for scientific accomplishments. In concluding, she urges the need for more gender-disaggregated S&T data from the private sector. There is also a need to engage in some discussion to clarify the definitions of S&T, considering such issues as the position of indigenous knowledge within these definitions.

SEX-DISAGGREGATED DATA RELATED TO SCIENCE AND TECHNOLOGY IN CANADA

Nancy Ghalam

Ms Ghalam's presentation focused on sex-disaggregated data in Canada in the areas of education and work in the formal economy. She discussed data sources and collection techniques, noting that Statistics Canada, the statistical bureau of the government of Canada, routinely disaggregates all social data by sex. Hence, a broad range of statistical information is available for gender-based analysis of science and technology issues. The data sources discussed included the population census which is conducted every five years, the labour force survey, a monthly household survey of 96,000 individuals, and the survey of consumer finances which is conducted as a supplement to the labour force survey. Administrative educational data from the provincial and territorial ministries is collected by the Centre for Education Statistics at Statistics Canada.

While these instruments are useful, they do have some notable gaps, such as the interaction between paid and unpaid work, or that between post secondary education and occupational achievement. In an attempt to fill some of these gaps, Canada has initiated other data collecting instruments, such as the General Social Survey, a national sample telephone survey of about 10,000 people and the Survey of Labour and Income Dynamics, a panel survey which supports research aimed at advancing the understanding of the labour market. Further labour data is collected by the Workplace and Employee Survey and supplemental educational information is collected by the National Graduates Survey.

The presentation concluded with a description of the use of sex disaggregated data for the purposes of the Employment Equity Act, an important policy initiative for the promotion of equal employment opportunities in Canada.

PRINCIPLES AND PRACTICES: GENDER-DISAGGREGATED DATA ABOUT PARTICIPATION IN UNITED STATES SCIENCE AND ENGINEERING

Mary Golladay

In her presentation, Ms Golladay reviewed the collection practices and challenges in obtaining and reporting gender-disaggregated data for science and engineering in the United States. She described the US system for the collection and reporting of information on science and technology. In particular, she described the Division of Science Resources Studies of the National Science Foundation which has the responsibility for collecting and disseminating information about S&T, noting their strategic interactions with other federal and state statistical units. Ms Golladay pointed out how the structure for collecting data impinged upon three basic principles in developing data to address gender-related issues:

- to understand the policy issues, which requires paying attention to policy makers
- to maintain the objectivity of the data-collection or reporting group and
- to disaggregate data to the greatest extent possible.

Ms Golladay then examined the instruments of data collection presently in use to collect gender-disaggregated data and the means of obtaining this data from various respondents. The instruments identified included institutional surveys and surveys of individuals. In commenting on the use of the collected data, Ms Golladay reviewed alternative presentations of data, noting how the manner of presentation could influence how widespread the data was used. In concluding, she urged for increased sharing of "effective practices" and experiences as a means to facilitate the use of data to influence and inform change.

GENDER IN INTERNATIONAL S&T STATISTICS AND INDICATORS

Gunnar Westholm

In his presentation, Mr Westholm described various issues of science and technology (S&T) data by gender as experienced by some of the largest international agencies: the Organisation for Economic Cooperation and Development (OECD) with Headquarters in Paris, Eurostat (the Statistical Office of the European Commission - EC) in Luxembourg and the United Nations' Educational, Scientific and Cultural Organisation (UNESCO) in Paris. Issues discussed included the available statistics on women and men's differential participation in S&T education and careers.

In the last few years, there has been a more concerted effort to collect gender disaggregated data for S&T. Mr Westholm discussed the recommendations for the collection of gender data in the main international guidelines/manuals. Also discussed were the reasons why such indicators (with the exception of education statistics) have not yet received the same attention as other kinds of international R&D (research and experimental development) and S&T statistics.

He noted the significant problems involved with trying to attain international comparability of data because of varying concepts and coverage of the underlying statistical populations. For many years, there has also been a rather low policy interest. Some of the international guidelines (the UNESCO *"Recommendation",* the OECD "Frascati" and the OECD/Eurostat *"Canberra"* Manuals) were presented, along with a discussion of the principal conceptual problems of international comparisons.

Overall, international organizations have made a lot of gains in collecting education data on gender, science and technology. However, much work remains in the collection and reporting such data as it pertains to S&T careers and employment. Some suggestions were given on how APEC could proceed in collecting gender, science and technology data and statistics.

GENDER, SCIENCE AND TECHNOLOGY: PERSPECTIVES AND PROSPECTS FROM UNESCO

Tony Marjoram

Mr Marjoram began his presentation by noting that science knowledge was gendered, and indeed, the impacts of science and technology also had differential impacts upon women and men. He noted how the application of science and technology is the most important factor in industrial, economic and social development. Women play an important but under-represented role in science and, especially, in engineering and technology. Their contribution to economic development could be more significant. Shortages of human resources in engineering, science and technology are considered to be a major constraining factor to economic development. Many countries realize that and, in addition to promoting gender equity and equality, are promoting the entry of women into engineering, science and technology to address this situation.

Another constraint that then becomes apparent, especially in developing countries, is the need for better quantitative and qualitative information regarding women in engineering, science and technology. There is a particular need for improved sex-disaggregated data and associated gender analysis regarding women in science and technology in terms of primary, secondary and tertiary education, career choice, entry and professional development. Without this, educational and employment planners and policy makers cannot address the situation regarding the "leaky pipeline" of women into and within engineering, science and technology.

There are various activities which are attempting to redress the gendered aspects of science and technology. These include those of the Gender Working Group of the United Nations Commission on Gender, Science and Technology which reviewed UN agency activities in gender, science and technology. The commission also presented a series of recommendations to ECOSOC on various issues affecting gender, S&T.

Particular reference was made to the south east Asia-Pacific region and the perspective, activities and prospects from UNESCO in gender, science and technology, as well as the development of UNESCO "Toolkits" of information and learning/teaching materials. These Toolkits focus on women and small-scale technology, gender, science and technology and gender-disaggregated data for engineering and technology.

In conclusion Mr Marjoram emphasized the need for co-operation and support from governments, national and international agencies in the development of these Toolkits, and in the promotion of gender, science and technology.

Discussant: ***Mariko Kamijo***

Ms Mariko Kamijo added to the panellists presentation by talking about the situation of Japanese women in science and engineering. In general, they enjoy better working conditions than the majority of Japanese women. However, these could still be improved, and the Japanese Women's Engineering Forum (JWEF) is endeavouring to do just that. A non-profit organization, the JWEF has collected data on women in engineering which they collected from two surveys. They found that the satisfaction rate of women in science and engineering in Japan was actually very high. However, they did find that women had slightly less access to training in the workplace than their male counterparts. This was due less to inequitable rules as to the impact of the burden of women's domestic duties.

Overall, the surveys reveal that the number of women in science and engineering in Japan was very small. Ms Kamijo stressed the importance of changing this, beginning with activities which seek to promote science and engineering careers to young girls.

Ms Kamijo noted that in Japan key sources of data on science and technology were the ministries dealing with students and workers. For the most part, this data is not gender-disaggregated, thus this remains a pressing concern. Ms Kamijo suggested that APEC could provide a mechanism to promote the collection and reporting of gender-disaggregated data on science and technology. Activities such as the support of APEC study groups, annual APEC reports and media dissemination could all prove useful.

PANEL 3: STATISTICS WITH A PURPOSE: POLICY-MAKING WITHIN APEC ECONOMIES

THE NEED FOR OBJECTIVE AND SUBJECTIVE INDICATORS IN GENDER STATISTICS

Fanny Cheung

Ms Cheung's presentation emphasized how objective indicators of women's status are not always enough to gauge the real situation of women. Simple census statistics are affected by the economy's overall social development which often masks the extent of gender disparity within the economy. Thus, while overall statistics such as those given in the 20th Report of the Population Crisis Committee may give a favourable ranking to Hong Kong, China, they are not able to reveal any gender disparities. Statistics need to be put in context to assist meaningful interpretation and cross-cultural comparison of the data.

Objective indicators are further limited in their ability to explain gender disparity related to subjective factors such as roles, attitudes, stereotypes and values. Statistics on these subjective factors and their trends would help to target socio-cultural roots of gender inequity. For example, the statistics show clearly that there is an overwhelming male dominance in all fields of science and technology, as well as a significant earning gap between women and men. There appears to be a correlation between women's earnings and family responsibilities arising from marriage and fertility. However, this information is not captured by simple statistics of women's earnings. Likewise, the reasons why men dominate in S&T are not reflected by mere numbers either. Clearly, there is an important role for subjective indicators.

Ms Cheung cited relevant findings from the Baseline Survey on Equal Opportunity on the Basis of Gender in Hong Kong and other research studies as examples of subjective indicators useful in understanding the participation rates of women and men in scientific and technological education and careers.

WOMEN IN THE REFORMED NEW ZEALAND SCIENCE ENVIRONMENT

Ellen Celia Förch

Ms Förch began her presentation by reviewing the gender representation in various employment categories in New Zealand. She then focused on the S&T sectors, focusing on some recent reforms which have taken place, and the results of surveys to assess the impact of these reforms on scientists. The major reform has been a change to a science provider/funder split and contestable bidding to a set of defined national strategic objectives. An Example of a survey done among scientist is that by the New Zealand Association of Scientists Survey in 1994. Responses from that survey were analysed for gender effects, although not specifically designed for that. A more recent survey was that of the 1997 Sommer Report.

These post-reform surveys suggest a profound effect on most scientists' morale and career paths. Ms Förch discussed the changes which have occurred for women including changes in career paths and employment, discrimination and harassment, staff support for science, job security and general morale. Anecdotal evidence points to a differential effect on women, resulting in problems with retention of qualified women within the science occupational area.

Ms Förch noted that although women's participation in science has increased over the past decade, there were still some serious obstacles. Some ways to overcome these include investigating the effect of women's social responsibilities on their careers, collecting information from departing scientists anonymously by third party in order to identify any gender-based reasons or differential retention problems, and tailoring question in surveys to that they elucidate gender issues beyond just elucidating gender difference in the responses.

BEYOND STATISTICS:
CASE STUDY FROM THAILAND

Malee Suwana-adth [3]

In this presentation, Ms Suwana-adth gave a brief overview of the gender in Thai's national development. She acknowledged that although 67% of Thai women actively participate in the labour force, considerations of gender in science and technology are relatively novel. To some extent, the issue has been raised in dealing with the significant brain drain from the public sector to the private sector. In response to this, the Ministry of Science and Technology and Environment established a National Committee on Human Resources Development.

Part of the efforts of the Committee have been devoted to the collection of gender-disaggregated data. The 1996 data indicated that male outnumbered females by 8% in the Ministry as a whole. This gender disparity was decidedly higher in the top four levels from division directors up. Here the male to female ratio was 143:100.

Ms Suwana-adth stressed the need for critical analysis beyond mere considerations of statistics. Analysis which Ms Suwana-adth and Ms Akarakupt undertook indicated qualitative requirements such as women's increased visibility in public, and the associated training required to facilitate that. Furthermore, they found that women pursuing S&T career paths should be encouraged to also pursue R&D management, commercialization of technology and S&T policy formulation. The list of factors affecting upward mobility of women in S&T included leadership, credibility and self-confidence.

In concluding, Ms Suwana-adth stressed the importance of maintaining family and society-sensitive female values into the integration process of national and APEC cooperation while seeking a greater balance in leadership by both women and men.

INCREASING THE PARTICIPATION OF WOMEN
IN SCIENCE AND ENGINEERING RESEARCH

Monique Frize

In her presentation, Ms Monique Frize first reviewed the factors that contribute to limiting women's participation. In particular, the relatively low enrollment rate in computer engineering courses by women in Canada (9 - 12 per cent), could be attributed in part to the greater opportunity which boys have for playing with computers. Most of the games have a decidedly male bias.

She pointed to some literature which asserted that indeed boys in America did receive more opportunities in school, receiving more attention, stimulation and positive feedback than boys. Likewise, sexist attitudes also contributed to limiting girls opportunities in S&T. On the question of whether girls and boys are genetically predisposed to some aspects of science more than others, there is still a lot of controversy in the literature.

[3] The paper presented was co-authored with Kobkeao Akarakupt

There are numerous solutions to the achievement of gender-balance in all fields of S&T. Ms Frize illuminated some key solutions in the educational system and in the workplace. She then gave an example of the work done by the "The Task Force on Women in Science and Engineering" in Canada. This was established in 1995 and its mandate was to advise the Natural Sciences and Engineering Research Council (NSERC) of Canada on how to create an environment which facilitates and encourages greater participation of women in science and engineering research. The task force made twenty-two recommendations to NSERC, many of which had been implemented by NSERC in 1996/97.

In concluding, Ms Frize noted that if R&D leaders would begin to see how diversity would benefit the research community and the economies, then women would finally take their right place in the S&T ranks.

Discussant: ***Romulo Virola***

Mr Romulo Virola's comments focused on the state of gender, science and technology statistics in the Philippines, and past and current efforts to provide these statistics. He ended with some suggestions for future efforts to generate more of the data in APEC member economies.

In the Philippines, there still exists a need for more gender-disaggregated data for science and technology. This data was needed to assist in the formulation of policies. Current tools such as censuses and administrative records can be used to generate more gender-disaggregated data. Mr Romulo pointed out that in addition to disaggregating S&T data by gender, it was important to also separate information by other factors such as age, as well as other subjective factors.

Mr Romulo pointed out that it was important for higher priority to be accorded to data and statistics by decision-makers. As in many other economies, in the Philippines, the master plan for statistics collection does not incorporate much gender disaggregation. However, the data which does exist does demonstrate that women are under-represented in Philippine S&T.

In conclusion, Mr Romulo stressed that there needs to be some determination of the priorities which need to be focused upon with respect to data in gender, science and technology. In addition, international comparability of data needs to be given more attention.

2.0 RECOMMENDATIONS

2.1 GROUP 1: ELEMENTARY AND SECONDARY EDUCATION

2.1.1 Issues

1. Science and technology (S&T) education should be made more attractive to, and directed at young women:

- by showing how S&T supports interests, values and knowledge traditionally associated with women;
- by encouraging girls only classes as the single most effective way of ensuring their success;
- by ensuring that by its very definition, S&T does not exclude from the outset the skills and knowledge of women; that is by formulating definitions of S&T that explicitly encompass the tolls and knowledge used and developed in the context of women's lives and work.

2. Science and technology education should be made available for all, at all levels, using locally appropriate forms of distance education, to supplement existing education facilities. For example, the availability of housing for the education of rural girls and women should be increased.

3. Teacher preparation needs to focus attention on attitudes, knowledge, and parental support. This means providing gender-sensitization for both teachers and parents on how to encourage young women and girls to achieve well in science and technology education. Teacher education should assist teachers both to recognize the entrenched biases of traditional S&T education and to modify pedagogy, curriculum, and assessment, to encourage girls and boys to become critical, challenging, independent, and creative thinkers. Parents must be helped to realize ways in which daughters will require S&T education in order to develop life skills to ensure independence and economic security.

2.1.2 Policy:

1. Making S&T courses a requirement for all students. These skills are essential because S&T pervades all subject areas today.

2. Data collection: Quantitative: Information on S&T course availability, course choices and reasons for choices by girls and boys.

3. Qualitative: case studies of effective programs and pedagogy which have succeeded in attracting and retaining young women to S&T subjects and fields ("learning communities")

4. Supporting data collection and sharing: APEC, in conjunction with other relevant organizations, such as UNESCO, OECD, World Bank, should be encouraged to support member economies in the development, production, and monitoring of national sex disaggregated data (Internet site as central in most available location to assemble data).

2.1.3 Stakeholders and actors

- Primary and secondary education should be a concern of the entire society, therefore, everyone is a stakeholder for this issue. For example, it includes parents, teachers, students, media, Ministers of education.

2.1.4 Comparability of data

An electronic manual on gender, S&T, which is descriptive, which is not standardized, for each member economy; the curriculum and main topics can be compiled and described centrally. The problem here is equity, not standardization of curriculum. Therefore, the data required is participation and performance levels of males and females, which is, fully comparable within its own context.

2.1.4 Required resources

Streaming girls and boys in traditional programs has been a way to manage scarce resources. However, quality science education is less a matter of money than of identifying and making accessible low cost teaching equipment. Quality science teaching has been achieved at low cost, by utilizing local resources creatively. In term of technological requirements, partnerships with industry can provide hardware for schools and community centres. Basically, quality S&T education is a question of priorities; political will is essential to make resources available and to recognize importance of human resources development.

Time frame: start today and don't stop until it is done. In APEC contexts, have the program of activity organized by the October meeting, in 1998, looking for implementation for the 1999 APEC Leaders Meeting, in Auckland. This should also be reported at the World Science Conference, in UNESCO, in 1998.

2.2 GROUP 2: RECRUITMENT AND RETENTION OF WOMEN IN POST-SECONDARY EDUCATION

The focus was placed on students rather than on faculty members

2.2.1 Issues

- Stereotyping of women: for example, the perception of women as not qualified and the weaker sex;
- Cultural pressures against women taking up an S&T career: For example, pressure to marry, to marry young, to have children, women as primary caregivers/nurturers;
- Poor packaging/lack of information on S&T careers;
- Demanding nature of S&T careers: (ex.: time, dedication, laden with masculine values.
- Male domination of technology/disciplines where power and resources are available.

- Absence of institutional support and networking, that hinders entry into S&T careers; and lack of retention in S&T careers.
- Invisibility of female role models in S&T career.
- Lack of gender sensitive teaching (curriculum, material and practice).

2.2.2 Majors issues and priorities

- Invisibility of role models;
- Stereotyping of women;
- Lack of accessible information and networking

2.2.3 Policies

- Universities should review curriculum material and practices along gender perspective. Development work on this is urgent.
- That APEC member economies promote equivalency of S&T courses.
- The issues identified should be simultaneously considered by the ISTWG and the HRDWG.

2.2.4 Data Collection

- Qualitative analysis of available data
- Data gathering to fill in information gaps.
- Standardization of data - based on common definition and scope of S&T disciplines.
- Data generation on role models and career opportunities for each economy

2.2.5 Recommendations

- Exploit the potential of plant/existing APEC web site, to be able to encourage women in S&T careers, with specific attention to recruitment and retention of women in post-secondary education.
- Implement the web site as an information medium and vehicle for data base, advertising for career information;
- Survey with gender perspective in each economy

2.2.6 Recommendations and work plan

ISTWG to generate/mobilize resources to implement the recommendation.

- Timetable: 3 years
- Potential collaborators: Equal Opportunities Commission (Hong Kong, China) National Census Office, Korean Women's Development's Institute, National Science Foundation, and others.

2.3 GROUP 3 - RESEARCH

2.3.1 Issues

- Identify gender variables to be clearly defined and come out with meaningful disaggregated data: example number of years in S&T workforce-
- Current data in gender and S&T do not measure the total picture of research personnel in rural economies.
- Need for exchange program for training for research
- Limited visibility of women scientists (who, what, where, what they are doing, success and failure rate.
- There are restrictions and barriers for women to advance in scientific careers.
- Lack of data on success rate with grant application.

2.3.2 Recommendations

- Identify gender variable;
- Influence national census and statistical parameters to impute contribution of women (scientific productivity to the overall economy);
- practical indicators need to be worked out.;
- Gender equity observed in exchange program (industry, visiting professorship, re-entry scholarship;
- Need to prepare inventory of women scientists in APEC economies for potential collaborative research and training;
- Need to review conditions, rules and regulations for scholarships;
- Need to encourage APEC economies to collect data (ex. Swedish article on Sexism and nepotism in peer review);
- Participation of women in the governance and decision making.

2.4 GROUP 4- WORKPLACE

Urge APEC Leaders to safeguard their investment in women S&T training

2.4.1 Issues

- Retaining women in the workplace
- Progression with equivalent experience

2.4.2 Data needs to identify obstacles in:

1- training -equal access
-trainees, facilitators, trainers by sex
2-promotion -who is promoted
-age, years of service, length of service before promotion,
-date of last promotion
3-number of people taking leaves
-length, purpose (training, maternity, care, other)

4-resignation, and lay off, unemployment, part time work
-numbers;
-reasons;
-length of service prior to resignations

2.4.3 Mechanism

- APEC Study Centre, with collaboration of WLN, women's studies, women's machineries
- ISTWG to include women in all its activities.

2.5 GROUP 5- ASSOCIATIONS

Definition of association: civil society which includes private sector, NGO's, professional organizations, academe and private R&D associations, etc.

2.5.1 Issue:

There is a wealth of human resources that are under utilized as provider, implementers, and users of data in gender in S&T

2.5.2 Recommendations:

We reiterate the call for action of the WLN to:

- create a partnership between research institutes, associations, and government statistical agencies, to formulate APEC specific training and information package on the development and use of sex disaggregated data;
- develop a manual on gender disaggregated data - i.e.: *Frascati Manual*, to be prepared jointly with AECD, UNESCO, APEC;
- develop a bank of best practices approaches of gender integration in the industrial, S&T at national and international levels.

2.6 GROUP 6- DATA COLLECTION MECHANISMS

This group's recommendations focused on coordination mechanisms to enhance comparability of data collected in APEC economy.

2.6.1 Recommendations

Many issues were raised and one major recommendation was made which can address many issues:

- The establishment of joint collaborative research and analysis of sex disaggregated data related to S&T to assist the ministers in fulfilling the terms of paragraph 16 of the APEC Economic Leaders Declaration (Vancouver), which also commits APEC economies to "take specific steps to reinforce the important role of women in economic development".

In order to implement this recommendation, other specific recommendations/ suggestions made were:

- The creation of an inventory of industry, S&T data in the broadest sense (including education, research and development, technology transfer, S&T services, etc.), for all sectors of the economy, especially industry and private enterprise.
- The establishment of a focal point for each economy. This could be coordinated through the existing APEC Study Center Consortium.
- In a general effort to create coordinating mechanisms within APEC , each working group should be invited to incorporate the obligations of CEDAW signatories into their agenda.

2.6.2 Process

1. Make already available data accessible:
    - through common inventories
    - through shared data base, ideally accessible on the Web.

2. Create coordination mechanisms:

within APEC:

- using APEC Study Centers;
- through collaborative projects between APEC working groups;
- by identifying gender as a cross-cutting issues of all APEC working groups, and committees.

outside APEC:

- through the collaboration of UNESCO, OECD, Eurostat, ASEAN, and APEC on definition of terms and on data gathering;
- through the joint preparation of a manual on gender disaggregated data, similar to the *Frascati Manual*. The organisations above, the industry and the academe should participate in the preparation of the manual.

3. In recognition of the complexity of the issue, both quantitative and qualitative data should be collected.

2.6.3 Remove barriers to primary and secondary education

It is important to make S&T courses compulsory for all student, recognizing that S&T skills are required in all of society.

2.6.4 Types of data required

Education

- tracking gender in different study programs (pre-university and university);
- career choices;
- monitor policy measures and initiatives;

Workplace

- tracking employment patterns in S&T (full time, part time, unemployment; lay-offs);
- years of experience of workers;
- provide years of experience and age at each promotion;
- time spent on household/parenting chores by gender;
- participation of women at various seniority levels.

Research

- graduate school enrollments; and under male or female professors;
- success rate by gender;
- allocation of scholarships, fellowships, grant, post-doctoral degrees, awards, prizes;
- Monetary level of grants;
- faculty positions and research positions (by level of promotions).

WELCOME ADDRESS

The Honourable William G. Padolina, PhD
Secretary, Department of Science and Technology
Republic of the Philippines

Biographical Note

Dr. William Padolina is the Secretary of the Department of Science and Technology (DOST) in the Republic of the Philippines. A licensed chemist, Dr. Padolina graduated with a Bachelor of Science degree in Agricultural Chemistry (*magna cum laude*) from the University of the Philippines-Los Banos (UPLB) in 1968. Not long after, he left for the United States under the auspices of the Fulbright Scholarship Program, where he got his PhD in Botany and Phytochemistry at the University of Texas-Austin in 1973. Despite his full-time secondment at DOST, Mr Padolina maintains his ties with academe as Professor of Chemistry at UPLB.

Secretary Padolina's career is distinguished by his successful balancing of the equally demanding tasks of teaching and research work, as well as academic and bureaucratic administration. At UPLB, among his first administrative tasks were as Chairman of the Department of Chemistry and Director of the Learning Resource Centre, becoming in the process an advocate of lifelong learning. He later became Director of the National Institute of Biotechnology and Applied Microbiology and UPLB Vice-Chancellor for Academic Affairs from 1988 to 1991.

At the DOST, Secretary Padolina served in a variety of top-level responsibilities prior to becoming Secretary. In late 1992, he was Undersecretary for Science and Technology services. In this capacity, he chaired the Steering Committee on Asian Rice Biotechnology Network and later the ASEAN Committee on Science and Technology. In 1996, he was elected President during the 40th General Conference of the International Atomic Energy Agency, becoming the third Filipino after the late Gen. Florencio A. Medina and Ambassador Domingo L. Siazon, Jr. to hold that distinction.

Dr. Padolina regularly publishes his findings in the fields of natural products, chemistry, and biotechnology. In recognition of his scientific work, he was named the 1982 Outstanding Young Scientist in Phytochemistry by the National Academy of Science and Technology. He received the 1989 Pantas Award for research Management and has also received a succession of individual honors in the field of chemistry and biotechnology.

WELCOME ADDRESS

Thank you for your introduction this morning, and welcome to the APEC Experts' Meeting on Gender, Science and Technology. This gathering of minds is imperative in view of a fundamental component in global economic and technical cooperation: the focus on human resources as a basic asset in society.

The process of technological innovation and diffusion, as we all know, relies a lot on the men and women who possess the intelligence, creativity, resourcefulness, and tenacity to unravel the mysteries of nature. These men and women, who compose our pool of talented scientific and technological human resources, are our hope in discovering and developing new products and processes that will enhance our respective economies' leverage to participate in heightened scientific and economic collaboration in the Asia-Pacific region.

It is therefore unfortunate to note that women, despite the major advances scored on their behalf, still find the doors of opportunity in science and technology not as open as they could be. As a result, the issue of gender equality has been given special attention by APEC member economies in Ministerial Meetings and international summits. I am pleased to mention that the Philippines is one of the pioneers, along with Canada, in advancing gender concerns in APEC through the establishment of the APEC Senior Leaders Women's Network.

As we gather today to discuss the pressing issues and concerns of gender equality in science and technology, let me remind you that we all wish to build upon the APEC spirit of cooperation expressed in the Seattle vision, the Bogor Declaration of Common Resolve, and the Osaka Agenda for Action. Moreover, under the different frameworks of cooperation such as the APEC Tenets of Sustained Growth and Equitable Development, the APEC Human Resource Development Framework, and the Promotion of Harmony Between the Environment and the Economy, we shall endeavour to integrate gender as a cross-cutting concern toward achieving the APEC objective of ensuring equitable socioeconomic development in the region.

Over the next two days, the experts gathered for this meeting shall focus on the formulation of policies and strategies to promote gender balance in scientific and technological training and careers. Specifically, your immediate objectives are to:

- Identify the critical data necessary to understand the underlying participation rates of women and men in science and technology;
- Examine systematic approaches and coordination methods for ensuring the collection of comparable gender-disaggregated data on science and technology;
- Discuss data analysis and policy actions that will help to remove barriers to women's participation in science, technology, and engineering education and careers.

As we take up the task at hand, let me remind you that gender issues straddle the whole gamut of varying customs, beliefs, and persuasions that arise from cultural diversity among APEC member economies. As such, delegates must proceed with extreme caution in the course of identifying appropriate coordination mechanisms in the design of gender-sensitive policies and strategies for scientific and technological development in the region. Delegates should also establish as benchmarks the gender-friendly practices of other economies - both developed and developing - that deserve closer study and replication.

We must take pains to explore the areas in industrial science and technology where gender disaggregation limits the full participation of the region's scientists, engineers, and researchers. Women, after all, comprise half of our populations and contribute accordingly to the economies of APEC. Thus investments in the development of women's intellectual resources and their enterprises make sound economic sense, for it is through such investments that we can bolster prospects for equitable economic growth, reduce large-scale poverty, and promote sustainable development in the Asia-Pacific region.

Thank you and good day.

KEYNOTE ADDRESS

WHY IS GENDER AN IMPORTANT ISSUE IN APEC SCIENCE AND TECHNOLOGY DEVELOPMENT

Dr. Marilyn Waring
School of Policy Studies
Albany Campus, Massey University
New Zealand

In this engaging presentation, Dr. Waring challenged APEC's leadership to acknowledge the whole fabric of women's lives. She talked about the importance of looking at both the pros and cons of science and technology, thereby acknowledging the duality of gain and loss, which co-exist in S&T. This examination indeed calls into question the often assumed neutrality of technological tools, especially when gender is taken into consideration. Dr. Waring argued that the critical questions to be asked are about power in S&T decision-making. In addressing strategies for improving gender equity in S&T, Dr. Waring stressed the importance of engaging in actions which were not only inclusive, but also transformative. She suggested a holistic framework for an equity analysis of gender in S&T.

On the question of data, Dr. Waring warned that of the constraints which had been observed as barriers to women in S&T in APEC, some would not be assisted by data, requiring instead determined women's struggles. She did note that time use data could be useful and outlined a number of ways in which this was so.

Biographical Note

Marilyn Waring is a senior lecturer in Social Policy and Social Work at Massey University in Auckland, New Zealand. A feminist economist with a Ph.D in Political Economy, a development consultant, and an activist for women's rights, she has worked in more than a dozen countries. She has numerous publications to her credit. Her first book, *If Women Counted: The New Feminist Economics* was published in 1989. It is highly acclaimed, and formed the basis of a Canadian National Film Board production entitled "Who's Counting?" Her latest book is *The Three Masquerades: Equality, Work and human Rights*.

ACKNOWLEDGMENTS

I wish to acknowledge the influence of the work of the following women scientists, technologists, engineers, academics, and social researchers in this paper - Corlann Gee Bush, Rachel Carson, Robin Fleming, Patricia Hynes, Carolyn Merchant, Sue Rosser, Vandana Shiva, and Alexander Stephens. I am grateful for their scholarship, insights and experiences.

At the APEC leaders' meeting in Auckland in 1999, the established tradition of the leaders' photo opportunity will be broken. The batik shirts of Bogor, the barong shirts of Manila, the leather jackets of Vancouver - the effect of the men in uniform, with its statement that leaders are uniformly men - will have to go.

Perhaps it just never occurred to those who began the fashion statement, and those who chose to continue it, that there would be women leaders at the heads of government meeting before the new millennium. But the presence of the New Zealand leader, and host, Jenny Shipley, is a pointed reminder about the assumptions of male power, and the problems of stereotypes.

For a time, the New Zealand Prime Minister might be viewed as the exception, a one-time occurance, so that the language, behaviour, culture of leadership, and way things are done are in a temporary suspension. Such behaviour would mirror the life "herstories" of many of the women who were first to break the ice in the fields of science and technology.

Sophie Germain, born in Paris in 1776, taught herself from her father's library and through correspondence with other scholars. Excluded by gender from attendance at the Ecole Polytechnic, she submitted papers using a false name. With one lecturer on the inside in the know, and encouraging her, she worked in number theory and analysis, and acoustics and elasticity. She won a number of prizes in mathematical physics, and died just before she was to receive an honorary doctorate from the University of Gottingen.

Ada Lovelace was born in London in 1815 and took an early interest in mathematics. In her early twenties she developed the idea of computer programming, specifying the data to be punched, the cards to be used and the order in which instructions were to be executed. Because the writing of mathematical papers was not considered a suitable occupation for a woman, she used the initials AAL to identify her work. The high level programming language developed by the US Department of Defense in the 1970s was named Ada after her.

In 1962, biologist Rachel Carson published *The Silent Spring*, a book which has served as the catalyst for the environmental protection movement. Carson was pilloried by industrialists, many scientists, and some politicians. They dismissed the work as superficially scientific, sentimental, nostalgic, and anti-progress. Carson's real threat was the presentation of another paradigm. She challenged the world view that nature exists for the use and convenience of man, but she also called for science to take another less travelled path - the path of biology, based on the understanding of insects as living organisms in relation to the whole fabric of life to which they belong.

If APEC is serious about issues of gender, science and technology, then all involved must make a similarly large paradigm shift. By serious I mean displaying the political will as opposed to endless reports and talk fests. By serious I mean traveling the path of the whole fabric of women's lives.

Gender analysis invites attention to the whole picture. It focuses on concepts, presumptions, arguments and language, and how, and by whom, needs are interpreted. The focus of analysis is whether or not policy talk challenges or reinforces existing power structures.
Just because gender challenges the existing paradigm and predominant values around science and technology, women's views are not minority views. The powerful dismiss them because they are without power, as defined inside the prevailing paradigm. Competing values can

only mean one thing - a redistribution of the money pot away from the old order, and this is threatening on too many counts. It offers the prospect of the loss of too much control, and especially control of the agenda.

Loss of control is usually behind resistance to fundamental change. In a very polite way the gender based analysis prepared by the Canadian Status of Women invites anyone working with gender analysis to be aware of their own values and how these influence their decision making, their willingness to learn, and their defensiveness and sensitivity. They suggest it is useful and beneficial to ask: how do my values and experiences heighten my perception and willingness to investigate? In what way might these cloud my vision or prevent me from asking questions and hearing answers? How do my values or those of the system or those of the dominant power base in society limit the range of policy options offered? If I don't know, who can I ask? (I must say, that as I wrote this with the men in uniform in mind, I laughed long and loud at the fantasy of any of them ever being exercised to use this line of gender analysis on any issue at all).

The systematic linking of gender relations analysis to science and technology is difficult because of the nature of the paradigm and the size of the problem. It invites reconsideration of all the basics: ideologies, research methods, state and market laws and practices, material conditions of distribution, interaction with nature, social constructions that differentiate and circumscribe material opportunities and outcomes.

Let us look at technology. The clichés invite us to think about it as comprised of tools having a clinical, objective, value-free sort of existence. Tools can apparently only do damage in the 'wrong hands'. Then there is the clichéd political stand off between the tech lobby - 'it is all good and it is all good for growth' - and the extreme eco-lobby whose pronouncements are so dire that they could confine me catatonically to a corner, scared to move or use anything at all. This stand off is not helpful.

We get a clear example of the presumptions of one standpoint from the Second APEC Ministers Conference on Regional Science and Technology Cooperation in Seoul in November 1996. "Active and intensive regional cooperation in science and technology *will enhance* the prospects for an accelerated, balanced and equitable economic growth...". Such statements suggest that APEC is firmly aligned with the patriarchal dualism of approach, and has the power of definition to go with it.

Technology is neither wholly good nor wholly bad - it has both positive and negative effects and it usually has both at the same time. That leaves us with the concept of tools. To believe that technologies are neutral tools subject only to the motives and morals of the user is to completely miss their collective significance. Tools and techniques do have tendencies to pull or push behaviour in definable ways. Ask the threatened individual or the summoned policeman in any disturbance whether the nature of a weapon present - knife, baseball, scythe, gun - raises the level of violence simply by its presence.

When we add gender to the debate about science and technology, then what are the important questions? It should come as no surprise to see that they are about power. Who is making technological decisions? (The answer, so as to make agency and motive explicit, should be gender disaggregated). On what basis? (What is the ideological and information base). What will the effects be? (And who is providing the answer to this question?).

Each of these questions is about the context in which technological decisions are made, technical information is conveyed, and technological innovations are adopted. At least four contexts can be distinguished for gender analysis purposes:

1. the design or developmental context, which includes all the decisions, materials, personnel, processes, and systems necessary to create tools and techniques from raw materials;

2. the user context, which includes all the motivations, intentions, advantages and adjustments called into play by the use of particular techniques or tools;

3. the environmental context, that describes non specific, physical surroundings in which a technology or tool is developed and used;

4. the cultural context, which includes all the norms, values, myths, aspirations, laws and interactions of the society of which the tool or technique is a part.[1]

Of these, more is known about the design or developmental context of technology than about the other three put together. And while there is no doubt at all that the user, environmental and cultural contexts are the impediments to women's under representation in the design and developmental aspects of science and technology, I have had the most uncomfortable feeling in preparing for this assignment that the increase in numbers in the first category is the primary political consideration of APEC, i.e. to invite more women to operate inside the current paradigm - not the far more urgent need to address the inclusion of all women who already operate invisibly in the other science and technology contexts.

Collectively, men know almost everything there is to know about the design and development of tools, techniques and systems. However, they understand far less about how their technologies are used - in part because there is less money in understanding than designing, in part because the burden of adjusting to technological change falls more heavily on women. What is worse is that most men do not know that they do not know anything about women and our interactions in the user, environmental and cultural contexts. Ironically, until recently, most women have not realized that they possessed information of any great significance. When men occupy all the sound and resource space, the myth that men and women are similarly affected by and benefit equally from technological change is easily promulgated.

Technology is an equity issue. It has everything to do with who benefits and who suffers, whose opportunities increase and whose decrease, who creates and who accommodates. Adding 'gender' to science and technology is not a matter of proceeding from a basis of 'integrating women into the mainstream of APEC's (science and technology) activities". If adding gender to the equation is not transformative, as opposed to integrative, then it has nothing at all to do with gender politics. 'Integration' is at last absent from the debates on indigenous peoples. How interesting that men should still think we women can be so assimilated - or would even wish to be.

An equity analysis of a technology would examine the following issues in each of four contexts:

1. Developmental Context	• the principles of science and mechanics applied by the tool or technique; • the resources, tools, processes, and systems employed to develop it • the tasks to be performed and the specific problems to be solved • the current tool, technique or system that will be displaced by its use
2. User Context	• the interplay of this innovation with others that are currently in use • the personal advantage and competitive advantage created by the use of technology
3. Environmental Context	• the ecological impact of accepting the technology versus the impact of continuing current techniques • the economic system involved and the distribution of goods within
4. Cultural Context	• the social system affected • the organization of communities • the impact on sex roles [2]

Women scientists appear to have tried to embrace this holism in their work. In her book, *Women Friendly Science*[3], Dr Sue Rosser examined the work of many twentieth century women scientists who used classical scientific methods, but who were flexible and open to the context of the study. Their observations were qualitative as well as quantitative, more numerous than those of male scientists, and inclusive of women and female animals. They gathered data using methods that were more interactive, and took interdisciplinary approaches to problem solving. Conscious of how biases permeate experiments, they formulated theories that were relational, interdependent, and multi causal rather than hierarchical, reductionist and dualistic. They were less willing to undertake military research, and sought the social usefulness of science more than their male colleagues. Concerned with integrating their scientific role into the rest of their life, these women found teaching and communicating science as important as research.

There is no doubt that if we wish to see that holism of contexts continue in the design and development of science and technology then we need more women there. And certainly that means addressing the vast number of socially constructed exclusions enumerated over many years. These include language, teaching methods, textbooks, case studies and curricula; role models, admission practices, promotion, family- friendly workplaces, child care, parental leave, access to scholarships, finance, legal prohibitions in regard to substantive discrimination, media stereotyping, sexual harassment, and all the rest of that list that has been exposed in endless fora for my whole lifetime.

The leaders of the APEC member economy governments and their representatives have spent millions of hours over 30 years telling us just how concerned they are about these issues. In every case whether or not they committed resources to address their concern on the front-line is scientifically measurable, and it will stand as my judgment of their ability to deliver on rhetoric. The Ministers, in their joint Communiqué of the APEC Ministers' Conference on

Regional Science and Technology Cooperation in Seoul, 13-14 November, 1996, identified the " importance of removing barriers, and promoting the full contribution of women to S & T innovation and creativity as an essential element in meeting APEC's goal of achieving sustainable and equitable development". I know that they wouldn't have been too keen to have anything at all in their communiqué if it was going to be subject to any interpretation that involved gender analysis and the multitude of barriers listed above.

But for those of us who are committed to change, and sometimes we have the opportunity to be active from the inside, the paradigm shift is paramount. Without this shift, we continue to forge a world in which only the development and design context, and only the women professionals who get there, are our concern in the universe of science and technology. We reinforce the existing power structure, and are willingly participants in it. In another APEC context, Marjorie Cohen has spoken of "a view of the world in which the interests of the powerful are defined as necessary, while the demands of the poor appear as greed".[4] The user, environment and cultural contexts of science and technology are certainly where we find women, and the poor.

I'll try to give some examples of what this holism might mean in terms of a concern about data needs. Because I'm a farmer, and because the APEC leaders have decided to fast track food on their free trade agenda, I'll look there first. But I'll also look there because women are the front line of food preparation, service, preserving, storage, purchasing. In particular when we include the formal, informal, subsistence and household productive sectors, women are overwhelmingly the larger labour force working in food production. Women food workers know well what data they require, but they are often not in a position to decide which scientific information can best help them make decisions about appropriate use of 'new' methods that will increase productivity and service work in a sustainable manner, reduce drudgery, and ensure quality control. Precious little data is available to women farmers, for example, about the various options and implications of mechanization, even if it is made appropriately for our body size and proportions, for weights that any human should safely carry, and if it invites independence as opposed to constant maintenance by some 'expert'. We certainly have vast experience to speak with authority about the priorities for the research agenda around food, (and tasteless 'nuked ' tomatoes is not one of them) but no one asks us.

In fact, technology inputs in the name of economic progress, overwhelmingly directed at males, have frequently had the effect of increasing the working day of women even more. Studies by the International Rice Research Institute (IRRI) in the Philippines demonstrate conclusively that the increase in rice production in the Asian region increased the work traditionally done by women twofold, while the money from the twice- yearly harvests went to the men because the land was in male names. Labour saving technology was applied to men's tasks (land clearing, ploughing), while women's planting, weeding and harvesting and storage work doubled with increases in crops and production.[5]

It should be noted that the female activities in this production arrangement constitute the bulk of the labour requirement for these crops. Regardless of such evidence, throughout the region men have higher levels of input in the early stages of production, such as field preparation, and monopolize most mechanical-technical inputs. Ploughing or threshing, by either animal or fuel- powered machines, is carried out by men, while hand threshing is a female labour intensive activity. Driving tractors is reserved for men, and all the menial tasks of the region-seed preparation, weeding crops, transplanting rice, picking cotton or tea, raising silk worms and cocoon reeling, are overwhelmingly women's tasks, and have the least technological inputs.

I can think of countless analogous examples of similar situations in New Zealand. I always remember the breathtaking incompetence of the purchase by male farmers of that vast new machine which was tax deductible, that was supposed to be labour saving and time saving, meaning, for example, the hay would be harvested, weather dependent, in a few hours less per year. The machines most in daily use, and most needed to free women's additional productive time, called automatic washing machines, or clothes dryers, or dish washers, were not, of course, tax- deductible, concerned as they are with the non-productive "household and domestic service" sector.

By now I feel the resistance in my audience. 'No no too broad I suspect some are thinking. She's not addressing the topic'.

Yet when the Ministers' communiqué says they are committed to "identifying the importance of removing barriers, and promoting the full contribution of women to S & T innovation and creativity as an essential element in meeting APEC's goal of achieving sustainable and equitable development" don't they mean that to be interpreted from a woman's point of view? For example, in the highly successful integrated pest management systems in the Philippines or in Indonesia where women are integral to success, farmers using the pesticides are affected 15% more by Parkinson's Disease than the rest of the population, and their children need only touch their clothing to get exposure levels that are too high.[6] Is this not a barrier to promoting women's contribution to sustainable development?

Don't they mean that 'contribution' might be impaired by agrochemical toxicity and the next generation affected when breast milk contains DDT, Dieldrin and Aldrin. Is that not science and technology - because it is health and women and children and a problem and outside the market so it must be 'social'?

Don't the Ministers mean that science and technology should be on the front line of communicating key data on water quality and health in the water ways of New Jersey or the Mekong. Widespread water pollution from combinations of industrial wastes, storm water overflows, chemical leaks and spillages, untreated sewage and pollution runoffs from fertilizers and pesticides increasingly affect the health of populations. If 'regulations' are resisted to control and contain the poisoning of the watercourses - because it is bad for business - then there is a role for science and technology in all contexts - or is that not what the Ministers mean either?

Some APEC participants do 'get it'. The paper prepared by Madame Deng Keyun[7] outlined a programme that raised the combustion efficiency of stoves, reduced firewood consumption, eradicated choking smoke, and developed renewable energy with the use of solar, biogas, growing alternative grasses, and trees which provided for current needs and commercial trade - and education, consultation and training were all part of the package. As well the programmes were sustainable in the long term.

But how do we deconstruct that story and others like it, to record 'data priorities'. The draft discussion paper on 'Gender, Science and Technology in Knowledge Based Economies:[8] Some Considerations for APEC' used for the 'Open Ideas Forum' claimed, in paragraph 19, that the “absence of consistent and comparable data is a major impediment to developing effective policies and programmes. Without comprehensive and comparable data it is difficult to design policies and programmes to ensure equal access to education, and to attract and retain highly talented women in scientific and technological studies and careers”.

It is as well it was a discussion document, because one page later at paragraph 22 we could read: “Building on more than 20 years of scholarship throughout the Decade for Women and beyond, there exists a range of specific strategies and innovative policy instruments to dismantle discriminatory practices and to attract and retain top female talent in science and technology”.

The background working papers prepared for the first meeting of the Ad Hoc Group on Gender and S & T in Singapore in September 1997 contain examples. I’ll be dead before either UNCSTD list of transformative actions for removing obstacles to women in S & T careers, or UNESCO’s Tools and Strategies for Policy Interventions are fully in place in APEC nation states, so that’s a good enough list to keep everyone busy for 30 years.

I must add that I have never understood at all this fixation with international comparability. Is the market ideology so omnipresent that all of life is a competition? In most data on gender, international comparability of unidimensional sets is utterly meaningless. If I am looking, for example, at figures from Japan on women in science and technology, how many of those classified as ‘part time’ actually work more than 40 hour weeks, and will do so for 15 or 30 years. When I look at retention levels of girls in sciences in New Zealand and Australia and Canada, how will I know what percentage of them were at all girl schools, or taught in single sex classes for science and maths, or taught by women teachers, or are working from a curricula where the case studies are not stereo typically male?

Likewise, when I look at how many women go overseas for further education or for special training or conferences, how will I know which were funded by development assistance from the Netherlands, who actually implement their gender policy in such matters, and where other development donors just didn’t bother to insist on gender equity in representation? Where will unidimensional number crunching tell me about such aspects as legal discriminations, human rights denials, cultural restrictions, as well as the wide diversity of access to resources, credit, employment?

Why does anyone think we need data when we need action? I know that’s a favourite tool of governments, and the most favourite tool of procrastinating male leaders. Why should any more scarce resources be diverted to discover yet again that in a myriad of guises the problem is male resistance?

Whose agenda is this? Women’s? I don’t think so - in which case its not an agenda about gender. I think women know we have quite sufficient critical data. While we share surviving many of the same tactics used to keep us out, keep us silenced, keep the agendas and the power of definition right out of our hands, I think we understand the myriad of differences between us that make systematic coordination and comparable collection of data a very disturbing concept. We are not automatons, and our lives are not mechanistically similar enough to see that as a priority. If transnationals and multinationals see it as important (and I can clearly see why they would) then let them collect it. The public resources have other agendas. Where it has not been done, gender disaggregating current data bases is long overdue. The object here is as a national comparator, between men and women.

As a project leader in this region in a number of national planning development assistance programmes, I am aware of the poor quality of some data bases. And I'm the first to accept that there are major logistical difficulties in some forms of data collection. A report of the UN Statistical Commission in 1993 noted that problems encountered by countries in implementing their survey programmes included a lack of strong commitment to statistics by governments, inadequate donor support, failure to present results of surveys in an attractive way, lack of coordination between different producers of survey data, timeliness, quality of results, delays due to processing bottlenecks and unsatisfactory distribution of survey findings.[9]

Frequently the difficult terrain, vast areas to cover, and communication difficulties influence the effectiveness of supervision and control of the field elements of the surveys. Quality of data may suffer because of the temporary nature of field staff, or the heavy workload of enumerators in multi-purpose surveys. Surveys frequently impose heavy burdens on interviewers and respondents, giving rise to fatigue. Survey data are often under-utilized, owing to a lack of analytical capabilities, especially in national statistical offices. Many statistical offices have serious shortcomings in report writing and analytical skills. There remains a large amount of data collected on women which is simply never analysed.[10]

In situations where various units within an agency are responsible for the different components of the survey - such as sampling, fieldwork and data processing - lack of coordination among those units poses problems for the survey design and implementation. Delays in data processing are often caused by the absence or late design of a processing system. The data processing system for any application consists of three important components: personnel, machines and methods. The monitoring of progress and effective quality control are other vital ingredients. If one is missing, the whole programme is in jeopardy. Frequently surveys are promoted when no software package has been specifically developed for processing the data collected.[11]

The influence of donors frequently plays a part in the difficulties encountered. In one developing country under the regime of *ad hoc* surveys, for survey one, donor A provided a data processing expert with the necessary computer equipment. For survey two, funded by donor B, the country wanted to retain the same data processing expert so that the systems and programmes he had designed could be further developed. It had also wanted additional micro-computers compatible with what had been used for the first survey. It was not possible to keep the expert because donor B fielded its own adviser and the equipment brought in was incompatible with the previous set.[12] Even in the poorest countries, in competitive 'aid' schemes, Toshiba competes with Macintosh.

The situation generally is complicated by the status of statistics. One expert, noting that by the end of 1992 only seven countries from Asia and the Pacific were participating in the World Bank National Household Survey Capability Programme (NHSCP), commented that governments' commitment to statistics were 'suspect in many countries in the developing regions.' This is attributed to three main factors: (1) Governments tend to give priority to projects whose outputs can be clearly identified, such as bore holes or bridges. (2) Users in the government sector are generally not so statistically sophisticated that the lack of data causes them any significant uneasiness. (3) The statistical offices have not yet found an effective way of promoting their products. A lack of commitment on the part of governments mainly explains the inadequate resources given to statistical offices and to survey work.

Further logistical difficulties can be located in the operational demarcations of UN agencies. For example, FAO's mandate is to work with ministries related to food and agriculture and rural development. The overwhelming majority of their work is with agriculture, livestock, forests, fisheries, food, rural development, and occasionally with ministries of local government or the interior (community development), health (nutrition), commerce (food processing, exports, food standards), but extremely rarely with women's affairs or statistics. This means that the ministries most likely to seek assistance for better indicators on women and rural development are not targeted for FAO assistance.

And I would be dishonest to overlook the extraordinary corruption and manipulation I have observed surrounding data collection in much of the world. Data is manipulated by governments for electoral purposes. It is manipulated to control different ethnicities. Economic data is invented to please the World Bank or the IMF. Literacy rates are manipulated to get UN Educational, Scientific and Cultural Organization (UNESCO) funding, and fertility rates are manipulated to get UN Population Fund (UNFPA) funding.

The needs for data collection provide great wish list opportunities for corrupt government officials seeking aid donors. High on the agenda are lots of vehicles, especially of the four wheel drive variety, along with many motor cycles. Mainline computers, and portables or notebooks are on the list, along with vast amounts of software. In the field, there's even more fun and games, where census responses are invented by the interviewer seated under a shady tree on the outskirts of the village, if they bother to get that close to the intended respondents. Study tours to foreign countries are also fun.

In previous work in this region, seven key constraints for women in science and technology careers were identified.[13] These were limited information because of the 'old boys' network; limited access to management and policy making training; lack of linkage to grassroots knowledge and networks; institutional structures, social/cultural constraints; restricted opportunities in education and employment; and women's multiple roles. The same conference identified five constraints to women's participation in research and development. These were institutional constraints, lack of enforcement of affirmative action laws and commitments, the stereotyping and non acceptance of women; household and family distractions; and family commitments restricting travel, promotion and other opportunities.

In a number of these cases change will not be assisted by data. Change will occur because some stubborn women battle. If data is the first step, then there is also a need for commitment to follow up in terms of policy implications. All too frequently, data is the only step. But if these experts are really committed to data, or see it as the only vehicle for co-opting Ministers, there is one data set that could be of assistance. Perpetua Katepa-Kalala states that 'the largest gap in gender disaggregated science and technology data is that for quantitative data on women's unpaid work'.[14] The most sophisticated instrument to deliver this data is the time use survey.

On a national level, what can time use data tell us? It can show what goods and services households produce, what the unemployed do with their time, how much additional work children in a household create, and whether equality in the distribution of household tasks has been achieved. The use of discretionary time by those in and out of the paid labour force can be analysed.

The data points to inefficiencies in the use of human resources by unnecessary fragmentation of time. The information also shows up which sex gets the menial, boring, low status and unpaid invisible work, with little or no technology, which in turn highlights oppression and subordination. In rural areas, such surveys show seasonal variations, allowing identification of suitable time slots for education and other programmes.

Time use data also provides measures of the interdependence of the activities of household members and of how paid work, caring work, house work, community work, leisure, and time spent on personal care are interrelated. This is vital, for an understanding of how the impact of paid labour force participation of women leads to growth in market activity to replace formerly unpaid activity in the home.

Time use data also tells when activities are carried out. It assists in planning post compulsory educational facilities. Targeting of hours and topics to match current and potential students' benefits, libraries, schools, community learning and private educational institutions.

The interdependence of market and non market activity makes it necessary to measure both. The changes in non market activity - such as child care - affect the context within which market activity is measured and can explain large amounts of the change in market activity. In Vietnam the provision of child care for women farmers increased their productivity by sixty percent.

Time use surveys also assist challenging the rhetoric of those occupying the dominant sound space. A study in a Siberian town compared the results of three time use surveys carried out in 1972, 1980, and 1990, covering a period of economic reform and the introduction of the market economy.[15] The studies indicated a reduction in men's paid working time, a flow of work from the public to the private economy as people put more time into working on their own plots of land, and an increase in self employment. The writers concluded that economic depression in the public sector had led to the "subsistencisation" of work. As food prices increased, people produced more of their own food in the subsistence economy, and spent more time doing that.

In studies in Australia Michael Bittman has concluded that as men gain more free time through fewer paid work hours they are not taking up more unpaid work at home, that while women are increasingly involved in paid work there is certainly no increase in leisure time for them, and that women's total work time is increasing. [16]

In the recently conducted European Time Use Survey the main objectives were to improve national accounts, particularly to give data for satellite accounts of household production; to contribute to the formulation of working time policy; to contribute to the formulation of gender and family policy; to contribute to the formulation of policy for senior citizens; to provide data on reasons for travel, for passenger transport and tourism; and to provide evidence on culture and leisure participation.

This is all significant progress towards a real picture of the total economy, but the work that I find the most exciting is being carried out in Australia, led by economist Duncan Ironmonger. As you will recall, he defined the household economy as the system that produces and allocates tradable goods and services by using the unpaid labour and capital of households. The household economy transforms intermediate commodities provided by the market economy into final items of consumption through the use of its own unpaid labour and its own capital goods.

Ironmonger was the first to adapt traditional input output tables showing the internal structure of the formal business and government sectors of the economy to the household. The traditional measures he calls the Gross Market Product (GMP). Household Input Output tables show the internal activity structure of the informal household sector of the economy and present the uses of intermediate commodities, labour and capital in each type of productive economic activity undertaken in households by unpaid labour and own capital. This he labels Gross Household Product (GHP). Gross Economic Product (GEP) is the total GMP and GHP. These input output tables can be prepared for different sorts of households, for example, those with and without children.

Grossing up the 1987 time use sample survey to reflect all Australian households, Ironmonger showed that seventy six million hours per week were used in meal preparation, sixty three million in cleaning and laundry and fifty three million in shopping. These were the three largest industries in the Australian economy, and compared with the three largest market sector industries of wholesale and retail trade with forty nine million hours per week, manufacturing with 49 million, and community services with forty one million. Women did 70 percent of the unpaid work in household industries; men did 67 percent of paid work in market industries. Overall, in the total economy women did 52 percent of all paid and unpaid work, in precise proportion to their being 52 percent of the population aged fifteen years or more.

Using the results of the National time use survey conducted in 1992, Ironmonger found that Australians do about 380 million hours of unpaid household work each week compared with 272 million hours in paid employment.

The value of the unpaid work, according to Ironmonger, calculated at the average salary rate, (including fringe benefits), of $14.25 an hour, was $283 billion in 1992. Add the contribution from household capital, which is $25 billion for equipment and vehicles, and $33 billion for the use of owner occupied housing, and the Gross Household Product was $341 billion, while the Gross Market Product was $362 billion. Household production therefore accounted for more than 48 percent of total production.

Drawing from the work of other commentators, Ironmonger has demonstrated the inter dependence of GMP and GHP. For example, investment in the United States rose from a level of about 33 percent of gross capital formation in equipment in market industries in 1900 to over 100 percent by 1950. In other words, by 1950, US residents were placing about as much new equipment in their households as they were putting into their business sector.

He draws attention to the significant fall in the UK from 1954 - 1974 in the proportion of household expenditure devoted to the purchase of services from the market. This fall was offset by a rise in the proportion of household equipment on capital equipment - cars, refrigerators, stoves, freezers, washing machines, vacuum cleaners, power tools, televisions, stereos and videos.

In his classic *The Third Wave* Toffler described the wholesale movement of tasks from market to the household as having been driven by the opportunities to externalize the labour costs of market industries. Such tasks include direct toll dialling, automatic bank tellers, self service petrol stations, customer selection of goods when shopping with few sales assistants, and lots of do it yourself home maintenance, decoration and renovation.

Ironmonger comments, product innovation in the household economy has been and will continue to be a major source of economic growth for both the market and the household. Moreover, many of the new commodities will have significant impacts on the use of time as they are adopted. New economic models, which include a more realistic portrayal of household activities in relation to both production and leisure, should help unravel these effects on the uses of time. They should also provide an improved understanding of the environmental resource impacts of household activities and how these can be minimized.

To underscore the magnitude of his findings he contends: ‘In regard to the business cycle fluctuations of Gross Market Product (GMP), it is my hypothesis that Gross Household Product (GHP) varies in a counter cyclical way so that Gross Economic Product (GEP) is relatively constant through the business cycle. I believe the trade off could be as high as 80 percent. This would mean that a $100 million rise in GMP would be balanced by a $80 million fall in GHP so that the cyclical effect on total economic output, GEP, is only a rise of $20 million’.

Finally, the political effects of his work are not lost on Ironmonger. He writes: ‘The most numerous and ultimately influential decision making units in the economy are not governments, firms, or multi national corporations, but households which have different methods of organization, management and decision making ... We are talking about a major change in our view of the world and a major change in what needs to be measured’.

The next step is also cataclysmic in terms of the existing order. Ironmonger’s work, duplicated now in Sweden and Norway, and without a doubt a universal truth, is that the single largest productive and service sector in a nation’s economy is the household sector. This sector has always been part of the new economic frontier promoted by APEC. There have been no minimum wages or minimum conditions or minimum hours of work. There have been customs barriers and tariff protections operating occasionally in terms of the equipment necessary to carry out the productive and service work, but there have never been capital depreciation allowances or taxation incentives for upgrading to a new technology.

Similarly, in this single largest productive sector, there have never been suspensory loans or tax breaks for research and development initiatives that originated with the front line professionals at work there. There has never been any effort to ‘fully integrate men’ into this largest economic sector, or to see efficiencies in this sector as being ‘an essential element in meeting APEC’s goal of achieving sustainable and equitable development’.

The question posed for my response at this meeting was why gender was an important issue in APEC science and technology development. I have responded by eliminating the uniform, the male garb of expectation, that would suggest that, size permitting, women can just fit into the current paradigm.

As I began my research for this presentation, I found a report of an APCWD Roundtable held in this region in 1979. In all the materials sent to me to prepare for this meeting, there are no new issues raised that differ from those of twenty years ago. Certainly there's a little more sophistication, and even more evidence of all the identified exclusions, stereotyping, discriminations from the numerous micro and macro surveys undertaken since the time, and the pilots on this and that, but the conclusion twenty years later is inescapable.

The absence of political will, and not an absence of data, inhibits the needed transformation. 'Why gender?' is always a question about the nature and fashion of male power, with all its accessories. I suspect it will be a long undressing.

END NOTES

[1] Concepts developed by Corlann Gee Bush.
[2] I am indebted to the work of Corlann Gee Bush at the University of Idaho for these Insights.
[3] 1990 Oxford and New York, Pergamon Press
[4] Women Envision: ISIS International. Nov - Dec 1997: Nos 51 - 52
[5] Gender Analysis in Rice Farming Systems Research
[6] IFAP (1990) 'Agro chemicals: a woman's view" Secretariat paper presented at the World Farmers' Congress organized by the International Federation of Agricultural Producers in Trondheim, Norway 4-8 June, 1990.
[7] Director of the Committee on Rural Energy of the Chinese Energy Society. 'Women's Group Activity in the Front Rural Energy'; Paper presented at the APEC Industrial S & T Working Group, Ad Hoc Group on Gender and S & T, Singapore, September 1997.
[8] There are some that aren't knowledge based? That's interesting. Some of the poorest most subsistence economies I am familiar with have the richest textures of complex knowledge I have ever encountered.
[9] 'Report to the Economic and Social Council' (E/CN.31993/18), para.23.
[10] 'Report of the Seminar on the Use of Multi Round Surveys for Estimating Vital Statistics' (ESCAP.STAT/SMUS/Rep.14), June 1991.
[11] ibid
[12] ibid
[13] APPROTECH - ASIA and WISE - Thailand 'Mainstreaming Women In Science and Technology', Manila, 1993: 6-7
[14] 'Data and Statistical Tools for Gender , and Science and Technology in APEC' - Draft Background paper.
[15] Victor Artomov and Galina Gvozdeva 1993 'Trends of Changes in the Time Budget of the Working Population of a Siberian town 1972 - 1990'. Conference Proceedings, Time Use Methodology: Towards Consensus, Rome.
[16] Michael Bittman, Lois Bryson and Sue Donath 1993 'Time Use and Comparative Welfare' Conference Proceedings, Time Use Methodology: Towards Consensus, Rome.

PAPERS PRESENTED AT THE

APEC EXPERTS MEETING ON

GENDER, SCIENCE AND TECHNOLOGY

WOMEN IN SCIENCE, MATHEMATICS, ENGINEERING IN THE US: THE CASE FOR DISAGGREGATED DATA

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The paper describes the network of agencies involved in the collection of scientific and technological data in the United States, and the various publications which report this data, especially that which is disaggregated by gender. In tracing some historical aspects about the collection of sex-disaggregated, S&T data, the author notes that although gender disaggregated data on education was being collected as early as the 1920s, its profile was increased with affirmative action requirements which arose in the 1970s. It was also in the 1970s that racially-disaggregated data on science and technology began to be collected and reported. Nonetheless, this data still is not abundant today. Dr. Malcolm stresses the importance of collecting qualitative measurements, along with the quantitative data which is more frequently reported.

WOMEN IN SCIENCE, MATHEMATICS, ENGINEERING IN THE US: THE CASE FOR DISAGGREGATED DATA

How do we determine if women and girls have access to education? How do we know how well they are performing in science, mathematics and engineering education? How do males and females compare with regard to the number of years of schooling, years of science and mathematics specific courses taken, performance levels on assessments of mathematics and science, degrees in science, mathematics and engineering, primary and secondary school level teachers and tertiary level faculty?

Answering these questions about males' and females' participation in education and especially education in science, mathematics, and engineering in the United States is the shared responsibility of several agencies. This decentralized data collection system involves a network that includes, for example, the U.S. Department of Education, the National Science Foundation, the Census Bureau in the Department of Commerce and the Department of Labor.

The United States has no central ministry of education; primary and secondary education is a responsibility of states and localities. But data collection about K-12 education has always been a federal responsibility, carried out by the National Center for Education Statistics. NCES depends on the collection of data from decentralized sources (by the states) based on agreed upon standards and protocols. State data tends to be aggregated from districts and district data from schools and so on. Such a system works only if the collecting groups know, understand and agree upon the rules for how the collection of data will be accomplished and reported.

Collection of data in ways that permitted disaggregation has a long history, earlier even than the movement for women's rights that occurred in the United States in the late 1960's and early 1970's. It is possible, for example, to determine how many males compared with females received doctoral degrees even from the 1920's. But this was not routinely presented until policy levers were in place that required the reporting of data in a disaggregated form.

Affirmative action requirements raised the value of disaggregated data. In the mid-1970's, data disaggregated by major racial and ethnic groups began to be collected and reported. Some of the earliest work in reporting disaggregated data relevant to science, mathematics, engineering, and technology (SMET) education and participation, collected in a single volume, was done outside of the federal government. An organization supported by the professional societies, the Scientific Manpower Commission (now the Commission on Professionals in Science and Technology or CPST), received funding from the Ford Foundation in the mid 1970's to bring together the data from the disparate sources across the federal government, professional societies and other research sources, and publish these in forms disaggregated by race or gender. CPST exists to this day; it still publishes *Professional Women and Minorities*, and serves as a forum for professional organizations' data collection and survey analysis, seeking to improve the quality, comparability and timeliness of data from these private sources.

Work done at AAAS in the mid 1970's supported the need to disaggregate data by gender across racial/ethnic groups since the experiences of women may vary by race, social class and the like. These data remain, perhaps, the hardest to come by and present continuing data collection and reporting challenges. A number of regularly published and available government reports, including several mandated by law, ensure a steady stream of gender disaggregated data on education, including education in science and technology. The Department of Education publishes the *Digest of Education Statistics*, first published in 1962 and *The Condition of Education,* which was mandated by the educational amendments of 1974, and was first published in 1975. Likewise, *Science and Engineering Indicators* (SEI) is a report to the President and Congress on the "health of science" which is produced by the National Science Board in even - numbered years; Women, Minorities and *Persons with Disabilities in Science and Engineering* is mandated by the Equal Opportunities in Science and Engineering Act of 1980. These documents provide ample data for analysis by policy makers and practitioners alike.

Because of the requirement to monitor the "health of science in the United States" *Science and Engineering Indicators* collects, assembles and displays comparative data obtained from many other countries of the world. The 1996 edition of SEI, for example, cites references to data from 23 countries. Chapters are built around themes that explore education participation at various levels, workforce and other "science and engineering productivity" indicators.

With a focus on monitoring the health of science and engineering, data is compared across years as well as with other countries. So it is possible to tell at a glance, for example, whether there have been increases in women's participation in engineering or biology, when these occurred and what the overall trends in participation (up, down, no change) happen to be.

Explanatory text and graphs that "tell a story" are accompanied by appendices of data tables that permit further analyses. These materials are made available on the National Science Foundation (NSF) World Wide Web site at www.nsf.gov. The specific URL for *Indicators* is as follows: http://www.nsf.gov/sbe/srs/

NSF, through its Science Resources Studies Division, depends on the working relationships with other data collection agencies within the US government and around the world to help make this data generally available. While equity or development objectives, policies and reporting requirements can ensure that data is collected, reported, and available, that is only the beginning of the story. An equally crucial part is how data gets used to inform policies, programs, practices and advocacy.

Advocacy may sound like a strange word in this line up of the uses of data. But this is often a crucial end use. In the early 1970's a direct comparison of the mathematics courses required for certain college majors with the mathematics that women entering college had taken made it quite clear why so few were majoring in science and engineering. Young women lacked the requisite mathematics preparation to enable such choices. Tests of mathematics achievement taken by randomized samples of US students confirmed performance differences and showed a gender gap favoring males.

Advocates, looking at patterns of mathematics course-taking, seized on the clear link between curriculum and performance and made an issue of this link. What seems so obvious now (i.e., you cannot demonstrate knowledge you have not had an opportunity to learn) was not necessarily obvious to all then as many looked to genetics, interest and "choice" for alternative explanations of the gender gap in mathematics performance.

A grassroots movement raising the issue of girls in math and a push by the advocacy community to take high level mathematics in secondary school eventually has given way to serious policy discussions about how much mathematics and science all students need to take. While US performance on the recently released Third International Mathematics and Science Study (TIMSS) taken by students at the end of secondary school showed abysmal performance overall in both science and mathematics, there was no significant gender difference in general mathematics scores; hence, young women can't be blamed for the overall problems in the performance.

At some point our simple head counts (how many males and females are in primary or secondary or tertiary education or how many degrees were awarded in various fields) had to give way to other indicators in order to figure out how to increase the participation of women in education. These other indicators include the quality of education, as measured by the specific courses, the preparation of their teachers, the access to labs and other facilities. They also include the outcomes of their education, as measured by relative performance on exams, admission to tertiary education or receipt of degrees in science, mathematics, engineering, and technology. We must come to understand more subtle issues such as the texture of the courses, that is, what is inside of the box called chemistry, physics or algebra.

Consider first a system of universal access to school that produces very different results for males and females 17 years later: How do we begin to understand what is producing this? In the past we have relied on something that we have called "pipeline analysis". That involved examining inputs, losses and outputs, and looking for possible differential treatment that explains losses.

For example, we now know that in the last 25 years we have seen rather remarkable changes in degrees awarded to women at all levels and in virtually all fields of science and engineering. This was related to changes in courses taken at the secondary level, in intended majors at the tertiary level and increased participation in graduate education. What is not as obvious are the changes in policies, practices, programs and culture that supported and guided the numerical shifts.

At the primary school level science and mathematics are supposed to be taken by all. Slight performance differences favoring males in science and mathematics scores on the National Assessment of Education Progress (NAEP) are seen for 4^{th} and 8^{th} graders. Here the questions to be asked and answered are subtle. These relate to the amount and quality of actual instruction in these subjects, the nature of classroom practice, the opportunities for engagement with science and mathematics experiences and concepts both in and out of school.

At the high school level science and mathematics are required in terms of number of years. The actual courses to be taken are often unspecified. Young women have increased course-taking of science and mathematics and are on a par with course-taking by young men for all but the most advanced courses. These course-taking data comes from actual transcript studies of students in the National Education Longitudinal Study or NELS that tracked students beginning in middle school (lower secondary).

At the point science and mathematics courses are chosen, we must monitor the choices made.

Counting helps us look at the relationship of curriculum and performance. The simple act of counting elevates the issues of girls' and women's education, and permits accountability and monitoring of change. What about elite schools of science and math - are young women as likely to participate as well as young men?

If differentials are found what are possible responses in terms of policy and practice?

- Analyze and attempt to affect the process of choosing - the role of counselors, parents, peers.
- Reduce the amount of choice; that is require a certain amount of course-taking for all.
- Provide interventions: access to role models, chances to explore careers and the preparation needed to pursue these, opportunities for hands on experiences.

Counting to affect policy needs to be done at the policy level closest to the student. Grassroots movement was needed to affect primary and secondary education since decisions are made one district at a time. Engaging local systems, individual schools and departments in the process of counting helps them "own" and "be responsible for" the problem. National data can serve to help make the case or issue a challenge but, in a highly decentralized system, it does not affect students' lives.

Parent focused interventions have been known to use salary data to make a case for SMET education, data which shows higher salaries for SMET fields and smaller salary differentials for men and women.

At the college and university level, we find more females than males enrolled in college but also see gender differentiation in the choices of majors and degree outcomes. Data available on intended freshman majors show increased selection of SMET majors by females but also an interest gender gap, especially in engineering, that favors males.

Data are needed on retention of men and women in SMET fields — from freshman year through the degree. This is incredibly difficult data to come by, most appropriately done at the institution or even the department or college level. Also difficult to come by is data on women faculty at different levels (ranks), fields, progression rates.

We know that some institutions are more successful than others in graduating women in SMET and in moving women toward graduate education and completion of the doctorate. In most cases we have incomplete understanding of why this is so. While the experience of women's colleges would imply that the presence of significant numbers of women as SMET faculty might have a role, it is not clear that this can be generalized.

Some colleges and universities have worked hard at understanding the dynamics at work within their own institution. For example, the Massachusetts Institute of Technology (MIT) has worked to understand the dynamics surrounding admissions, including the role of the SAT or Scholastic Assessment Test. Their study revealed that the SAT is not a good predictor of actual performance in courses as measured by GPA (grade point average) for female students, thus supporting the policy of admitting women with lower scores since they will end up with higher grades and stronger performance.

Some departments, such as psychology and chemistry, receive accreditation through national

professional societies or accrediting entities. Departments in these fields may be required to collect gender disaggregated data as a part of the self - study process.
In the US the one field which has been most resistant to enrollment increases by women is physics. Several societies, including the Association for Women in Science, are working together to study the "climate" of physics departments. Women physicists interact with faculty and students and seek to understand the dynamics which might be producing "gendered" outcomes. Among the elements that have been suggested are the presence of significant proportions of foreign students, mostly males, especially from countries with different perspectives and attitudes on the role of women in science; the absence of significant numbers of successful women faculty; and different patterns of support for graduate education of males and females.

We need to move back and forth between quantitative and qualitative research. For example we might be able to use quantitative data to determine which schools are doing particularly well in the education of girls and women in science and mathematics. These might be measures of percentage participation in courses or relative test performance. But this identification would need to be supplemented by actual qualitative research that seeks to determine what is different about the teaching or policies in well performing versus poorly performing schools.

We need to make data generally available for secondary analysis by gender researchers and others. Consider electronic forms to present data which can support greater detail in the data, and more manipulation of the data by researchers in the university and non - profit sectors. Almost no statistical agency has the person power to support the level of analysis that this paper advocates; nor should it be assumed that staff will have the knowledge of the barriers that women and girls face in science, mathematics, engineering and technology.

Putting more people on the job of data analysis also allows a broader "ownership" of the problems within the society. Data can thus be used to help solve problems as well as to help describe them.

Barriers in graduate education may be social, cultural, attitudinal and/or financial. Real concerns arise about the challenges of juggling/balancing professional, career and family responsibilities.

Data Supporting Policy

The bottom line for data collection is to be able to answer the questions that policy makers want answered. But this means listening to them to find out what they want to know; this means avoiding the tendency to hold on to data that supports the time series in favor of changing these to accommodate more relevant framing of questions. Supporting policy makers will likely mean pushing the "culture for data collection and analysis" to its lowest levels.

What is the role of "extra - curricular" participation in science (science fairs, science clubs, museum and science center attendance) in supporting commitment to science and mathematics courses and careers?

Obviously there will be more questions than answers in the near term. But an honest effort to seek answers can result in the redesign of systems so that they support quality SMET education, and access to careers for both women and men; it will also give our countries a human resources base that supports sustainable development

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ARE GENDER DIFFERENCES IN ACADEMIC ACHIEVEMENTS OF HK SECONDARY STUDENTS DISAPPEARING?

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Abstract

Considerable research in Western countries has found that gender differences in cognitive performance are rather small and decreasing Are gender differences in academic achievements disappearing in Hong Kong? Recent research suggests that it might be more valid to assess gender differences by examining the norms for standardised tests because such national norms are based on large representative samples, and are more free from publication bias and experimenter bias. This research examined the gender differences in the participation and the performance of students in Hong Kong Certificate Education Examinations and Hong Kong Advanced Level Examinations from 1978 to 1997.

Because gender differences in performance are not evenly spread out in different grade groups, and the curriculum content, examination standards, and overall passing rates change over years, a special statistical tool is necessary to represent the overall gender differences in performance. The effect sizes "d" (defined as the differences between mean of males and mean of females divided by average standard deviation) of all major science and mathematics subjects were computed. Changes over time were computed by correlational analysis. Study results indicate there were significant decreases in gender differences in both the participation and performance of students in science and mathematics of Hong Kong Certificate Education Examination, but no such result appears in Hong Kong Advanced Level Examination. The possible reasons for and the implications of such findings are discussed.

Biographical Note

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ARE GENDER DIFFERENCES IN ACADEMIC ACHIEVEMENTS OF HK SECONDARY STUDENTS DISAPPEARING?

In the pioneering review of the literature on sex differences, Maccoby and Jacklin (1974) concluded that there was a gender difference favouring girls in verbal ability, and there were differences favouring boys in quantitative and spatial abilities. Over the past decade, meta-analysis review which focuses on effect-size summarization, and on explaining variability, has become a popular method of reviewing work in gender differences. Many (Hyde 1981; Feingold 1988; Hyde, Fennema and Lamon 1990; Hyde and Linn 1988; Linn and Petersen 1986) concluded that the magnitude of cognitive gender differences is too small to be meaningful, while others (Hyde, Fennema and Lamon 1990) found that gender differences grew large with increasingly selective samples, and their magnitudes declined over the years. Recently, Feingold (1988, 1993) suggested that it might be more valid to assess gender differences by examining the norms for standardized tests such as examinations, because such national norms are based on large representative samples, and are more free from publication bias and experimenter bias.

This research studies the gender differences in the participation and performance of boys and girls in the Hong Kong Certificate Education Examination and the Hong Kong Advanced Level Examination. It studies the magnitude of the overall gender differences and the differences in the high ability groups; and it also explores the change in gender differences over time.

Method

At a level equivalent to grade 11, most Hong Kong students take the Hong Kong Certificate of Education Examination (HKCEE), and two years later, they have to take the Hong Kong Advanced Level Examination (HKLE) before they enter university. This study examines the data extracted from the annual reports of these two examinations (HKCEE 1978-1997; HKLE 1980-1997). It studies gender differences in English and Chinese, mathematics, science and some other common subjects. Gender differences in participation are expressed as the ratios of the percentages of males to percentages of females who took the examination. (M%:F%).

Gender differences in performance are examined after the effects of differential participation are excluded. Following most overseas meta-analysis research (Feingold 1988; Feingold 1994; Hyde 1981; Hyde, Fennema and Lamon 1990; Hyde and Linn 1988; Linn and Peterson 1986), the two popular statistical tools “d” and “w^2" are used to represent the magnitudes of overall gender differences; “d” is the effect size of gender differences which is calculated by dividing the mean differences between the gender groups by their average within groups standard deviation. “w^2" measures the proportion of variance in the entire distribution of scores that can be accounted for by gender differences. In order to compute d and w^2, the grades in the examination reports are converted into marks by giving a weighting to each grade as follows: 6 for A; 5 for B; 4 for C; 3 for D; 2 for E; 1 for F.

The gender differences are also analysed by computing ANOVA scores. Moreover, in order to understand the gender differences better in daily-life terms (Eagle 1995; McGraw and Wong 1992), gender differences in passing percentages are also reported. For gender differences in overall performance, the differences between the percentages of males and females who are awarded E % in the examination (M% - F%) are calculated. Thirdly, gender differences in performance in different grade groups are compared by computing two ratios: first, is the ratio M:F which simply is the ratio of the number of males to females getting the grade; another one is the ratio M%:F% which is the percentage of males to that of females getting the grade. The latter ratios reflect the gender differences in performance after the gender differences in participation being controlled, in an equal participation situation. In the final and most important part, the time change in gender differences is examined by computing the correlational analyses between the different statistical tools and the examination years.

Results

With respect to participation in 1997 HKCEE, as expected, males dominate the science subjects while females dominate the arts subjects. Using the M%:F% ratios of physics and chemistry to make an estimation, 8 boys for every 5 girls take the sciences stream in Hong Kong. In table 1, the extreme end for males are all technology and engineering subjects, while on the extreme end for female, there are fashion and clothing, home economics and shorthand. In these extreme ends, there are nearly no cross-sex subject choice (Table 1).

This pattern of segregation is also seen with the Advanced level examination. In some cases, the gender disparity observed is even larger. Girls are poorly represented in physical science and high level mathematics. This is also true for pure mathematics and applied mathematics which have more boys. It is observed also that there were more girls in lower level physics than the more advanced physics classes, as shown in table 2.

On the performance assessments, it was found that in the core subjects of the HKCEE, in line with the cultural norms, boys did better in mathematics (d = 1.4) while girls did better in the English and Chinese language courses (d. = -.53 and -.62). The gender differences in English and Chinese language courses are greatest among all subjects, the differential assessed on the basis of passing students being 14% and 16%. It was determined that sex accounted for 12% and 17% of their overall variations.

However, on the basis of performance, in contrast to cultural expectation, the effect sizes of most common science subjects were in favour of girls. Girls performed better than boys in physics, chemistry, biology and additional mathematics. In fact, girls performed better in nearly all common subjects, except mathematics and computer studies in which girls were only very slightly behind (d = .14 and d = .07). Even in terms of overall performance, girls were better than boys. There were 7.8% more girls who passed at least 5 subjects. (Tables 3 and 8)

In the Advanced Level Examinations, gender differences in Chinese and English languages were again significant and, as expected were in favour of girls. Unlike results in the HKCEE, gender differences in mathematics and science subject did exist and were in favour of boys. (D=.48 and .40). But the effect-size of the easier mathematics course, mathematics and statistics, was very small (Table 4).

According to Cohen's (1977) guidelines, an effect-size d of .2 to .49 is called small; a d of .5 to .79 is medium; and a d of .8 or above is large. That means, except for Chinese and English language courses, all the effect-sizes found in the results of the population in 1997 can be considered as "small".

However, a closer examination reveals that the gender differences in most A grade groups were much larger than that in other grade groups. For example, in the HKCEE level Chinese language course, the percentage of boys getting an A grade to percentage of girls getting an A grade was 3 to 10; that ratio in English was 4 to 10; that ratio in mathematics was 17 to 10, and in A-Level physics it was 2 to 1. Note that the factor, differentiation in participation, had already been excluded in this analysis. If the participation factor was not excluded, the gender differences in A grade groups would have been even larger. For example, in A-Level physics, for every single girl in the population getting an A grade there would have been 3.7 boys getting an A grade (Tables 11 and 12).

To examine the changes over time, the correlation and analyses were computed on years and participation/performance statistics. It was found that the gender differences in participation were declining significantly. At both the certificate and A-level, there were more girls taking science and mathematics subjects. Besides, in the past 18 to 20 years, the trend has changed from more boys to more girls participating the HKALE (r= -.98, p less than .01) For example, in 1997, for every 10 girls, there were 8 boys taking the A.L. examination (Table 5, 6 and 7)

However, the trends in gender differences in performance were diversified. Convergence of scores was found in Certificate-level physics and mathematics (r - .86 and -.88; p less than .01). However, the gender differences in Advanced Level pure mathematics and science subjects did not show the same decline. On the other hand, there was a convergence of scores found for the A-Level English courses, unlike in that of the Chinese and English language courses at the Certificate level. The latter were actually found to be increasing. Again similar to the trend shown in participation, the overall performance at the Certificate level (i.e. award %E or over) changed from favouring boys to favouring girls (r = -.89; p less than -.01) (Tables 8, 9, and 10).

Discussion

In terms of participation, gender segregation still exists, even though it is declining. To enhance the development of the full potential of both sexes, some measures should be taken to encourage more girls to take science subjects. Schools should not forbid or discourage girls and boys from taking cross-sex typed subjects, like design and technology, shorthand or home economics.

With respect to performance, according to Cohen's convention where an effect-size d of .2 is classified as small, d of .5 is classified as medium and that of .8 is large, most of the effect-sizes found in science and mathematics were not large. For example, in the core Certificate Level subject of mathematics, a d. Of .14 implies only a gender difference of 0.`4 of the average standard deviation; A w^2 of .009 implies that gender explains only .9% of the variance in the results, which means 99.1% of the variance is due to factors not related with gender. Indeed, difference within sex groups are much greater than the difference between sexes. Besides, evidence has shown that according to a stable trend, girls are now performing better than boys in all science subjects at the certificate level. It is likely that sex stereotypes in Hong Kong society has exaggerated the magnitude of gender differences in mathematics and science abilities. It is especially true when we are talking about the whole population and certificate level.

However, as pointed out by other researchers (Rosenthal 1984; Eagly 1995) a small effect size can still have important social and personal consequences. When qualifications are based on having a scale score above some specified value, a small effect can make many more males than females qualify for a given job or a given school. As this study has found, gender differences are much greater in selected groups, such as that of the high performers. The more competitive a job or an enrolment for university is, the greater the influence of this gender factor. Feingold (1988 and 1994) suggested that the large gender differences in the high ability group can be attributed to the higher standard deviation together with the slightly higher mean of the group. This study lends some support to his explanation. In many cases in Hong Kong, the favourable sex (in terms of means) also has slightly higher standard deviation, which together may create the large gender differences in the A-grade groups. Further research is required to evaluate whether there exists other factors which contribute to these large effects.

The results of this study raise many unanswered questions:

1. Why are gender differences in the language subjects so large? In particular, at the Certificate level, they have shown a tendency to increase further in recent years. Would this become one of the major obstacles for boys to pursue further education?

2. Why are girls performances in mathematics and physics not improving over time at the A-Level, while they are at the Certificate-level, and more girls are taking science subjects at the Advanced-Level? What are the implications of this on gender differences in university enrolments in S&T, and subsequently in S&T careers?

3. Why is there a trend favouring girls both in overall participation as well as overall performance, especially at the HKCEE level? Do these changes reflect societal changes, psychological changes of girls or due to our recent changes in school curricula, pedagogies and examination methods?

4. Why are there huge gender differences found in the high ability groups? Are gifted females underachieving in science and mathematics, and gifted boys underachieving in languages? What are the reasons behind this, and what are their implications?

In conclusion, gender differences in participation of HK students, though still existing, are obviously declining over time. However, the trends in gender differences in performance are not consistent among different subjects and at different levels. This study suggests that Hong Kong educators should look into several issues: the study of languages by boys, the study of advanced level science and mathematics by girls and the under-achievement of high abilities boys and girls. Innovations in curricula and assessment methods, changes in teachers', parents and students attitudes, modification in learning strategies and habits, may all be needed to reducing the gender differences found.

Table 1. Gender Differences in Participation of Cert. Level Exam, 1997

Subjects	**M**	**F**	**M% : F%**
Design & Technology	595	0	

Subjects	**M**	**F**	**M% : F%**
Metalwork	1201	5	254.73 : 1
Technical Drawing	2739	24	121.03 : 1
Electronics & Electricity	1583	15	111.92 : 1
Engineering Sciences	1686	21	85.14 : 1
Textile	164	21	8.28 : 1
Physical Education	282	125	2.39 : 1
German	4	2	2.12 : 1
Physics	**17970**	**11674**	**1.63 : 1**
Chemistry	**17449**	**11714**	**1.58 : 1**
Additional Maths.	**11966**	**8155**	**1.56 : 1**
Computer	**9017**	**6169**	**1.55 : 1**
Biology	**16298**	**12324**	**1.40 : 1**
Govern. & Public Affairs	448	379	1.18 : 1
Religious Studies	6028	6057	1.06 : 1
Mathematics	**35118**	**37248**	**1 : 1**
Chinese Language	**35161**	**37342**	**1 : 1**
English Language	**35262**	**37493**	**1 : 1**
Buddhist	797	1077	1 : 1.27
Travel and Tourism	608	856	1 : 1.32
Chinese History	**11715**	**17190**	**1 : 1.38**
Economics	**14027**	**21204**	**1 : 1.43**
Econ. & Public Affairs	291	449	1 : 1.45
Geography	**10754**	**16658**	**1 : 1.46**
Commerce	3853	5961	1 : 1.46
History	**7074**	**11087**	**1 : 1.48**
Principles of Accounting	**6284**	**10609**	**1 : 1.59**
French	52	94	1 : 1.70
Chinese Literature	**4538**	**9279**	**1 : 1.93**

Subjects	**M**	**F**	**M% : F%**
Typewriting	1886	4695	1 : 2.35
Social Studies	131	432	1 : 3.11
Music	36	119	1 : 3.12
Human Biology	471	1929	1 : 3.86
Ceramics	8	45	1 : 5.30
Account & Catering	6	80	1 : 12.57
English Literature	9	710	1 : 74.39
Fashion & Clothing	1	144	1 : 135.79
Home Economics	0	472	
Shorthand	0	18	

Note: the common subjects are bold-faced.

Table 2. Gender Difference in Participation of A. Level Exam, 1997

Subjects	M	F	M% : F%
Design & Technology	45	0	
Engineering Science	158	34	5.79:1
Applied Maths (A)	1001	234	5.33:1
Computer Studies	219	62	4.40:1
Applied Maths (AS)	894	267	4.17:1
Chemistry (AS)	297	129	2.87:1
Pure Math (A)	**4458**	**2083**	**2.67:1**
Physics (AS)	**6132**	**3456**	**2.21:1**
Chemistry (A)	**4787**	**4075**	**1.46:1**
Physics (AS)	442	443	1.24 :1
Biology (A)	**2524**	**2622**	**1.20 :1**
Biology (AS)	15	19	0.98 :1
Chinese Language and Culture	**10895**	**13509**	**1: 1**
Use of English	**10881**	**13553**	**1: 1**
Music (A)	5	5	1: 0.80
Computer App.	**1072**	**1261**	**1: 0.94**
Sociology (AS)	5	7	1: 1.12
Math & Statistics	**1371**	**2305**	**1: 1.35**
Sociology (A)	10	17	1: 1.37
Ethics & Religious S.	57	103	1: 1.45
Music (AS)	2	4	1: 1.61
Chinese History (A)	**1081**	**2267**	**1: 1.68**
Library Studies	312	683	1: 1.76
Business Study	543	1189	1: 1.76
Economics	**2423**	**5335**	**1: 1.77**
Chinese History (AS)	386	905	1: 1.88

Subjects	**M**	**F**	**M% : F%**
History (A)	548	1294	1: 1.90
Art (A)	15	36	1: 1.93
Geography (A)	**1586**	**4115**	**1: 2.08**
History (AS)	462	1234	1: 2.15
Govern. & Public A. (AS)	38	109	1: 2.30
Art (AS)	8	23	1: 2.31
Chinese Literature	**786**	**2666**	**1: 2.72**
Govern & Public A. (A)	27	112	1: 3.33
Psychology	48	262	1: 4.38
English Literature (AS)	6	54	1:7.23
English Literature (A)	5	166	1:26.66
French	0	2	

Note: The common subjects are bold-faced.

Table 3. Magnitude of Gender Difference in Performance in Cert. Level Exam, 1997

Subject	Difference in % pass	Male		Female		Analysis of Variance		Effect Size
	(M% - F%)	M	SD	M	SD	F	w^2	D
Language								
English	-13.8	1.5	1.0	2.1	1.2	4604***	0.124	-0.53
Chinese	-16.4	1.8	1.1	2.5	1.4	6345***	0.168	-0.62
Maths								
Maths	2.0	2.7	1.4	2.5	1.3	321***	0.009	0.14
Additional Maths	-6.5	3.0	1.5	3.2	1.6	100***	0.010	-0.13
Science and Technology								
Physics	-4.4	2.6	1.4	2.7	1.4	36***	0.002	-0.07
Chemistry	-6.3	2.6	1.4	2.8	1.4	186***	0.013	-0.16
Biology	-3.9	2.6	1.4	2.8	1.4	106***	0.007	-0.13
Computer Studies	0.7	2.4	1.4	2.3	1.3	16***	0.002	0.07
Others								
Computer	0.7	2.4	1.4	2.3	1.3	16***	0.002	0.07
History	-6.9	2.1	1.1	2.4	1.2	280***	0.031	-0.26
Geography	-6.0	2.1	1.2	2.3	1.2	226***	0.016	-0.19
Economics	-5.5	2.0	1.2	2.2	1.2	209***	0.012	-0.16
Chinese History	-3.6	2.0	1.1	2.1	1.1	46***	0.003	-0.08

***$p < 0.01$
** $p < 0.05$
* $p < 0.10$

Table 4. Magnitude of Gender Difference in Performance in A. Level Exam, 1997

Subject	Difference in % pass (M% - F%)	Male M	Male SD	Female M	Female SD	Analysis of Variance F	w^2	Effect Size D
Language								
Use of Eng.	-8.2	2.3	1.1	2.7	1.3	842***	0.068	-0.35
Chin. L. & Cult.	-8.6	2.6	1.2	3.1	1.6	1404***	0.113	-0.38
Maths								
Math & Stat	1.8	2.7	1.4	2.6	1.4	4***	0.002	0.07
Pure Maths	1.2	3.0	1.6	2.8	1.4	24***	0.007	0.12
Ap. Maths (AL)	8.1	3.2	1.6	2.6	1.3	47***	0.075	0.40
Ap. Maths (AS)	-0.7	2.9	1.5	2.7	1.3	5**	0.009	0.13
Science								
Physics (AL)	13.5	2.9	1.5	2.2	1.3	541***	0.110	0.48
Physics (AS)	17.5	1.8	1.0	1.2	0.9	80***	0.177	0.62
Chemistry (AL)	3.0	2.8	1.4	2.6	1.3	48***	0.011	0.14
Chemistry (AS)	-1.8	2.8	1.5	2.7	1.4	2	0.007	0.12
Biology (AL)	-2.4	2.3	1.2	2.4	1.3	8***	0.003	-0.08
Biology (AS)	-8.4	2.1	1.5	2.2	1.0	0.1	0.006	-0.11
Others								
History (AL)	-4.2	2.8	1.4	3.0	1.5	9***	0.010	-0.13
History (AS)	-4.7	2.5	1.3	2.8	1.4	18***	0.021	-0.20
Geography	-6.8	2.3	1.2	2.7	1.4	98***	0.034	-0.27
Economics	3.7	2.7	1.4	2.5	1.3	45***	0.011	0.15
Chinese Lit.	-8.8	2.2	1.3	2.5	1.3	58***	0.033	-0.27
Chin. Hist (AL)	-3.9	2.3	1.3	2.4	1.2	4**	0.002	-0.07
Chin. Hist (AL)	-8.0	2.5	1.3	2.9	1.5	29***	0.044	-0.29

***p < 0.01
** p < 0.05
* p < 0.10

Table 5. Gender Differences in Participation in Cert. Level Exam by Subject by Year

Ratio of Males to Females (M:F)

Year	Chin.	Eng.	Maths	Phys.	Chem.	Bio.	Comp.	Total
78	1.11	1.10	1.16	3.27	2.77	1.08		1.11
79	1.06	1.05	1.09	3.12	2.78	1.11		1.06
80	1.02	1.02	1.07	3.08	2.80	1.13		1.02
81	0.97	0.97	1.00	2.97	2.68	1.12		0.97
82	0.91	0.90	0.94	2.83	2.63	1.10		0.91
83	0.89	0.89	0.91	2.80	2.63	1.10		0.89
84	0.88	0.88	0.90	2.63	2.49	1.18	1.77	0.88
85	0.90	0.89	0.91	2.56	2.42	1.30	1.60	0.90
86	0.91	0.90	0.93	2.52	2.38	1.41	1.54	0.90
87	0.88	0.87	0.90	2.40	2.27	1.45	1.68	0.87
88	0.88	0.87	0.89	2.36	2.24	1.52	1.74	0.87
89	0.86	0.85	0.87	2.26	2.14	1.53	1.46	0.85
90	0.85	0.84	0.84	2.21	2.08	1.52	1.45	0.84
91	0.84	0.82	0.85	2.13	2.03	1.54	1.42	0.85
92	0.88	0.86	0.88	2.09	1.98	1.58	1.40	0.86
93	0.92	0.89	0.92	1.94	1.85	1.56	1.39	0.90
94	0.93	0.81	0.83	1.79	1.72	1.48	1.48	0.91
95	0.91	0.89	0.92	1.68	1.62	1.41	1.39	0.90
96	0.93	0.93	0.91	1.64	1.59	1.37	1.42	0.93
97	0.94	0.94	0.94	1.54	1.49	1.32	1.46	0.94

Table 6. Gender Difference in Participation in A. Level Exam by Subject by Year

Year	Eng.	P. Math	Phy.	Chem.	Bio.	Total
80	1.61	6.20	3.99	3.84	2.31	1.64
81	1.47	5.69	3.81	3.60	2.16	1.50
82	1.31	5.47	3.63	3.38	2.04	1.32
83	1.33	5.59	2.80	3.51	2.12	1.33
84	1.26	5.39	3.55	3.28	2.08	1.26
85	1.24	5.24	3.60	3.34	2.22	1.24
86	1.24	5.58	3.67	3.37	2.23	1.24
87	1.21	5.12	3.29	3.01	2.05	1.21
88	1.16	4.96	3.14	2.87	2.00	1.18
89	1.10	4.81	3.03	2.73	1.95	1.10
90	1.07	4.38	2.79	2.39	1.81	1.07
91	0.96	3.54	2.40	2.06	1.64	0.96
92	0.94	3.39	2.26	1.93	1.49	0.94
93	0.87	2.94	2.02	1.62	1.10	0.88
94	0.84	2.78	2.17	1.49	1.24	0.84
95	0.85	2.43	1.87	1.36	1.12	0.85
96	0.80	2.15	1.79	1.26	1.02	0.80
97	0.80	2.14	1.77	1.17	0.96	0.80

Table 7. Correlation of Gender Difference in participation (M:F) with Time

Subjects	r	Average M:F over Last 3 yrs
Cert. Level (1978 - 97)		
Chin. Lang	-0.53**	0.93
Eng. Lang.	-0.61***	0.92
Mathematics	-0.63***	0.93
Physics	-1.00***	1.62
Chemistry	-0.99***	1.57
Biology	0.75***	1.36
Computer St.	-0.88***	1.42
Total	-0.56	0.92
A. Level (1980 - 97)		
Eng. Lang.	-0.98***	0.82
Pure Maths	-0.96***	2.24
Physics	-0.93***	1.81
Chemistry	-0.98***	1.26
Biology	-0.93***	1.03
Total	-0.98***	0.82

***$p < 0.01$
** $p < 0.05$
* $p < 0.10$

Table 8. Gender Difference in Performance in Cert. Level Exam. By Subject by Year

	Effect Size							
Year	**Chin.**	**Eng.**	**Math.**	**Phy.**	**Chem**	**.Bio.**	**Comp.**	**Overall** (**Awarded 5E) M% - F%**
78	-0.14	-0.17	0.39	0.20	0.07	0.04	0	0.43
79	-0.21	-0.19	0.44	0.28	0.07	0.04	0	2.10
80	-0.28	-0.16	0.50	0.51	0.06	0.03	0	1.80
81	-0.31	-0.12	0.45	0.30	0.06	0.03	0	2.34
82	-0.33	-0.14	0.46	0.23	0.11	0.05	0	2.79
83	-0.23	-0.14	0.47	0.17	0.12	0.05	0	2.90
84	-0.33	-0.14	0.42	0.30	0.28	0.12	0.53	1.85
85	-0.37	-0.15	0.39	0.13	0.21	0.08	0.56	0.24
86	-0.32	-0.12	0.42	0.14	0.22	0.07	0.30	0.77
87	-0.27	-0.14	0.36	0.20	0.12	0.08	0.17	0.60
88	-0.29	-0.11	0.40	0.13	0.15	0.05	0.24	0.71
89	-0.32	-0.17	0.37	0.15	0.13	0.04	0.17	-0.50
90	-0.23	-0.14	0.20	0.13	0.11	0.06	0.18	-0.58
91	-0.28	-0.16	0.36	0.10	0.05	0.01	0.20	-0.24
92	-0.33	-0.18	0.33	0.06	0.04	0.03	0.17	-2.37
93	-0.34	-0.20	0.21	0.00	-0.02	-0.03	0.12	-4.00
94	-0.35	-0.24	0.19	-0.02	-0.04	-0.06	0.11	-5.50
95	-0.29	-0.19	0.18	0.01	-0.06	-0.09	0.06	-4.80
96	-0.49	-0.47	0.21	0.00	0.08	-0.08	0.05	-5.90
97	-0.62	-0.53	0.14	-0.07	-0.16	-0.13	0.01	-7.80

Table 9. Effect Size (d) of Gender Differences in Performance in A. Level Exam by Subject by Year.

Year	Eng.	P. Math	Phy.	Chem.	Bio.
80	-0.45	0.24	0.46	0.12	-0.02
81	-0.35	0.31	0.41	0.12	-0.06
82	-0.48	0.24	0.36	-0.01	-0.15
83	-0.43	0.27	0.43	0.14	-0.15
84	-0.42	0.22	0.40	0.08	-0.09
85	-0.37	0.30	0.40	0.02	-0.15
86	-0.39	0.33	0.59	0.16	0.07
87	-0.35	0.27	0.46	0.16	0.01
88	-0.42	0.42	0.58	0.10	0.05
89	-0.27	0.31	0.57	0.06	-0.01
90	-0.28	0.30	0.49	0.11	-0.01
91	-0.38	0.32	0.50	0.16	-0.01
92	-0.26	0.23	0.40	0.17	-0.18
93	-0.23	0.25	0.42	0.17	-0.11
94	-0.26	0.18	0.33	0.10	-0.14
95	-0.28	0.13	0.33	0.10	-0.13
96	-0.32	0.18	0.48	0.18	-0.26
97	-0.35	0.12	0.48	0.14	-0.08

Table 10. Correlation of Effect Size (d) in Performance with Time

Subjects	r	Average d over last 3 yrs
Cert. Level (1978-97)		
Chin. Lang.	-0.64***	-0.47
Eng. Lang.	-0.60***	-0.40
Mathematics	-0.88***	0.18
Physics	-0.86***	-0.02
Chemistry	-0.51**	-0.05
Biology	-0.71***	-0.10
Computer Studies	-0.85***	0.06
Overall (awarded 5E)	-0.89***	
A-LEVEL (1980 - 95)		
Eng. Lang.	0.71***	-0.32
Pure Maths	-0.19**	0.14
Physics	-0.02	0.43
Chemistry	0.41*	0.14
Biology	-0.29	-0.16

*** $p < 0.01$
** $p < 0.05$
* $p < 0.10$

Table 11. Gender Difference in Performance in 1997 by Subject by Grade

Subjects	No. of Males			No. of Females		
	A	B	C	D	E	F
HKCEE						
Chin. Lang.	0.3	0.4	0.5	0.7	1.0	1.5
Eng. Lang (Syl. B)	0.4	0.5	0.5	0.7	0.9	1.3
Mathematics	1.6	1.3	1.1	0.9	0.8	0.9
Ad. Maths.	1.8	1.4	1.6	1.3	1.3	2.1
Physics	1.9	1.6	1.5	1.4	1.4	1.8
Chemistry	1.5	1.4	1.3	1.3	1.4	1.9
Biology	1.2	1.2	1.2	1.2	1.3	1.5
Computer	2.2	1.6	1.5	1.4	1.4	1.4
HKALE						
Chin. & Cult	0.4	0.5	0.5	0.7	1.0	1.6
Use of Eng.	0.4	0.5	0.6	0.7	0.9	1.2
Math. & Stat.	0.7	0.6	0.6	0.6	0.6	0.6
Pure Maths	3.7	2.5	2.3	2.0	1.9	2.0
Physics	3.7	2.9	2.6	2.1	1.7	1.1
Chemistry	1.6	1.3	1.4	1.2	1.1	1.0
Biology	0.8	0.8	1.0	1.0	0.9	1.0

Table 12. Gender Difference in Performance in 1997 by Subject Grade (In situation of equal participation)

Subjects	Percentage of Males			Percentage of Females		
	A	B	C	D	E	F
HKCEE						
Chin. Lang.	0.3	0.4	0.6	0.8	1.1	1.6
Eng. Lang (Syl. B)	0.4	0.5	0.6	0.7	1.0	1.4
Mathematics	1.7	1.4	1.2	0.9	0.9	0.9
Ad. Maths.	1.2	0.9	0.9	0.9	0.9	1.4
Physics	1.2	1.0	1.0	0.9	0.9	1.2
Chemistry	1.0	1.0	0.9	0.9	1.0	1.3
Biology	0.9	0.9	0.9	0.9	1.0	1.2
Computer	1.5	1.1	1.1	0.9	0.9	1.0
HKALE						
Chin. & Cult	0.5	0.6	0.6	0.8	1.2	1.9
Use of Eng.	0.5	0.6	0.7	0.8	1.1	1.4
Math. & Stat.	1.1	1.1	0.1	1.0	1.0	0.9
Pure Maths	1.8	1.1	1.1	0.9	0.9	0.9
Physics	2.1	1.6	1.4	1.2	0.9	0.6
Chemistry	1.4	1.1	1.2	1.0	0.9	0.9
Biology	0.8	0.9	1.0	1.0	1.0	1.1

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DATA ON GENDER AND SCIENCE AND TECHNOLOGY IN THE WORK PLACE: THE KOREAN CASE

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The paper examines gender differences in S&T education, careers, research and development and decision- making agencies in Korea. In particular, the author notes that while Korea has almost achieved gender parity among natural science degree recipients, women are still under-represented in engineering; only 8.3% of engineering bachelor's degrees were awarded to women in 1996. Data shows that this gender gap is even larger in science and engineering careers, especially in S&T faculties and decision-making committees. The author points to the need for the increased availability of gender-disaggregated data in order to more accurately measure the participation of all potential scientists and engineers in Korea. In concluding she suggests ways in which this could be accomplished.

Biographical Note

Young-ock Kim is a Fellow in the Research Division of the Korean Women's Development Institute and is an advisory member of the Korean Women Workers Association. Her academic background has focussed primarily on Women's Studies and Economics and she is currently a Ph.D candidate at Korea University. She has published extensively on women's issues with particular attention to employment.

Data on Gender and Science and Technology in the Work Place: Korean case

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I. Potential Women Scientists and Engineers[1]

The data for high school enrollments shows that there is no significant gender gap in girls and boys enrollment in secondary schools in Korea. In 1995, 89.4 percent of girls and 90.3 percent of boys were enrolled in high schools. However, enrollment in higher educational institutions shows a marked gender disparity. As of 1995, only 38.6% of girls were enrolled at the post secondary school level This was almost half of that of their male counterparts whose enrollment rate was 69.7%.

Women tend to gravitate toward the humanities, arts and teaching profession. On the other hand they are under represented in social science, medicine and pharmacy, natural sciences and engineering. In particular, women earn far fewer bachelor's degrees in engineering; only 4.2 percent of women graduates earned their degrees in the field of engineering in 1996. For men, engineering was the most popular field, surpassing social sciences in the number of bachelor's degrees earned. The female share of engineering degrees was just 8.3 percent in 1996. (Table 1.)

Table 1. Bachelor's degrees, by field and gender, 1996

	Total	*Huma-nities*	*Social science*	*Natural science*	*Engineering*	*Medical & pharmacy*	*Arts*	*Teaching or others*
Men	100.0 (107,896)	9.8	29.7	10.9 (11,774)	33.0 (35,564)	3.6	4.4	8.6
Women	100.0 (76,316)	23.2	18.8	12.4 (9,441)	4.2 (3,233)	4.3	13.2	23.9
%women	41.4	62.6	30.9	44.5	8.3	45.3	68.2	66.4

Source: Ministry of Education, Statistical Yearbook of Education, 1996.

Some progress has been made over the last several decades, especially in the number of degrees awarded to women. Women constituted 41.4 percent of bachelor's degree recipients in 1996, up from 31.8 percent in 1980. But there is still large room for improvement, especially in reducing women's under representation in science and engineering. Women are less likely to choose engineering than they are to choose natural sciences. While women are approaching parity among natural science bachelor's degree recipients (44.5% in 1996),

[1] This paper considers a person who has a degree in natural science or engineering as a potential scientist or engineer.

women account for less than 10 percent of engineering bachelor's degree recipients (8.3% in 1996). The gap between the number of men and women degree recipients in engineering continued to increase throughout the eighties and nineties. (Figure 1).

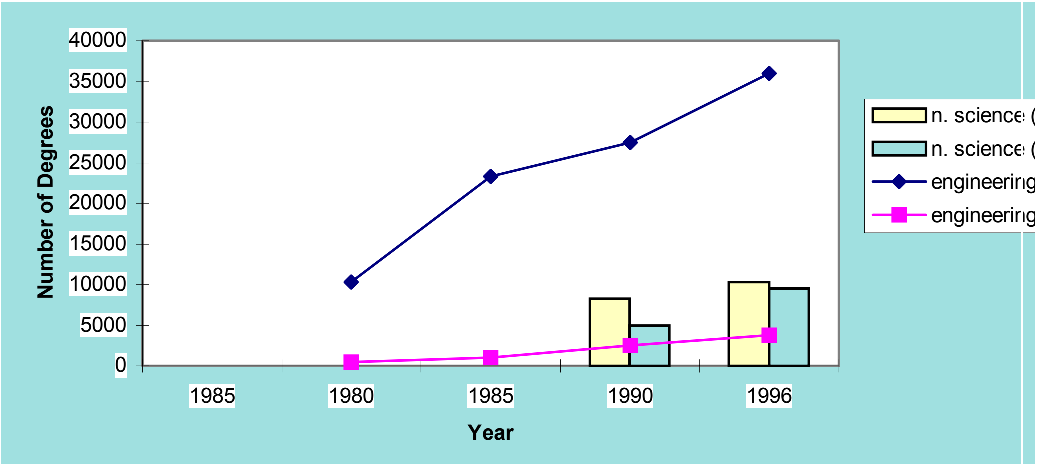

Figure 1. Bachelor's natural science and engineering degrees, by gender: 1980-1996
Source: Ministry of Education, Statistical Yearbook of Education, 1996.

II. Women's Employment as Scientists and Engineers

Women are a smaller proportion of the science and engineering labor force than they are of science and engineering degree recipients. That is, there is an under utilization of women potential scientists and engineers; in other words, there exists a leaky pipeline for women scientists and engineers. There are several reasons for this. First of all, women's entry into science and engineering is more recent. Because the labor force is composed of many years' worth of degree recipients and because women were a smaller fraction of earlier years' degree recipients, one would expect women to be a smaller fraction of the labor force as a whole than they are of current degree recipients.

Secondly, women tend to have greater tendency than men to be out of the labor market. This factor, in addition to the first reason, explains in part the fact that far fewer women than men attain the rank of full professor in academia or attain senior positions in industry.

Finally, differences in women's and men's areas of specialization in science and engineering are expected to be reflected in their participation in the labour force. Even among the more recent graduates, one would expect the proportion in the labor force to reflect the proportion of degrees received by women and men.

This paper looks for relevant statistical data in order to appreciate how actively women science and engineering bachelor's recipients participate in the Korean labor market. The employment rate will be estimated based on the existing data, followed by the analysis of women employees in science and engineering occupations. This research provides evidence of the under utilization of potential female scientists and engineers, even after taking into account the considerations described above: their relatively recent entrance into the labour force, their tendancy to be out of the labour force more than their male counterparts and the differences in areas of specialization.

The education of women and men for scientific and engineering careers entails large investments in education. Thus, from a national perspective, when well trained women are not retained in the work place, it represents a loss and a waste of financial and human resources which should be utilized by each sector of the economy which demands them.

1. Employment Rate

Some statistical measures are needed in order to show female scientists' and engineers' participation in the labor market. The labor force participation rate is one of them. The labor force is defined as those who are employed and those who are seeking employment. The labor force participation rate is the number of those employed and those who are unemployed expressed as a percentage of the population. Unfortunately the labor force participation rate, unemployment rate and economically non-active population of potential scientist and engineers can not be calculated in Korea due to a lack of relevant data.

Instead, "the employment rate" can be estimated. Every tertiary level educational institution is supposed to report "the number of degree recipients and the number of those in the military service or employed among degree recipients" to the Ministry of Education each year. The number of those who advance into master's courses are unknown. The employment rate (E) is calculated as:

$$E = N*100/(G - M)$$

where
N = the number of the employed

G = the number of graduates and
M = the number of those in the military service.

Users should take great care when analyzing this rate. The employment rate is calculated based on the statistical data that each university reported to the Ministry of Education. Thus, there is a possibility of an overestimated employment rate because the reference period is relatively long, and even those who are employed for one or two weeks are counted as employed.

Engineering graduates showed relatively high employment rates in 1996. But in this same field, the employment rates of female students were lower by 14 percent point. 46.3 percent of women graduates in science were employed compared to 53.0 percent of male graduates, with 6.7 percent difference. So far it has been explained that the employment rate of female students was lower because "the industries prefer the graduates of economics, management, and engineering majors, and many females majored in non-economics and management subjects or non-engineering fields." However this is not a sufficient reason to explain the gender gap in employment rates. The employment rate of female engineering college graduates is still lower than that of male graduates in the same major by 14 percent point. (Figure 2)

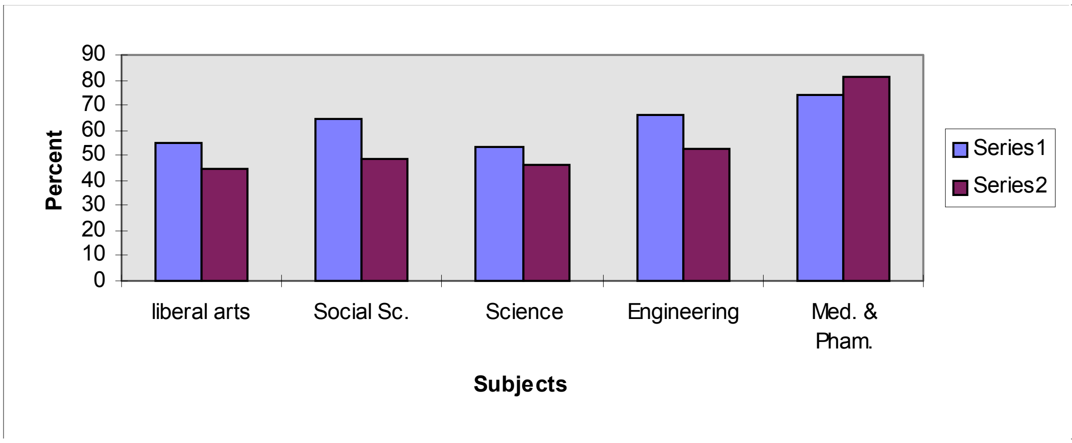

Figure 2. Employment Rate of Bachelor's Graduates, by Field and Gender, 1996
Source: Ministry of Education, Educational Statistics Yearbook, 1996.

There is a big difference in the employment rate among departments when comparing the male and female graduates in the departments. The smallest employment rate gap (5%) was found in the department of computer engineering. However, in the case of industrial Engineering and chemical Engineering, the employment rate of female graduates tended to be 20 percent lower than that of male graduates of the same major. There was a 10 percent gap in the department of electronic engineering. In sciences, the gender gap in the employment rate of the same majors is relatively narrower than in engineering.

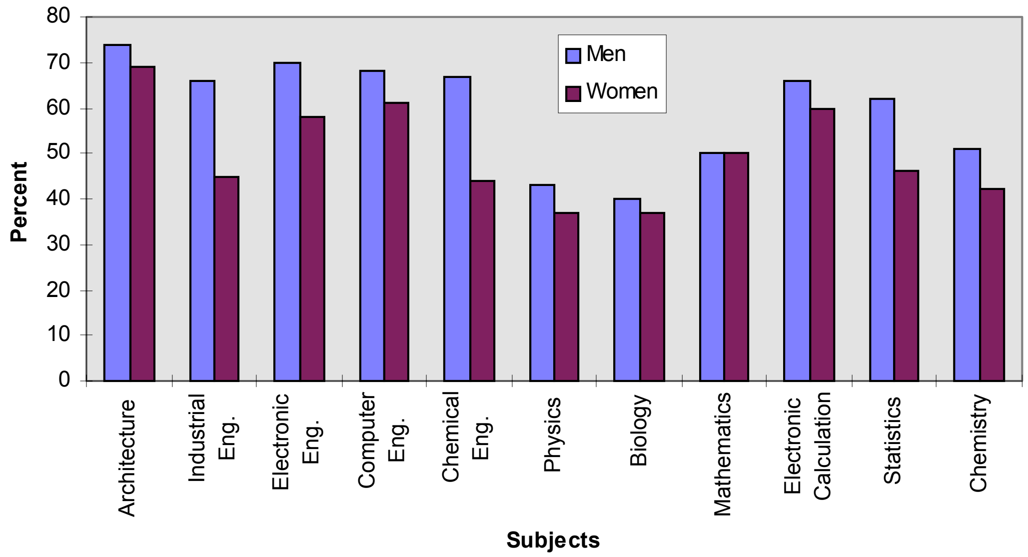

Figure 3. Employment rate of Bachelor's of Science and Engineering Graduates, by Field and Gender, 1996

Source: Ministry of Education, Educational Statistics Yearbook, 1996.

2. Research and Development (R&D) Personnel in Science and Engineering

Following the recommendation of OECD, the Ministry of Science and Technology has conducted every year the Survey on Science and Technology Research and Development Activities since the middle of the 1980's. But gender segregated data was not acquired until 1990. The number of women among the science and technology research personnel is increasing more rapidly than that of men, but as of 1995 it was still only 8.0 percent. The total number of researchers was 128,310 persons in 1995. More than half, 53.5%, of the researchers are employed in the R&D sector of private companies. The proportion of those employed in government financed research institutes was 11.7 percent and those in universities was 34.8 percent in 1995. However, women constituted only 4.7 percent of the

R&D personnel of private firm institutes, while women accounted for 12.6 percent of university institutes.

The fact that there are more women in the governmental sector than in the private sector is not peculiar in Korea or in the field of science and technology. In a market economy, private research institutes are concentrated more on applied and development research rather than on basic research, preferring the results which are directly connected with profit. They also tend to avoid employing women because of the maternity protection costs of hiring female researchers.

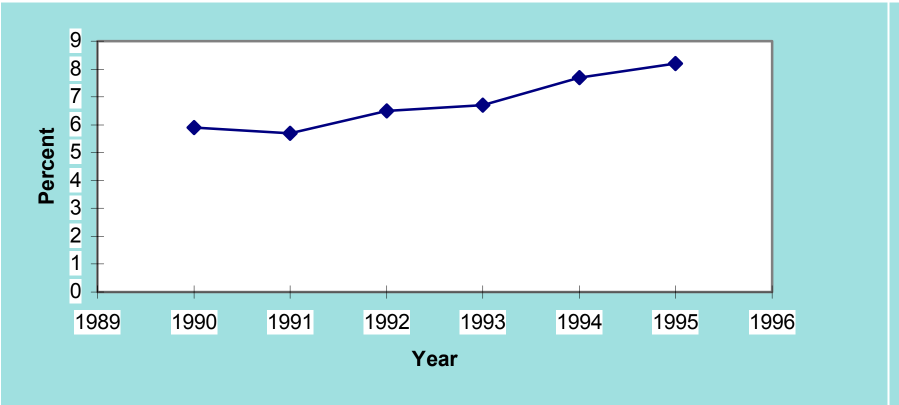

Figure 4. Women as a Percentage of Research and Development Personnel, 1990-1995
Source: Ministry of Science and Technology, Survey of R&D in Science and Technology.

Table 2. Women Scientific and Engineering Researchers, by the Type of R&D Institutes, 1995

	Total	*Women*	*% women*
Public Institutes	15,007	1,257	8.4
University Institutes	44,683	5,622	12.6
Firm Institutes	68,625	3,356	4.9
All	128,315	10,235	8.0

Source: Ministry of Science and Technology, Survey of R&D in Science and Technology, 1995

The vast majority, 82.4% of female R&D researchers in firm institutes were the age of 30 in 1995, while only 36.4 percent of their male counterparts were under that age. Thus, not only do women constitute a small minority in private firm R&D institutes, but they are also disproportionately young compared to women in other types of institutes. (See figures 5 and 6)

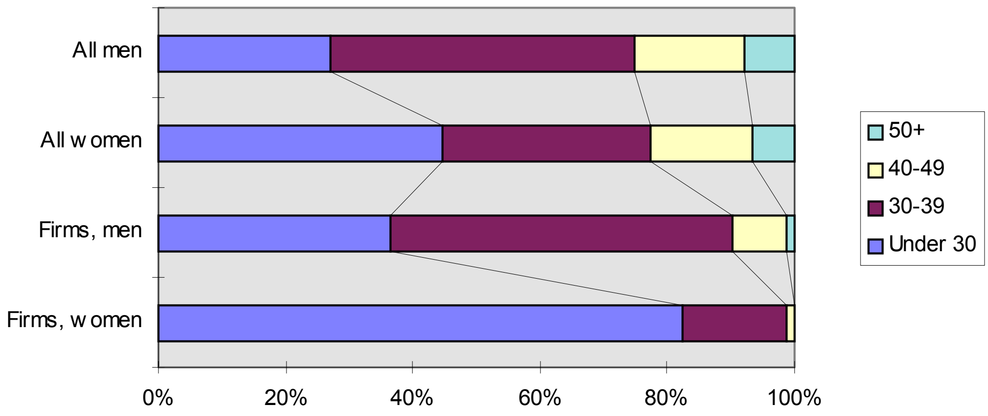

Figure 5. Age Distribution of scientific and Engineering Researchers by Gender, 1995
Source: Ministry of Science and Technology, Survey of R&D in Science and Technology, 1995.

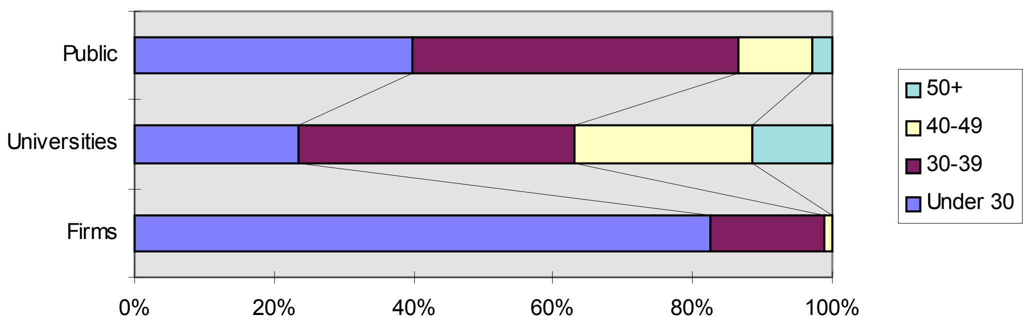

Figure 6. Age Distribution of Women Scientific and Engineering Researchers by Type of Institutes, 1995
Source: Ministry of Science and Technology, Survey of R&D in Science and Technology, 1995.

What is the position of women R&D researchers in national R&D Institutes. According to the Database of R&D Personnel by the Korea R&D Information Center, 22 research institutes in the Dae-Duk Research Complex under the Ministry of Science and Technology employed a total of 4,106 male researchers and 203 female researchers as of 1995. Thus women researchers accounted for 4.7 percent. The ranks of researchers were research fellows, senior researchers, and researchers. The proportion of women was 2.0 percent for research fellows, 3.1 percent for senior researchers, and 12.4 percent for researchers.The proportion of women decreases rapidly as the rank increases. Although considering their more recent entry into science and engineering, far fewer women than men have attained the rank of senior fellow.

The institutes with more than 10 percent women among research fellows were the Atomic Energy Hospital and the Research Institute for Genetic Engineering, followed by 8.6 percent for the Korean Research Institute of Chemistry. In contrast, in the cases of the Korean Mechanical Research Institute and the Research Institute for Aviation and Space, there were no women at all among the research personnel. And very few women were found in the Korean Institute for Atomic Energy Safety Technology, Korean Resource Research Institute, Korean Ocean Research Institute, and Research Institute for Electricity.

When analyzing the distribution of women researchers by major fields, we can see that women are employed more in the fields of life science, chemistry, and computer information area where activities are carried out in experiment rooms. Very few women are employed in the fields of earth science (geology, and oceanography), and mechanical and electric engineering, all of which require outdoor activities and traveling.

Table 3. Researchers in the National Scientific and Engineering Research Institutes under the Ministry of S&T by Gender and Rank, 1995

	Total	Senior	Researchers	Assistant
Men	4,106(100.0)	1,299(31.6)	2,032(49.5)	775(18.9)
Women	203(100.0)	27(13.3)	66(32.5)	110(54.2)
% Women		2.0	3.1	12.4

Source: Korea R&D Information Center, Databases on R&D Personnel.

3. Women faculty in science and engineering division

The Korea Science and Engineering Foundation updates the database on science and technology research personnel biannually in relation to financial assistance for research projects. This database provides the distribution of women faculty in science and technology by fields. Table 4 shows the total number of people and women employed as doctoral scientists and engineers in educational institutions in 1995. Women S&T faculty accounted for 2.8 percent of the total S&T professors. Biological science had the the highest rate of 9.6 percent, followed by 6.2 percent in chemistry and 5.6 percent in mathematics. The rates remained between 2 to 3 percent in construction engineering, chemical engineering, computer engineering, earth science, and physics. The rates were under 0.5 percent for material engineering, electric, electronic, mechanical, and civil engineering.

Figure 7 compares the proportion of female professors by major fields in science and engineering division with the proportion of female graduates. In general, there are more women professors in the departments where there are more female graduates than in other departments. However, the proportion of female professors is surprisingly low in comparison with the proportion of female students. For example, the highest rate of female professors was found in the department of biology (9.6%). However, the proportion of female graduates of the department was 63.1 percent. Likewise, in the engineering division, the female professor rate is much lower than the female graduates rate. In the departments of construction engineering, computer, and chemical engineering, the proportion of females students is more than 10 percent, but female professors make up only 2 percent of faculties.

Even considering the fact that women's advancement into the science and engineering fields has been increasing rapidly since the 1990s, and the number of female graduates before were too small to produce well trained professors, the female professor rates are still too low. In the fields of science and technology, where there has been a low rate of women advancing, female professors provide a role model for students, and carry out the function of mentoring through counseling and career guidance.

Therefore, the presence and number of female professors are very significant in promoting women's advancement into science and technology fields and in ensuring their success. The employment of female professors should be seen from such a perspective, and separate research is necessary to uncover the systematic obstacles and discrimination that women experience in the employment process of college professors.

Table 4. Scientific and engineering faculty, by gender and field: 1995

Field	Total	Women	% women
Mathematics	1,142	65	5.6
Physics	947	19	2.0
Chemistry	1,110	69	6.2
Biology science	1,172	113	9.6
Earth science and resource engineering	403	10	2.5
Material engineering	697	4	0.5
Electric engineering	532	1	0.1
Electronic engineering	1,526	9	0.5
Mechanical engineering	1,982	3	0.1
Chemical engineering	1,011	28	2.8
Computer engineering	983	27	2.7
Atomic energy engineering	47	1	2.1
All	13,299	375	2.8

Source: Korea Science and Engineering Foundation, Databases on R&D Personnel, 1995.

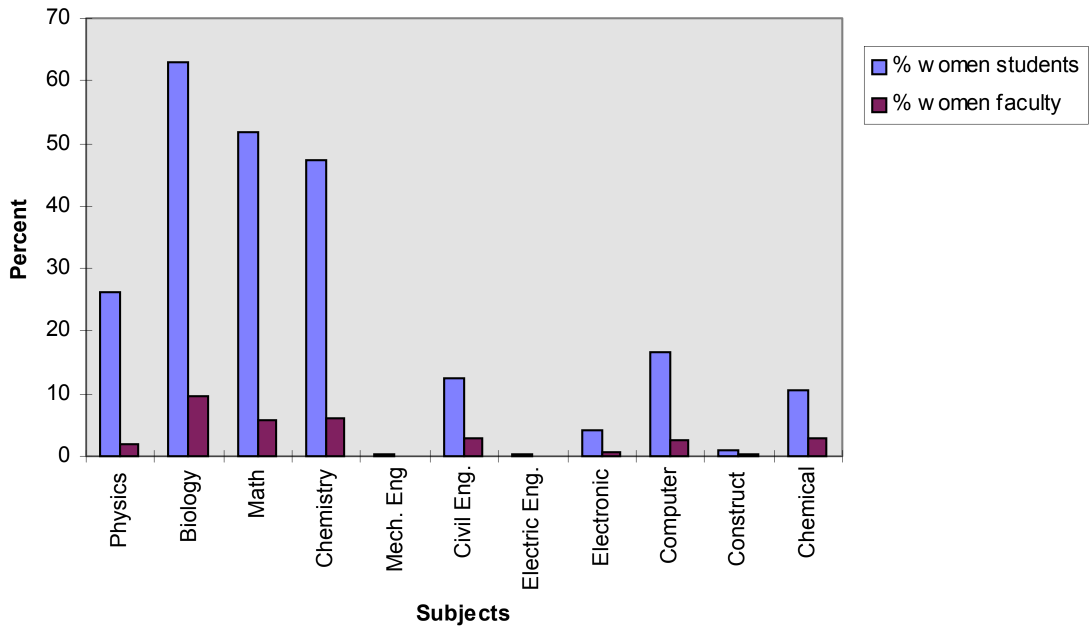

Figure 7. Female student and faculty rates in science and engineering, by field: 1995
Source: Female student rates are from Ministry of Education, *Educational Statistics Yearbook, 1996*. Female faculty rates are from Korea Science and Engineering Foundation, *Databases on R&D Personnel, 1995.*

III. Access to decision making

Women scientists and technologists should remain in the labor market and have careers, as well as participate in the whole process of innovating, applying, supervising, and evaluating science and technology. The reasons for this are because, firstly, women's perspectives are required not only for women's rights but also for sustainable development, which is the current global concern. Women’s perspectives are required on the production and consumption of science and technology.

Secondly, domestic political and economic situations are changing. As GNP has increased, there has been increasing interest not only in material welfare, but also in health, environment, and safety issues. With political democratization, the rights of the people to know and make choices have been promoted. There have been diverse demands of various strata of society, and sometimes it is difficult to reach a consensus. The coordinating role of women is urgently required. Women need to participate in various committees and bring about reconciliation based on their comprehensive understanding of the convenience, costs, and side effects of science and technology.

Although decision making in science and technology should be made in more gender sensitive ways, women's participation in decision making processes remains very low. As of 1994 there were 330 governmental committees with 16,612 members. Among them, there were only 1,191 women who accounted for 7.2 percent of these members. Notably, in the case of the Office of Science and Technology, there was only one woman appointed, or 0.5 percent among the 192 members of the 12 committees which included the Comprehensive Science and Technology Review Committee and the Atomic Energy Committee.(See table 5)

The Korean government has a goal of increasing the proportion of women in various governmental committees to 15 percent by the year 2,000. In order to correct the remarkably low participation of women in the committees in the fields of science and technology, it is necessary to give serious consideration to such temporary measures as a quota system for women.

Table 5. Governmental Committees and the Number of Women Members, 1995

	Number	Number of Members			
			Total	**Women**	**% Women**
All Government	324	**Merited**	1,927	22	1.1
Ministry of S&T	14	**All**	16,546	1,153	7.0
		Merited	111	0	0
			200	2	1.0

Source: Ministry of Political Affairs (2)

IV. Policy Implications

1. Initiatives to Collect Aggregated Data

The existing data in Korea shows that the employment rate of women graduates in science and engineering is lower than that of males by more than 10 percentage points. It continues to explain the reason why only a limited number of women are employed as researchers, mostly in the public sector. Women are also found in relatively lower ranks. However, the seriousness of the under representation and under utilization of women in the science and engineering fields have not yet been adequately exposed due to the lack of comparative data.

Women scientists and engineers may differ in their experiences of under representaion and unemployment by field, age level, and other demographic variables.[2] The macro-level data for reviewing the general employment situation of women scientists and engineers is far from sufficient. Databases on R&D personnel and faculty cited in this paper are limited in their coverage.

Furthermore, a considerable part of the existing data is not segregated by gender. For example, the statistics on research personnel published by the Ministry of Science and Technology are not classified according to gender. Some educational statistics by the Ministry of Education are also not classified by gender, which reduces its effectiveness considerably.

It is, thus, necessary to develop new aggregated, gender-segregated statistics, and to integrate and improve the existing databases on women scientists and engineers. Initiatives are recommended as follows:

- Census data should report the number of scientists and engineers in Korea; and census should be redesigned to identify scientists and engineers those with a bachelor's degree who reported a science or engineering occupation.

- Scientists and engineers are identifiable on census data only by self-described occupation and not by field of degree; this eliminates those who have left science or engineering employment. In addition, many active scientists and engineers are excluded because their occupational responses were too generic to classify them within science and engineering (e.g., manager or college professor). In order to

2. Korean newspapers, one day in 1996, reported the case of women scientist who had received a doctoral degree in chemistry abroad and applied for an admission to a Chinese-medical college, after a long spell of unemployment.

complement census data, a large-scale survey of establishments be needed, which has occupational estimates by detailed industry category.

- National surveys of bachelor's or doctorate degree recipients in science and engineering should be conducted, as a primary source of data on scientists and engineers with bachelor's degrees or higher in a scientific or engineering field. Key variables to be included are fields and levels of education, occupation, work activities, earnings, years of professional experience, demographic, and other information on the scientific and engineering workforce. In addition, there is a need to design a longitudinal survey on degree recipients. Among the variables included in this survey should be date of birth, educational history, employment status (unemployed, employed part time, or employed full time), field of degrees, labor force status, occupation, post-doctorate status, primary work activity (e.g., teaching, basic research), salary, sector of employment (academia, industry, government), sex, and years of professional experience. The Survey of Doctorate Recipients by the NSF is an example of such an undertaking.

- Linkage with private sectors to supplement governmental statistics. Considering the amount of time and financial resources required for developing a new set of statistical data it will be meaningful to initiate efforts to systematically organize the information maintained by private research institutes, as well as the membership information of academic associations.

2. Micro-economic establishment data

Women scientists are less likely to be represented in firms than in public sectors in Korea, which implies that private institutions or workplace may provide a harsh and unfavorable atmosphere for women employees. Here, we need to explain women's under representation in the workplace. That is, to identify the obstacles for women scientific and engineering professionals in the development of their careers in the private labour market.

Unfair practices in the workplace seem to be a major obstacle. Although stiff social and legal pressures now make blatant discrimination less likely than in the past, subtle barriers and biases are far from removed. These small, incremental obstacles are compounded over time, resulting in significant disparities in the career advancement of women and men. The very notion of a glass ceiling may be misleading. The popular metaphor implies a well-defined, albeit invisible barrier that either repels the unfortunate or is shattered by the fortunate. But small incremental obstacles that slow down careers appear to be much more prominent than clear cut barriers, as G. Sonnert(1995) points out[3].

Most studies addressing inequality have focused on high school and college education and on early career opportunities; relatively little attention has been paid to gender disparities in the later stages of science careers. We do not know much about the detailed experience of women scientists and engineers in the work place during the continuous process of career building. This lack should be filled up soon by conducting micro-level surveys of “research and development” institutes, academia, and other relevant establishments.

3. Data on unpaid work

One of the peculiarities in women's employment is that most women lack lifelong job careers. Men usually remain on the labor market from the time they entered working life until their retirement. Women, on the other hand, take breaks from employment at various point throughout their working lives.

Korean women report an apparently low economic participation rate of 45.6 percent in the age category of 25-29 years. Women of the same age group in Japan, Chinese Taipei and Singapore reported economic participation rates of 64.3 percent, 62.6 percent and 79.4 percent respectively; thus the Korean women's rate is about 20-30 percentage points lower.(See table 6.) Thus, the dual burden on the shoulders of Korean women seems to be heavy enough to make many women stop working outside their homes during the period of child bearing and rearing.

Unpaid work represents a significant component of individuals' activities, particularly for women's, time budgets. Shortage of time is one of the factors which impact upon the ability of individuals to access education, training and employment opportunities in the paid work force. There is a large body of evidence indicating that women's unpaid work constitutes a major barrier to women's ability to participate and contribute fully to the paid economy.

3. Gerhard Sonnert(1995), Gender equity in science: still an elusive goal, Issues in Science and Technology, 1995, winter, v12 n2, p.53-6.

Table 6. Female Economic Participation Rate by Age

	Korea (94)	Japan (93)	C.Taipei (93)	Malaysia (90)	Singapore (94)	United States (94)	Canada (91)	Australia (90)
Female Total	47.9	50.3	44.9	42.2	50.9	58.2	58.2	52.2
15-24	42.3	46.7	40.7	42.0	55.2	58.2	65.1	68.8
25-29	45.6	64.3	62.6	51.4	79.4	76.7	78.0	67.7
30-34	48.6	52.7	56.4	49.3	64.5	74.3	76.3	
35-54	60.9	68.0	53.2	47.8	52.1	76.3	74.9	67.5
55+	35.3	30.3	15.5	29.8	13.0	23.7	17.0	11.4
Male Total	76.4	78.0	72.7	77.1	79.6	74.7	74.8	75.6

Source::- ILO, Yearbook of Labor Statistics, 1992, 1995.
- Chinese Taipei, Yearbook of Manpower Survey Statistics, 1993.

The issue of family is also an important determinant of women's persistence in science and technology after graduation. Among those who are married, women scientists and engineers are more likely than men to face problems in accommodating dual careers.

In the field of science and technology where the depreciation of knowledge occurs rapidly, women should minimize the discontinuity in employment so as to be a professional human resource. The roles of childbirth and child rearing tend to come into conflict with women's pursuit of careers. Unpaid work determines the performance and continuity of careers in this way. We should, therefore, link unpaid work to paid work to drive explicit strategies that lead to successful science careers.

Thus, any survey of scientists and engineers should include information on marital status, number of children and other family situations of respondents. At the same time, we should continue to take initiatives to take into account the value of women's unpaid work. This information will help to examine whether marriage and science are compatible for women, and formulate relevant policies for the career advancement of women scientists and engineers, reducing the economic waste due to the loss of high quality human resources.

GENDER STATISTICS AND TECHNOLOGY IN THE PHILIPPINES

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This paper looks into the data sets available at the Philippines' Department of Science and Technology (DOST), for assessing the involvement of women and men in science and technology. These data sets are informed by the same rationale underlying most other gender-disaggregated data and management information systems with a specific focus on scientific and technological activities. The initial part of this paper briefly reviews this rationale, after which an analysis of gender differentials in science and technology is made using the available data from DOST. The paper concludes with a summary of the major trends and findings revealed by the DOST's gender statistics and a few observations on further improving these.

Biographical Note

Virginia Miralao has served as consultant to inter-governmental agencies, national government offices and non-governmental organizations. Serving as technical expert or project sector specialist, her consultancy assignments bring her to several places in the Philippines and to other countries. She has prepared technical country and region-wide (Asia Pacific) papers for a number of agencies, including the ILO and UNESCO Paris. Ms. Miralao's research work includes demography, family planning and health; gender issues and the family; agrarian reform and rural development; and the monitoring and evaluation of development programs and projects. She has written reports and papers based on her research and consultancy work, a number of which have been published as separate monographs or journal articles. Ms. Miralao served as the gender-specialist for a recently completed project on the development of a national gender-disaggregated statistical system for the Philippines.

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Gender Statistics in Science and Technology in the Philippines

1.0 Introduction

This paper looks into the data sets available at the Philippines' Department of Science and Technology (DOST) for assessing the involvement of women and men in science and technology. These data sets are informed by the same rationale underlying most other gender-disaggregated data and management information systems with a specific focus on scientific and technological activities. The initial part of this paper briefly reviews this rationale, after which an analysis of gender differentials in science and technology is made using the available data from DOST. The paper concludes with a summary of the major trends and findings revealed by the DOST's gender statistics and a few observations on further improving these.

1.1 The Rationale for Monitoring Gender Differentials in Science and Technology

Science and technology are widely acknowledged in modern-day societies to play a vital role in human progress and social development. Science and its applications (commonly referred to as technologies) have wrought improvements in virtually all areas of social life. These have increased productivity and generated further employment, and contributed vastly to improvements in health, transportation, communications, leisure and recreation. In view of their quantitative and qualitative contributions to societal well-being, science and technology have spawned an optimistic ideology of progress and are often considered essential for economic development.

At a more micro-level, science and technology represent the cumulation and acquisition of new knowledge and skills which constitute the seed for personal autonomy, and which opens to individuals avenues for better employment and increasing incomes, and prestige and social recognition. Hence, access to science and technology and their associated skills becomes an increasingly important determinant of a person's social status and life conditions.

Gender considerations in science and technology therefore, stem basically from women's and men's differential access to scientific and technological activities and resources. The generally lower participation rate of women in the sector is traced to women's historical subordination in social and economic life and which has reduced their opportunities for education and employment in fields requiring scientific and technological skills and applications. Available data from most countries reveals that there are fewer women graduates in science and technology fields despite increasing female enrolment at all educational levels. Employed women are also found mostly in sales and services work with little scientific and technological content, whereas men outnumber women in jobs with greater science and technology requirements.

Because of the genders' differential access to science and technology, women expectedly also benefit less from ongoing developments in the sector. They do not share equally in the opportunities for developing innate talents and potentials for science and technology. Neither do they share equally in the higher prestige or status bestowed on science and technology educational degrees and achievements, nor in the higher salaries or incomes commanded by science and technology occupations. Likewise, little thought has been placed on the differential impact of scientific and technological innovations on women and men. Although new technologies have undoubtedly improved the lives of both men and women, their adoption and propagation are often based on other considerations, i.e., as their commercialization potentials, to the neglect of their differential impact on the sexes and other subgroups in the population.

Finally, because there are generally fewer women than men in science and technology, women are also under-represented in science and technology policy-making bodies. As a result, science and technology innovations are rarely directed towards improving productivity in areas of endeavour where women are found, or to meet particular women's needs. For a long time for example, scientific and technological innovations in agriculture were directed to men even as worldwide, women constitute a significant proportion of the agricultural labour force. Not until recently were agricultural extension services extended to women farmers, and farm tools and equipment designed to ergonomically fit the physique of women, reduce the tediousness and drudgery of their work, and improve their productivity on farms.

Similarly, in the development of contraceptive and reproductive technologies (i.e., surrogate breeding and in vitro pregnancies), little consideration was initially placed on the safety of these on women's health and on their implications for gender roles. In brief, for women to contribute to and benefit equally from science and technology (S&T), there is a need to close the gaps in the sexes' access to scientific and technological knowledge and resources, and in their involvement in the design and application of S&T policies and programs. It is mainly for this reason that a statistical database and system are usually set in place to monitor male and female participation in science and technology.

2.0 DOST's Gender-Disaggregated Statistical Information

In response to the increased awareness of the value of gender-disaggregated statistics, much effort has been exerted within the Philippine Statistical System to present population-related statistics (i.e., labour force, education, health and other demographic data) in gender-disaggregated formats. Each government department has been similarly enjoined to build and use gender disaggregated databases in their planning functions, as well as in monitoring the implementation of, and evaluating the impact of their services and programs. Being the lead agency for science and technology, DOST provides the major data inputs necessary for assessing male and female participation within its sector.

The data available at DOST for profiling the involvement of women and men in S&T are of different types and come from different sources. For purposes of this presentation, these data sets are classified into 3 major clusters, namely: 1) data provided by science and technology agencies and institutions on the composition and characteristics of their personnel; 2) data drawn from other surveys or sources (i.e., labour force surveys and education statistics) and used for determining/estimating available human resources for S&T development ; and 3) data provided by implementing agencies of S and T programs on their program beneficiaries and participants.

3.0 Institution-based Data on Scientific and Technological Personnel

Of the institution-based data on S&T personnel available at DOST, the largest set comes from the 1993 National Survey of Scientific and Technological Activities (NSSTA) which was undertaken among 1283 research and development (R and D) institutions in government, the academe, private industry, and other non-government science and research organizations. [1] The survey identified some 14,886 R and D personnel in these institutions of which slightly over half (52.7%) are male and 47.3% are female. The survey further indicates relative gender parity among the R and D personnel of institutions found in the academe and in government where women comprise 49.7% and 48.3% respectively of R and D personnel (see Table 1). However, males outnumber females in private industry R and D institutions, while women outnumber men in the few non-governmental and non-private sector R and D organizations. In private industry, women comprise no more than 29.6 % of R and D personnel, but 55.7% of those in non-governmental science foundations.

Table 1. Distribution of R and D Personnel by Sector and by Gender (1993 NSSTA)

Sector	Male		Female		Total
	N	%	N	%	
Academe	3448	50.34	3402	49.66	6850
Government	2838	51.68	2654	48.32	5492
Private Industry	1166	70.41	490	29.59	1656
Others	393	44.26	495	55.74	888

When the personnel complement of R and D institutions are further broken down by category of personnel, Table 2 shows slightly more women (52.9%) than men among the highest personnel category of “Scientists and Engineers”, and comprising of those engaged in basic, applied and experimental R and D. There are more men than women however, among the lower-level personnel categories of "Technicians" (those with vocational/technical training) and "Auxiliary/Other" personnel (referring to the administrative/clerical/ support staff of R and D institutions). Men outnumber women 3:1 among “Technicians” and 3:2 among "Auxiliary/Other" personnel.

Table 2. Distribution of R and D Personnel by Category of Personnel and by Gender (1993 NSSTA)

Category	Male		Female		Total
	N	%	N	%	
Scientists and Engineers	4477	47.10	5027	52.90	9504
Technicians	974	74.24	338	25.76	1312
Auxiliary	1798	59.20	1239	40.80	3037
Others	597	57.80	436	42.20	1033

The 1993 NSSTA also provides a disaggregation of the "Scientists and Engineers" category by gender and field of scientific activity as shown in Table 3. The data here points to some differences in women's and men's fields of R and D specialization. Women comprise a higher percentage, 61% to 64%, of scientists in the Medical Sciences, Natural Sciences, Social Sciences and Humanities. In contrast, men comprise a higher share, 56.7% and 61.3%, respectively of scientists in the Agricultural Sciences and in Engineering and Technology.

Table 3. Distribution of Scientist and Engineers by Field of Science Activity and by Gender (1993 NSSTA)

Scientists & Engineers	Male		Female		Total
	N	%	N	%	
Agricultural Science	1635	56.71	1248	43.29	2883
Engineer & Technology	926	61.32	584	38.68	1510
Medical Science	327	35.90	584	64.10	911
Natural Science	596	38.35	958	61.65	1554
Social Science	786	37.27	1323	62.73	2109
Others	47	39.17	73	60.83	120

Finally, consistent with the greater number of women among the highest personnel category of "Scientists and Engineers" and the greater number of men among the lower "Technicians" and "Auxiliary" personnel categories, the 1993 NSSTA reveals that there are more women than men R and D workers who have completed a Bachelor's degree (52.9%) or a Master's degree (56.2%). Conversely, Table 4 shows that there are more men (82.8%) than women among those not completing a college degree, although it is also true that there are more male (55.2%) than female Ph.D. holders among R and D workers.

Table 4. Distribution of R and D Personnel by Level of Education and by Gender (1993 NSSTA)

Education	Male		Female		Total
	N	%	N	%	
Below BS/BA	1326	82.77	276	1723	1602
BS/BA	3465	47.12	3889	52.88	7354
MS/MA	1210	43.76	1555	56.24	2765
Ph.D.	520	55.20	422	44.80	942
Others	1325	59.60	898	40.40	2223

In sum, data from the 1993 NSSTA indicates overall gender parity in the numbers of women and men employed in R and D institutions, but alerts us to some gender gaps in the sector. These are 1) the significantly greater representation of men among the personnel of private-sector R and D institutions which probably offer the best compensation packages for scientists and technologists; 2) the tendency for female and male scientists to specialize in different fields with more men specializing in the Agricultural Sciences and in Engineering and Technology, and with more women specializing in the Medical Sciences, Natural Sciences, Social Sciences and the Humanities; and 3) a tendency for R and D institutions to be less discriminating of male than female education. By and large, R and D jobs require of women at least a Bachelor's or a Master's degree which gives women an edge in the highest professional category of scientists, but which also limits the entry of female undergraduates in R and D institutions.

Trends showing differences in the fields of specialization of male and female scientists and in their educational characteristics find support from another set of DOST data taken from the personnel profile of the member institutions of the Philippine Council for Advanced Science and Technology Research Development.[2] The Council has a network of 10 universities and six R and D institutions throughout the country. More than half of its high level S and T personnel with MS or Ph.D. degrees, 583 (or 56.2%) are women and a fewer 454 (43.8%) are men. The majority of the Council's scientists are in Biotechnology research (583); followed by Materials Science (226); Information Technology (123), Photonics (104); Electronics, Instrumentation and Control (42).

Table 5, which presents a gender disaggregation of the Council's personnel by educational degree and field of scientific activity, shows the field of Biotechnology to be predominantly female: 58.2% of the Ph.D. holders working in this field are females as are 75.7% of those with MS degrees. In the field of Materials Science, 56.9% of Ph.D. holders are male although 66.1% of MS holders are women, suggesting that the field may eventually become gender-balanced. On the other hand, the limited number of personnel in the remaining fields (Information Technology, Photonics, and Electronics, Instrumentation and Control) are predominantly male at the Ph.D. and MS levels.

Table 5. Distribution of PCASTRD Personnel by Field of Scientific Activities and by Gender (1996)

Areas Concern	**Educational Attainment**									
	M.S.					**Ph.D.**				
	Male		**Female**			**Male**		**Female**		
	N	**%**	**N**	**%**	**Total**	**N**	**%**	**N**	**%**	**Total**
Biotechnology	73	24.3	228	75.7	301	118	42.0	164	58.2	282
Information Technology	59	63.4	34	37.0	93	23	77.0	7	24.0	30
Materials Science	42	24	82	47.0	175	29	57.0	22	43.1	51
Electronics, Instrumentation, and Control	27	77.1	8	22.9	35	7	100.0	0	0.0	7
Photonics	47	63.5	27	36.5	74	29	72.5	11	27.5	40
Total	248	39.6	379	60.4	627	206	50.2	204	49.8	410

The predominance of women in Biotechnology receives further confirmation from the findings of another study on women scientists and managers in leading agricultural research institutions which was undertaken by the International Service for National Agricultural Research of the Hague and the Philippine Council for Agriculture, Natural Resources and Forestry Research and Development.[3] Of the four institutes covered in the study, Table 6 shows the personnel complement of the Institute of Biotechnology and Applied Microbiology to comprise heavily of women (73.5%). Greater gender parity is noted among the personnel of the Institute of Plant Breeding and the Philippine Rice Research Institute where women constitute closer to half (47.6% and 42.7% respectively) of these institutes' personnel stock. Representing the other extreme is the Philippine Root Crops Research and Training Centre which has a greater number of men (60.7%) than women scientists and managers among its ranks.

Data compiled by DOST on the researchers of the Department of Agriculture (DA) similarly attests to improvements in the involvement of women scientists in agriculture. [4] Researchers engaged in the Crop Sciences account for the largest number of researchers at the DA, of which roughly equal numbers are female (202) and male (195). Table 7 indicates that DA researchers specializing in other fields (i.e. Animal Sciences, Basic Sciences etc.) are fewer in number, and that fields are gender-typed. The Animal Sciences and Soil Sciences/Agricultural Engineering are more male, while the Basic Sciences and the Social Sciences are more female. Consistent with earlier findings, data on the educational backgrounds of DA researchers show female researchers to be better educated than their male counterparts. Over two thirds of the DA researchers who are MS or Ph.D. graduates are women (see Table 8).

Table 6. Distribution of Scientist and Managers in Selected Agricultural Research Institute by Gender (ISNAR-PCARRD Study)

Institute	Male		Female		Total
	N	%	N	%	
Institute of Biotechnology & Applied Microbiology	26	26.5	75	73.5	102
Institute of Plant Breeding	33	52.4	30	47.6	63
Philippine Rice Institute	59	57.3	44	42.7	103
Philippine Rootcrops Research & Training Center	17	60.7	11	39.3	28
Total	136	45.9	160	54.1	296

Table 7. Distribution of DA Researchers by Field of Specialization and Gender

Category	Female		Male		Total
	No.	%	No.	%	
Animal Sciences	9	13.6	57	86.4	66
Basic Sciences	26	96.3	1	3.7	27
Crop Sciences	202	50.9	195	49.1	397
Fisheries	0	0.0	2	100.0	2
Social Sciences	43	63.2	25	36.8	68
Soil Science/Ag Eng'g	33	45.2	40	54.8	73
Others	9	90.0	1	10.0	10
Total	322	50.1	321	49.9	643

Source: DOST

Table 8 Distribution of DA Researchers by Educational Level and Gender

	Female		Male		Total
	No.	%	No.	%	
BS	242	45.8	287	54.2	529
MS	73	70.2	31	29.8	104
Ph.D.	7	70.0	3	30.0	10
Total	322	50.1	321	49.9	643

Source: DOST

Similar data compiled on the researchers of the Department of Environment and Natural Resources (DENR) reveals the Department to have a much smaller research complement of only 106 researchers, around half (52) of whom are Forestry researchers who are all males [5] (see Table 9). The dominance of men in Forestry research accounts for the heavily male composition of DENR researchers.

Data provided by DOST on the personnel of five of its attached offices/agencies confirms earlier findings regarding the relatively equal representation of women and men in S and T institutions, but continuing differences in the genders' fields of specialization and educational qualifications. [6] One notes from Table 10 that of the five DOST-attached offices, Philippine Volcanology and Seismology (PHILVOCS) is the least gender-balanced owing to its dependence on engineering and other physical sciences which are male-dominated. By contrast, the Philippine Council for Health Research and Development (PCHRD) is more female since health-related fields tend to be selective of women. The Industrial Technology Development Institute (ITDI) also has more women overall, partly because the Institute has a large staff (263 people) and covers many areas of specialization, including electronics, microbiology, food processing, and fuels.

In general, S and T institutions with a large or an expanding staff tend to be more gender-equal, as are those that recruit from several areas of specialization. One may expect that the promotion of multi- or cross-disciplinary studies or bodies of knowledge within offices and departments and the scientific community in general, will likely minimize disciplinary boundaries and erode existing differences in women's and men's areas of S and T specialization. Already, DOST has a personnel complement of 4851 of whom 51% are males and 49% are females. [7] Moreover, as many as 68% of the Department's technical positions are occupied by women.

Table 9 Distribution of DENR Researchers by Field of Specialization and Gender

	Female		Male		Total
	No.	%	No.	%	
Animal Sciences	1	20.0	4	80.0	5
Basic Sciences	5	100.0	0	0.0	5
Crop Sciences	2	25.0	6	75.0	8
Forestry	0	0.0	52	100.0	52
Social Sciences	7	41.2	10	58.8	17
Soil Science/Ag Eng'g	1	20.0	4	80.0	5
Others	11	78.6	3	21.4	14
Total	27	25.4	79	74.5	106

Source: DOST

Table 10. Distribution of DOST-attached Agency Personnel by Gender and

Educational Level

Degree	Science and Technology Information Institute				
	Female		Male		Total
	No.	%	No.	%	
BS	35	68.6	16	31.4	51
MS	3	50.0	3	50.0	6
Ph.D	0	0.0	1	100.0	1
Undergraduate	4	50.0	4	50.0	8
Secretarial/Vocational	4	57.1	3	42.9	7
Total	46	63.1	27	36.9	73
Degree	**Technology Application and Promotion Institute**				
	Female		Male		Total
	No.	%	No.	%	
BS	29	53.7	25	46.3	54
MS	0	0.0	6	100.0	6
Ph.D	1	100.0	0	0.0	1
Undergraduate	2	22.2	7	77.8	9
Secretarial/Vocational	4	80.0	1	20.0	5
Total	36	48.0	39	52.0	75
Degree	**Philippine Volcanology and Seismology**				
	Female		Male		Total
	No.	%	No.	%	
BS	58	42.3	79	57.7	137
MS	7	63.6	4	36.4	11
Ph.D	2	40.0	3	60.0	5
Undergraduate	0	0.0	40	100.0	40
Secretarial/Vocational	2	16.7	10	83.3	12
Total	69	33.7	136	66.3	205

Table 10 ctd.

Degree	Philippine Council for Health Research Development				
	Female		Male		Total
	No.	%	No.	%	
BS	40	75.5	13	24.5	53
MS	93	87.7	13	12.3	106
Ph.D	232	49.6	236	50.4	468
Undergraduate	0	0.0	0	0.0	0
Secretarial/Vocational	0	0.0	0	0.0	0
Total	365	58.2	262	41.8	627
Degree	**Industrial Technology Development Institute**				
	Female		Male		Total
	No.	%	No.	%	
BS	30	22.2	105	77.8	135
MS	198	69.5	87	30.5	285
Ph.D	31	63.3	18	36.7	49
Undergraduate	4	36.4	7	63.6	11
Secretarial/Vocational	0	0.0	0	0.0	0
Total	263	54.8	217	45.2	480
Source: DOST					

Source: DOST

Finally, the last set of institution-based data come from the National Research Council of the Philippines (NRCP) and the National Academy of Science and Technology (NAST) which represent the country's leading or organizations of scientists. [8] Both NRCP and NAST stipulate requirements for membership, although NAST has more stringent conditions for membership admission making the Academy the equivalent of a "learned society". In this sense, the NRCP and NAST data are additionally indicative of the prestige or social recognition bestowed on scientists.

Table 11 presents data on NRCP's 1994 membership broken down by gender and by the Council's 12 major divisions. Again, one notes that there are roughly equal numbers of men and women among NRCP's 2187 members. Six of its 12 major divisions covering the Biological Sciences, Social Sciences, Earth Sciences, Governmental, Educational and International Policies, Medical Sciences and Mathematical Sciences exhibit tendencies towards gender parity, with women comprising anywhere between 40% to 56% of scientists in each of these divisions. Three other divisions are selective of females and these are the Pharmaceutical Sciences, Chemistry and the Humanities where women constitute between 61% to 96% of scientists. On the other hand, the three remaining divisions namely, Agriculture and Forestry, Engineering and Industrial Research, and Physics are selective of men. Between 66% to 80% of NRCP scientists in these divisions are men.

Table 11 National Research Council of the Philippine (NRCP) Membership 1994

Discipline	Female		Male		Total
	N	%	N	%	
Governmental, Educational and International Policies	68	48.2	73	51.8	141
Mathematical Sciences	44	40.4	65	59.6	109
Medical Sciences	104	45.0	127	55.0	231
Pharmaceutical Sciences	90	95.7	4	4.3	94
Biological Sciences	218	56.0	171	44.0	389
Agricultural and Forestry	77	28.9	189	71.1	266
Engineering and Industrial Research	52	34.2	100	65.8	152
Social Sciences	159	50.0	159	50.0	318
Physics	12	20.0	48	80.0	60
Chemistry	165	74.0	58	26.0	223
Humanities	73	61.3	46	38.7	119
Earth Sciences	42	49.4	43	50.6	85
Total	1115	51.0	1072	49.0	2187

Despite the increasing numbers of women involved in S and T activities, NAST's 1996 Directory of Academicians and Outstanding Young Scientists reveals that significantly more male scientists are awarded recognition for their achievements than women scientists. Of the 50 Academicians in 1996, only 17 were women; and of the 136 Outstanding Young Scientists during the year, only 37% were women (Table 12). Women’s lower representation in scientific awards owes to the historical male bias of the Academy which has gone unnoticed for some time and is just slowly being rectified. Membership in the body of Academicians is limited to 50 at any one point in time, and no additional replacement is possible until the death of a member. It may be worth noting however, that eight Academicians have been awarded the title of National Scientist. Of these, four are female and four are male.

Some quarters also argue that men's higher representation in NAST awards can be traced partly to the Academy's bias for the Natural and Physical Sciences over other fields of knowledge such as the Social Sciences and the Humanities. In view of women's and men's predilections to specialize in different fields, giving equal recognition to the various fields of scientific endeavour and branches of knowledge can contribute to advancing gender equity within scientific bodies.

Table 11 National Research Council of the Philippine (NRCP) Membership 1994

Discipline	Female		Male		Total
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Chemistry	165	74.0	58	26.0	223
Humanities	73	61.3	46	38.7	119
Earth Sciences	42	49.4	43	50.6	85
Total	1115	51.0	1072	49.0	2187

Table 12 Distribution of NAST Academicians and Outstanding Young Scientists by Gender and Field of Study (1996)

Academicians	Male		Female		Total
	N	%	N	%	
Math/Computer Science	1	100.0	0	0.0	1
Physical/Engineering Science	2	100.0	0	0.0	2
Bio/Chemical Science	7	46.7	8	53.3	15
Agricultural Science	11	84.6	2	15.4	13
Health/Medical Science	7	70.0	3	30.0	10
Social Science	4	50.0	4	50.0	8
Humanities	1	100.0	0	0.0	1
Total	33	66.0	17	34.0	50

Outstanding Young Scientists	Male		Female		Total
	N	%	N	%	
Math/Computer Science	9	81.8	2	18.2	11
Physical/Engineering Science	15	79.0	4	21.0	19
Bio/Chemical Science	18	47.4	20	52.6	38
Agricultural Science	21	65.6	11	34.4	32
Health/Medical Science	8	53.3	7	46.7	15
Social Science	14	66.7	7	33.3	21
Humanities	0	0.0	0	0.0	0
Total	85	62.5	51	37.5	136

4.0 Data on Science and Technology Workers from Surveys and other Sources

DOST estimates of the available pool of S and T workers in the country are drawn primarily from the Scientific and Technological Labour Force Survey conducted by DOST's Science Education Institute (SEI) and the National Statistics Office (NSO) in 1990.[9] Using UNESCO's classification of S and T workers into those engaged in R and D, and those engaged in Science and Technology Education and Training (STET) and in Science and Technology Services (STS), the survey results indicate that the country's S and T workers consists chiefly of science education teachers. This pool of science educators and trainers totaled 208,480 in 1990 of which a large 81% are women since the teaching field in the country is heavily dominated by women. On the other hand, the pool of workers engaged in STS and R and D is much fewer totaling only some 45,490 and 23,720 respectively in the same year. Women also claim fewer of the jobs in these two latter categories: 34.2% of STS jobs and 42.4% of R and D jobs.

The 1990 DOST-SEI/NSO survey too, presents a gender disaggregation of S and T workers using the standard classifications for major industries and occupational groups. Here, the survey results reveal that of the seven major industry classifications, women outnumber men only in the category of Community, Social and Personnel Services; and of the eight major occupational groupings, women outnumber men only in the category of Professional, Technical and Related Workers.

At this point, it may be appropriate to call attention to some of the differences in the results of the 1990 DOST-SEI/NSO survey and those of the 1988 and 1994 National Labour Force Survey rounds. Both the 1988 and the 1994 Labour Force Surveys reveal that the numbers of women workers exceed those of men in two major industry groups (Wholesale and Retail Trade, and Community, Social and Personal Services), and in four major occupational classifications (Professional, Technical and Related Workers; Clerical Workers; Sales Workers; and Service Workers). This discrepancy in the results of the 1990 DOST-SEI/NSO survey and the labour force surveys may be owed to differences in the surveys' of S and T workers. The 1990 DOST-SEI/NSO 1990 survey however, does not provide a further explanation of its definitions or a listing of the specific industry activities and occupational jobs subsumed under its classification of the "S and T working population".

Other estimates of the country's supply of S and T workers come from education-related data, particularly current enrolment rates in colleges and universities and data on college graduates by major fields of studies. The data used by the DOST-SEI Report on "Gender Data on S and T Manpower Development" and taken from the Bureau of Higher Education focuses on the Basic Sciences, Applied Sciences, Engineering Sciences, and Science Education for the period 1990 to 1993.[10] The data here (Table 13) indicates substantially higher proportions of female graduates in the Basic Sciences (65%) and Science Education (63%), but much lower proportions in the Applied Sciences (28%) and Engineering Sciences (16%).

Although these patterns are in accord with earlier noted trends regarding the gender-typing of fields of studies, the <u>total</u> number of "college science and technology graduates" point to a far greater gender gap (of 75% male and 25% female) in science and technology than is suggested by the earlier mentioned institution-based and labour force surveys which show men overall to have only a slight edge of a few percentage points over women in science and

technology activities. Likewise, the DOST-SEI Report on college graduates show Science Education graduates to comprise the smallest proportion of graduates (3240 out of 113,608 or 2.85%), whereas the 1990 DOST-SEI/NSO survey indicates that workers engaged in Science and Technology Education and Training comprise the largest proportion (75%) of the country's S and T working population.
Such discrepancies again are likely due to definitional differences in the use of the term "science and technology". The Bureau of Higher Education data set analysed by DOST reflects the common bias of delimiting science and technology to the natural and physical sciences as against a probably more inclusionary usage of the term in other data sources or surveys.

Table 13. Total Number of BS, MS, and Ph.D. graduates in the Basic Sciences, Applied Sciences, Engineering Sciences and Science Education in 1990 to 1993 by Gender

	Male		Female		Total
	N	%	N	%	
Basic Sciences	3,319	35.13	6,129	64.87	9,448
Applied Sciences	20,434	71.85	8,006	28.15	28,440
Engineering Sciences	60,651	83.68	11,829	16.32	72,480
Science Education	1,189	36.70	2,051	63.30	3,240
Total	85,593	75.34	28,015	24.66	113,608

Source: Bureau of Higher Education cited in "Gender on S and T Manpower Development", Ester B. Ogena, Ph.D., Science Education Institute, DOST (no date).

5.0 Data on Science and Technology Program Participants and Beneficiaries

DOST has also begun to build up a gender-disaggregated data file on the recipients of S and T programs and projects. It administers several such programs, the more important of which are grants and scholarships; other programs designed to modernize production sectors through technology transfer, financing assistance and the adoption/commercialization of new technologies; and consultancy services to upgrade the technological content of various industries.

The first of DOST's scholarship programs is the Engineering and Science Education project (ESEP) for high school students financed by the World Bank.[11] Since its inception, ESEP has received some 16,346 applicants from elementary school graduates of whom two-thirds or a full 67% are female and 33% are male. A lower 53% of the female applicants successfully qualified for the program as against 58% of the male applicants. However, female students still constitute 65% of the program's 8934 qualifiers or recipients. After one academic year moreover, ESEP's female scholars outperformed by a slim margin their male counterparts in English tests; whereas the latter outperformed, also by slim margins, their female counterparts in science and mathematics tests.

No actual numbers have been reported on the recipients of DOST's college undergraduate S and T scholarships. The DOST-SEI report however, mentions that 59% of program applicants are male and 41% are female. Men also claim a higher 63% of program qualifiers, with women accounting for the remaining 37%. Interestingly, however, the majority of female (60%) and male (69%) S and T college scholars have opted to pursue degrees in the Applied Sciences. But probably due to self-selection processes, there are somewhat more women opting for degrees in the Basic Sciences (29% vs. 25% for males) and in Science Teaching (11% vs. 6% for males).

The DOST-World Bank grant program for MS and Ph.D students in the Sciences, Math and Engineering on the other hand, had 508 grantees from 1989 to 1996, 59% of whom are females and 41%, males. Women's overall advantage is reflected both at the level of MS grantees and Ph.D grantees, with women accounting for 57% and 68% respectively of grantees at these levels.

Shown next in Table 14 is data on the beneficiaries of some of DOST's ongoing programs for modernizing production processes and directed at companies and entrepreneurs.[12] Here, the data on four DOST programs reveals that this has reached many more male beneficiaries (62%) than women beneficiaries (38%). Moreover, of the total 60 female beneficiaries, 45 are beneficiaries of a single program which provides financing to high-school seniors to start-up businesses or companies. DOST's three remaining programs (the Inventors/Inventions Assistance, Technology Financing and Technology Business Incubators programs) each have a fewer number of beneficiaries who are overwhelmingly male (over 80%).

DOST likewise enters into contracts with private sector firms to promote research and development, technology transfer and the establishment of laboratories and pilot facilities. Between 1992 to 1996, DOST entered into some 564 such contracts, 30% of which were with companies, 23% with female entrepreneurs, and a larger 47% with male entrepreneurs. (See Table 15)

Finally, it should be mentioned that a number of DOST offices periodically submit reports on women-oriented initiatives that they are undertaken within their units. These appear to consist of two major types of activities. The first consist of various gender-related training designed to promote gender sensitivity and awareness within offices and the adoption of gender-responsive methodologies for program planning and the monitoring and evaluation of projects. The second are attempts to increase female participation in programs and projects.

The Metal Industry Research and Development Centre for example, reports about exerting efforts to increase the number of women participants in their training programs for non-traditionally female technologies (e.g. welding and electroplating); and stepping-up its assistance to food-processing enterprises run by women. PHILVOCS reports on mobilising women in community disaster management – harnessing their organisation and management skills in times of calamities and addressing women's peculiar vulnerabilities during periods of crises. Finally, PCHRD reports on developing a locally fabricated diagnostic device for monitoring iron status among clients and which is particularly useful for adolescents and pregnant and lactating women who run the highest risk of anaemia or iron-deficiencies.

Table 14. Beneficiaries of Selected DOST programs by Gender

	Total # of Beneficiaries	Number of Female
DATBED	82 high school students	45
Investors/Inventions Assistance	24 inventors	1
Technology Financing VF STF	 55 entrepreneurs 23 projects	 9 4
Technology Business Incubators	6 entrepreneurs	1
Total	190	60 (31.2%)

Source: DOST

Table 15. Gender Profile of S and T Consultants, 1995

Program	Total Number	Gender Distribution			
		Female	% of Total	Male	% of Total
Manufacturing Productivity Extension Program (MPEX)	219	111	51	108	49
S & T Expert Volunteers' Pool	168	59	35	109	65
Municipal Science & Technology Advisory Program (MSTAP)	792	344	43	448	57
Total	1169	514	43	665	57

Source: DOST

6.0 Concluding Observations

The foregoing review of DOST's gender statistics indicate that developments in the S and T sector in recent decades have not been particularly disadvantageous for Filipino women. Gender data from DOST points to the following general patterns and findings:

There are indications that access to S and T knowledge and resources is relatively gender-equal. S and T institutions in the country employ roughly equal numbers of women and men, and there are slightly more women in fact among the highest personnel category of "Scientists and Engineers" in R and D institutions. However, it is also evident that S and T institutions require of women higher educational levels than they do of men. Hence, this suggests that women with less than a college education or only a college education are less likely to be recruited into S and T institutions than men of similar educational qualifications.

Historical differences in the sexes' areas of S and T specialization have narrowed over the years so that there is today greater gender-mixing in most fields of science and technology. Nevertheless, there are a number of fields that remain selective of either women or men. In particular, the Basic Sciences, Biochemistry and Science Teaching attract more women, while the Applied Sciences, Agriculture, and Engineering and Technology attract more men.

Data on school/college enrolments and graduates suggest a continuous supply of women candidates to S and T jobs or positions. There are more women recipients of DOST high school scholarships and women recipients of DOST college scholarships, though fewer females than males are increasingly opting for degrees in the Applied Sciences. Data on the country's college graduates too, indicates that there are more women completing college and pursuing post-college degree and non-degree programs than men, which accounts for the earlier noted advantage of women in attaining higher level S and T positions.

Despite the increasing entry of women in science and technology, and their presence in S and T institutions, most scientific awards go to men. This is due in part to the traditionally male bias of scientific societies and to the tendency of science academies to favour the Natural/Physical Sciences (with more males) over other branches of knowledge that attract women or both women and men. Ongoing trends towards the integration of knowledge and towards multi-and cross-disciplinary research and studies may be expected to erode the gender-typing of S and T specialization, and improve the social recognition of women's S and T contributions.

The DOST is staffed with about an equal number of women and men, but 68% of its career service technical positions are occupied by women. In addition, the Department has eight women Bureau Directors, four women Regional Directors, two women Assistant Secretaries and two women Undersecretaries. Although a woman has yet to be appointed as Head/Secretary of DOST, women are relatively well placed to influence the S and T bureaucracy and public sector S and T programs.

Currently available data covers mostly ongoing S and T activities in government and the academe and less data has been generated for the private sector or for businesses and industries which are likely the prime movers and users of S and T. The limited data available on the private sector suggest that private-sector R and D institutions employ more men than women. Likewise, data from DOST reveals that more men than women are availing of its production-or business-oriented programs (see below).

With regard the beneficiaries/recipients of S and T programs, the data from the DOST shows that more women than men accessing the S and T scholarship and training grants. More men on the other hand, avail themselves to programs designed to improve production activities through the adoption or application of new technologies. Nonetheless, DOST has moved to sensitize its offices and projects to gender concerns and to raise women's involvement in otherwise traditionally male-oriented S and T projects.

Although the gender statistics being compiled by DOST now allow us to note movements in women's and men's involvement in S and T, there are also a number of areas where these can be further reviewed, situated, and improved. One such area is perhaps the development of a conceptual framework that reflects the context of S and T development in the Philippines and which would then guide the collection, analysis and interpretation of S and T statistics. Being a country of limited resources, the Philippines may be expected to improve its S and T capacity more through the diffusion and adoption of foreign-made technologies than by trailblazing in scientific discoveries and inventions. Such technological diffusion and adoption probably occur more at the level of businesses and enterprises; these are least covered in the country's S and T statistics. The S and T information that we have available focus more on the education and supply of scientists and technologists in government and academic institutions, and on the participants of public–sector S and T programs and projects.

A profile of national S and T activities cannot be complete without the generation and analysis of private-sector S and T statistics, particularly in view of policy reforms directed at economic liberalization. In turn, the generation of private-sector S and T statistics requires additional background studies on the S and T content and/or requirements of industries of varying types (e.g., garment firms, appliance manufacturers, plastics, and resins companies etc.) and scales (SMIs, large businesses) and the capacity of these industries to absorb new technologies. Part of the difficulty in interpreting the available data on the S and T labour force by major industry (and occupational) groups is that little is known about the S and T requirements or demand of the industries in which workers find themselves. Tracking the placement/recruitment of male and female personnel in industries of varying S and T content (high, medium and low technology industries) thus becomes important in assessing the genders' overall participation in scientific and technological activities.

Another area for improving S and T statistics is in the definition of "science and technology" fields and activities. Current usage is far from uniform and various data sources, including those reviewed here, do not adhere to the same definition and classification of S and T activities. Two points are worth considering in attempts to arrive at more consistent definitions of S and T. The first is to guard against the common bias of limiting S and T to the Natural/Physical Sciences and their applications, and to the exclusion of other fields of knowledge. The term "technology" for instance is often used to refer only to physical technologies or devices while ignoring a range of social, behavioural and organizational management technologies which are equally important in improving the country's capability to adopt or develop technologies appropriate to its changing conditions.

The second is to guard against the equally common bias of equating science and technology to "modern-day S and T", the conduct of which requires high levels of education and complex facilities. This notion of S and T tends to exclude forms of indigenous knowledge (arrived at through historical experience rather than through controlled experiments) and the everyday kind of science played out in people's lives. Indigenous knowledge is known to form essential components of community healing/health maintenance practices, as well as of farming, fishing and other production activities. S and T definitions that are too restrictive or that are too biased in favour of certain activities directly affect the statistics generated for the sector and the distribution of men and women in S and T endeavours.

7.0 Notes and References

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[4]Data on DA researchers supplied by DOST.

[5]Data on DENR researchers supplied by DOST

[6]Data on the personnel profile of selected DOST agencies are based on reports submitted by the Science and Technology Information Institute, Technology Application and Promotion Institute; Philippine Volcanology and Seismology, Philippine Council for health Research Development, and Industrial Technology Development Institute.

[7]*Gender Analysis in Industrial Science and Technology under APEC.* Amelia C. Ancog, Beatriz D. del Rosario, Maruja V. Lorica, Virginia Novenario, Karen Castañeda, Aida Ansaldo and Emilio Amparo, DOST. n. d.

[8]Data on NRCP scientists are from Sylvia H. Gurerrero's article on "The situation of Women Scientists and Managers in Asia" appearing in "ASEAN Symposium on Women in Science and Technology: Papers and Proceedings". Women in Science and Technology Development Foundation, Inc., Manila:994; NAST-related data are from NAST's 1996 Directory of Academicians and Outstanding Young Scientists.

[9]Figures from the 1990 DOST/SEI-NSO S and T Labour Force Survey are cited in *Gender Data on S and T Manpower Development.* Ester B. Ogena, Science Education Institute. DOST n. d.

[10]Also cited in Ogena, above.

[11]Also cited in Ogena, above

[12]See Ancog et. al. above. Other data on DOST program beneficiaries are based on agency/unit reports submitted by MIRDC, Philvocs and PCHRD.

SEX-DISAGGREGATED DATA RELATED TO SCIENCE AND TECHNOLOGY IN CANADA

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Abstract

Statistics Canada, the statistical bureau of the government of Canada, routinely disaggregates all social data by sex. Hence, a broad range of statistical information is available for gender-based analysis of science and technology issues. This paper begins with a presentation of Canadian statistics in the areas of education and work in the formal economy, including a discussion of data sources and collection techniques. The paper concludes with a description of the use of sex disaggregated data for the purposes of the Employment Equity Act, an important policy initiative for the promotion of equal employment opportunities in Canada.

Biographical Note

Nancy Ghalam is a Senior Research Analyst with the Canadian government statistical agency, Statistics Canada. She holds a BA Honours degree from the University of Winnipeg in Economics and French, and is currently writing her Master's thesis on "Attitudes Towards Gender, Work and Family" at the School of Canadian Studies, Carleton University in Ottawa. Her work at Statistics Canada has focused on the analysis of gender and women's issues, particularly with respect to women and work. She is the author of numerous articles and publications, including the 1995 statistical report, Women in Canada, Third Edition. Ms. Ghalam also works as an instructor in the areas of social data and survey research methods.

SEX-DISAGGREGATED DATA RELATED TO SCIENCE AND TECHNOLOGY IN CANADA

Introduction

Statistics Canada, the Canadian government agency responsible for the collection of national statistics, routinely disaggregates all social data by sex. Hence, a broad range of statistical information is available for gender-based analysis of many science and technology issues. This paper presents a selection of indicators of women's participation in science and technology in Canada, followed by a more detailed discussion of the major sources of these statistics. It concludes with a brief description of the use of sex-disaggregated data for the purposes of the *Employment Equity Act*, an important policy initiative for the promotion of equal employment opportunities in Canada.

Like those in many other APEC economies, women in Canada remain highly under represented in the area of science and technology, both in institutions of higher learning and in the workplace. In 1996, women accounted for only one in five (20%) people employed in engineering, mathematics and other natural sciences occupations, a situation that has changed little over the past fifteen years (Chart 1). In addition, it is unlikely that female representation in science and technology careers will increase dramatically in the near future, as women currently account for relatively small shares of total university enrollment in these fields (Chart 2).

Under Canadian legislation known as the *Statistics Act*, Statistics Canada is required to collect, compile, analyze, abstract and publish statistical information on virtually every aspect of the nation's society and economy. Although Statistics Canada data are generally produced from surveys, they are also generated as a by-product of administrative activities. Sex-disaggregated data related to science and technology can be obtained from the Census of Population, from sample surveys such as the Labour Force Survey, and from administrative files. Although much data exists to illustrate the fact that women remain very much a minority in science and technology, it is more difficult to measure and analyze the determinants of this situation. In an attempt to better understand the dynamics of the labour market and the relationship between education and labour market outcomes, Statistics Canada has introduced several new surveys. Some of these include the General Social Survey, the Survey of Labour and Income Dynamics, the National Graduates Survey and the Workplace and Employee Survey.

Census of Population

By law, Statistics Canada must take a census of the population every five years. The Census of the Population consists of a self-completed mail-back questionnaire that collects basic demographic data, such as age, sex, marital status, household and family composition from every household in Canada. At the same time, statistics on social, cultural and economic characteristics, including education and participation in the formal work force, are collected from a 20% sample of households. The large sample size means that indicators related to gender in science and technology, such as field of study and employment and earnings by occupation can be estimated for relatively small sub-populations. This is especially important for analysis of specific occupations in science and technology fields.

The Census provides the most detailed source of data on occupation[1]. For example, using these data, the major group, "Occupations in Natural Sciences, Engineering and Mathematics", can be further disaggregated into minor groups such as Occupations in Physical Sciences. This category, in turn, consists of several career groupings: chemists, geologists, physicists, meteorologists, and other physical sciences technologists and technicians. This richness of Census data makes possible in-depth analysis of the representation of women in specific occupations. Although women account for 20% of overall employment in natural sciences, engineering and mathematics occupations (Chart 1), there is a great variation within this major grouping. For instance, 37% of biologists were women in 1991, compared with just 5% of mining engineers (Chart 3).

However, the sheer magnitude of conducting and processing a national census and the fact that it occurs on a five-year basis, means that these statistics are less timely than those obtained from smaller but more frequent sample surveys. For example, the most recent Census was carried out in May 1996, with data on labour force activity and education scheduled for release in the spring of 1998. The Census also asks a limited number of questions for reasons of both cost and a desire to minimize respondent burden. Nonetheless, new questions pertaining to unpaid work activities were added to the 1996 Census questionnaire.

Labour Force Survey

The Labour Force Survey (LFS) is the primary source of data on the Canadian labour market. It is a monthly household survey of a sample of 96,000 individuals who are representative of the civilian, non-institutionalized population 15 years of age or older in Canada's ten provinces. Since its inception in 1945, the objectives of the LFS have been to divide the working-age population into three mutually exclusive groups - employed, unemployed, and not in the labour force[2]. The LFS supports analysis of women's labour force participation in terms of educational attainment, marital status, and age of children in the home, as well as employment and unemployment by industry, occupation, full or part-time employment status and self-employment, to name but a few of the available variables. Approximately 85% of all households in the sample are interviewed by telephone, while the remainder is contacted through a personal visit.

The data on the representation of women by occupation presented in Chart 1 are from the LFS. As discussed previously, the advantage of these data is that they are collected far more frequently than data from the Census. On the other hand, the LFS sample is not large enough to produce labour force estimates for detailed occupational groupings and residents of Canada's two territories are excluded from the LFS survey population.

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[1] Occupation refers to the kind of work persons were doing during the week prior to the Census, grouped according to the 1980 Standard Occupational Classification structure.

[2] The concepts and definitions of employment and unemployment adopted by the survey are based on those endorsed by the International Labour Organization.

Survey of Consumer Finances

The Survey of Consumer Finances (SCF), carried out as a supplement to the LFS, provides detailed information on the income of individuals and families in Canada. Statistics Canada has conducted the SCF on a periodic basis between 1951 and 1971, and annually since 1971. Since this information is linked to the LFS, the result is a database containing comprehensive income, demographic and labour characteristics, all disaggregated by sex.

One of the variables this survey provides is the female-to-male earnings ratio for people employed in different occupations. In 1995, female university graduates employed full-time for the entire year in natural science occupations earned 82% as much as their male counterparts (Chart 4). This ratio is relatively high compared to the average of 76% for all professionals with a university education. However, this is largely due to the fact that men's earnings in the natural sciences are relatively low compared to other fields. At the same time, women's earnings are fairly consistent across all the occupations presented in Chart 4, ranging between $48,900 in medicine and health to $43,500 in teaching. The Census of Population also produces earnings data by occupation, and while this information is less timely than statistics from the SCF, it is available for detailed occupational groupings and for small sub-populations.

Administrative educational data

The core of the information produced by the Centre for Education Statistics at Statistics Canada is administrative data collected from provincial or territorial ministries of education, and in some cases, directly from educational institutions. These administrative statistics cover all schools, trade schools, colleges and universities and provide information on students and faculty by sex. Data on students generally covers enrollment and graduation by age, type of institution, full-time, part-time registration status, and field of study. Available statistics on teachers include variables such as age, subject taught, tenure/experience, qualifications and salary. This is at least one example of a data source providing some measure of the representation of women in decision-making positions in educational institutions. The data on women as a percentage of university enrollment by field of study presented in Chart 2 come from administrative sources. Statistics on the highest level of educational attainment are also collected as a matter of course in most household surveys, including the Census.

Filling in the gaps

Established data sources like the Census of Population, the LFS, the SCF and administrative education statistics are very useful in providing a "snapshot" of women's participation in science and technology. While these types of cross-sectional data are useful for monitoring trends, they tell us little about the dynamics of the labour market, about the interaction of paid and unpaid work, or about the relationship between post secondary education and occupational achievement, to cite but a few examples. In an effort to measure and analyze the determinants and the dynamics of socio-economic trends, several new data collection initiatives have been put into place at Statistics Canada in recent years.

The General Social Survey

The General Social Survey (GSS), a national sample telephone survey of approximately 10,000 individuals, was initiated in 1985 to fill gaps in the national statistical system with respect to socio-economic data. The GSS is conducted annually, with key topics repeated every five years. Several cycles of the GSS provide indicators related to gender in science and technology: work and education (1989), education, work and retirement (1994), and time use (1986, 1992, and 1998). In particular, the 1989 cycle included modules on new technologies and human resources as well as knowledge of and attitudes towards science and technology, for example, use of computers.

Time use data collected by the GSS has also been essential to Statistics Canada efforts to measure and value unpaid work. The issue of unpaid work was raised in the Background Paper for this meeting; "...it is frequently the competitive demands of household work which inhibit severely women's abilities to take advantage of career and sometimes educational opportunities in S&T," (Katepa-Kalala, p.11). The amount of time spent on unpaid work activities is collected in the GSS cycles on time use, and the National Accounts Division of Statistics Canada prepares estimates of the value of unpaid household work.

The Survey of Labour and Income Dynamics

The Survey of Labour and Income Dynamics (SLID) is a panel survey launched in 1994. The SLID supports research aimed at advancing the understanding of labour market behaviour and economic well-being by exploring the links between demographic events, labour market events and changes in income. Both longitudinal and cross-sectional data are produced from a sample of over 60,000 individuals drawn from the LFS, who are interviewed annually for six years. However, it is the longitudinal nature of the survey which will provide an opportunity to analyze people's job mobility and earnings dynamics over time in all areas of the labour market, including science and technology. Some of the many topics covered by the survey include job characteristics, jobless spells, personal income, educational activity and attainment, as well as demographic and household information.

The SLID also collects statistics that help to understand the relationship between paid and unpaid work. For example, it requests information about time spent caring for people or children other than one's own, and whether that care-giving limits the amount of paid work the respondent was able to do. In addition, respondents are asked if they received any unpaid help to care for their children and whether this increased the amount of paid work they were able to do.

The National Graduates Survey

The National Graduates Survey (NGS) is an example of the type of sample surveys that have been implemented to investigate education-related issues which cannot be addressed by administrative data. It surveys graduates of universities, colleges and trade schools to examine their transition from school to the labour force. The graduating classes of 1982, 1986 and 1990 were surveyed two and five years after graduation, and the same is being done for the class of 1995. Information disaggregated by sex is available, for example, on the qualifications, the subject of specialization and the relationship between the program of study and the employment subsequently obtained.

The Workplace and Employee Survey

The Workplace and Employee Survey (WES) is a new survey designed to provide an integrated view of the activities of employers and their employees. Current business surveys do not collect sex-disaggregated data because their unit of analysis is individual companies, not individuals. Therefore, there is little or no data available, for example, on the representation of women in decision-making positions in Canadian enterprises, or the dynamics of firm's decisions to hire employees or to provide them with training. The WES is designed as a dual survey, comprising a sample of business establishments and a sample of employees working within these establishments. This means that it will be possible to relate employer activities and employee outcomes at the level of the individual workplace.

The establishment portion of the survey covers topics such as training, technology use, hiring practices, and workforce characteristics. The employee questionnaire also covers a wide range of topics, including job characteristics, requirements when hired, use of technology, participation in decision making, recent work history, education and family situation. The survey collects data by occupation and sex, allowing for an analysis of establishments and workers in the area of science and technology. A pilot of the WES was conducted in 1996, and the first survey will go into the field in April 1999.

Sex-disaggregated data and the Employment Equity Act

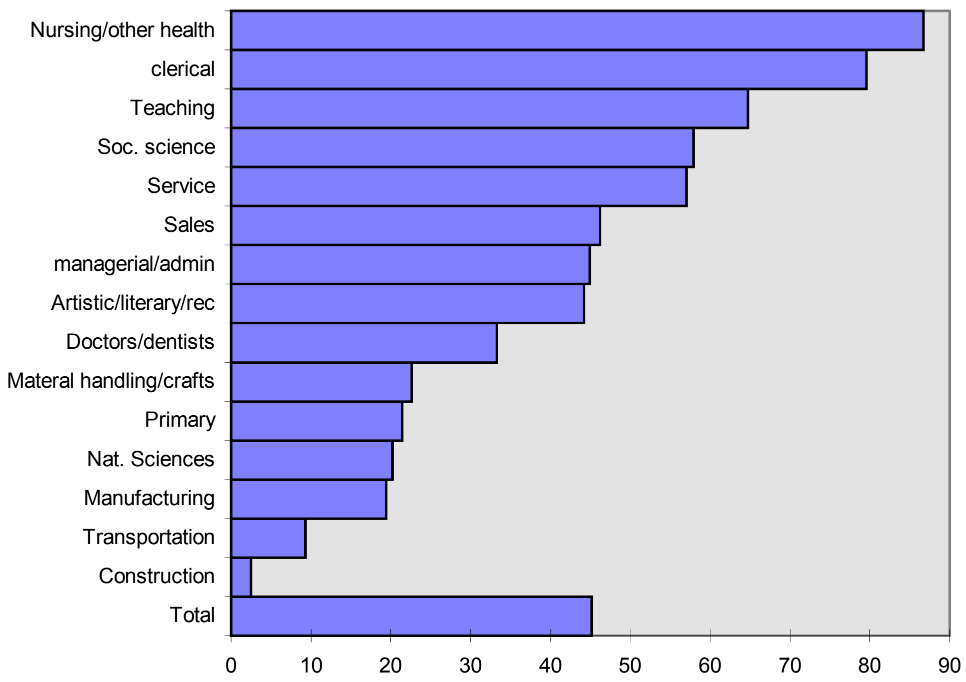
The use of sex-disaggregated data is for the purposes of employment equity is one example of how these statistics can be used to promote increased employment of women in science and technology. The term "employment equity" was coined by Judge Rosalie Abella in her 1984 Royal Commission Report, *Equality in Employment*. She defined employment equity as "a strategy designed to obliterate the present and residual effects of discrimination and to open equitably the competition for employment opportunities to those arbitrarily excluded". On August 13, 1986, the federal government of Canada passed the *Employment Equity Act* with the objective of achieving equal employment opportunities in the workplace.

The intention of the employment equity legislation is to identify and remove barriers to the employment of four groups of people - women, Aboriginal peoples, persons in a visible minority, and persons with disabilities - and to ensure that they achieve a level of employment that is at least proportionate to their representation in the work force, as defined by qualification, eligibility and geography. In order to develop and evaluate employment equity programs, data are required on the size and characteristics of the population in each of the four designated groups. The Census of Population is the primary data source for this information, although many surveys now collect information about membership in employment equity designated groups.

Conclusion

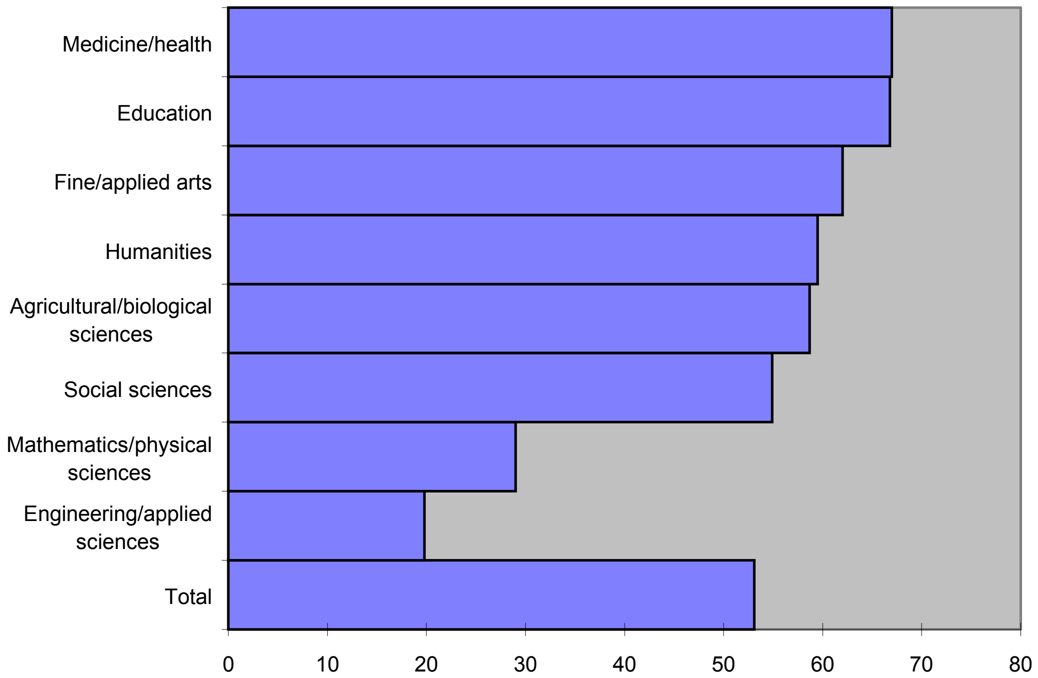
Canada has a highly developed statistical system where data collected from individuals is routinely disaggregated by sex. Statistics from the Census of Population, from established survey vehicles such as the Labour Force Survey and administrative educational data clearly show that women in Canada remain under represented in the area of science and technology. Recognizing the importance of not only monitoring trends, but of understanding their dynamics and determinants, Statistics Canada has expanded its data collection activities. New longitudinal surveys such as SLID, the introduction of innovative collection techniques and continued efforts to measure unpaid work are examples of the kinds of initiatives that will help to fill gaps in our understanding of gender, science and technology, and this, in the context of the country's broader socio-economic situation.

Chart 1: Women as percentage of employment, by occupation, Canada, 1996



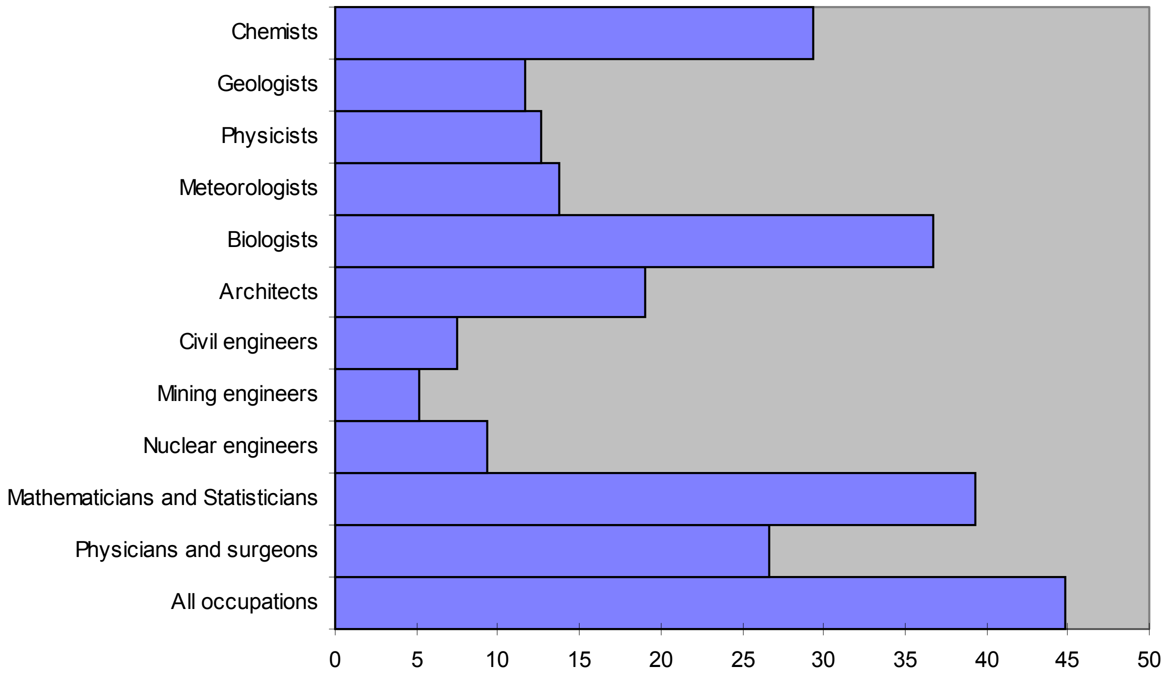
Source: Statistics Canada, Labour Force Survey

Chart 2: Women as a percentage of university enrolment by field of study, Canada, 1994 - 95



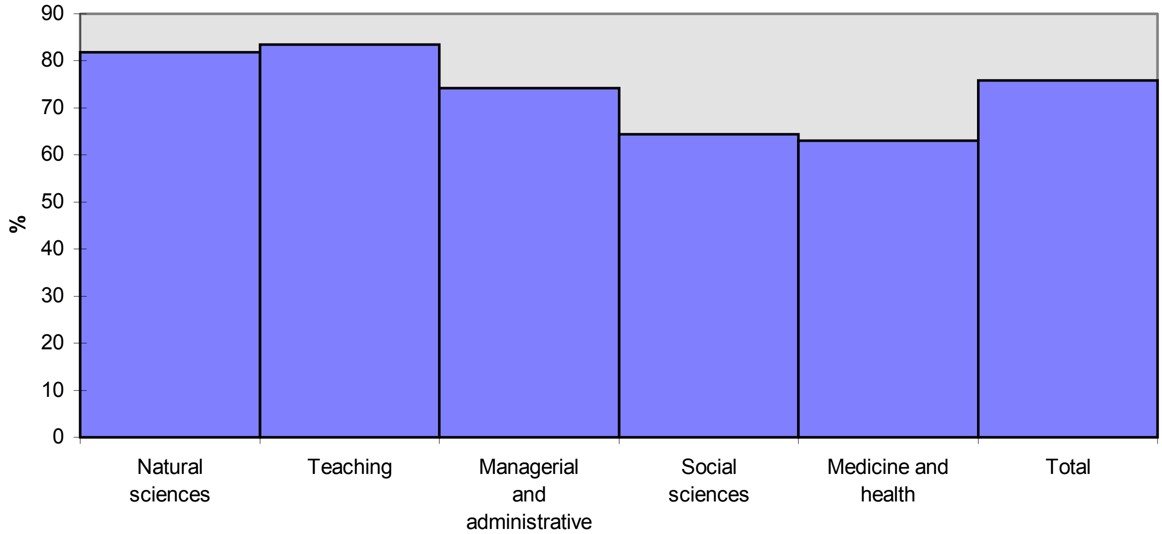
Source: Statistics Canada, Centre for Education Statistics

Chart 3. Women as a percentage of the labour force, by occupation, Canada, 1991



Source: Statistics Canada, Census of Canada

Chart 4: Female-to-male earnings ratio of university graduates by occupation, Canada, 1995



Source: Statistics Canada, Survey of Consumer Finances

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PRINCIPLES AND PRACTICES: GENDER-DISAGGREGATED DATA ABOUT PARTICIPATION IN UNITED STATES SCIENCE AND ENGINEERING

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Data on education and labour force participation have been collected and reported separately in the United States for women and men for a long period of time. This paper reviews the collection practices and practical problems in obtaining and reporting gender-disaggregated data for science and engineering in the United States. The paper first outlines the institutional context in the U.S. for the collection and reporting of information on science and technology, because this structure affects the practical implementation of the principles that are reviewed. It then examines the instruments of data collection presently in use to collect gender-disaggregated data; considers the means of obtaining these data from various respondents; reviews alternative presentations of data in tabular formats; and discusses guidelines for the interpretation of results. The paper stresses three principles which apply to both collection and presentation of data: First, understand the policy issues involved; second, maintain objectivity and quality standards in the data collection agency or unit; third, disaggregate data to the greatest extent possible.

Biographical Note

Dr. Golladay is Director of the Human Resources Statistics Program of the division of Science Resources Studies Division, the statistical arm of the National Science Foundation. In this position, she is responsible for directing a program to collect, analyse and disseminate data on the dimensions and characteristics of the science and engineering workforce in the United States. Included in this portfolio is the preparation of a biennial report required by the US Congress on *Women, Minorities, and Persons with Disabilities in Science and Engineering,* which draws from national data sources. Mary Golladay has held management positions in the division for over a decade; her responsibilities have included the management of surveys on academic research infrastructure (facilities and instrumentation) as well as those on the education system and workforce. She received MA and PhD degrees from Northwestern University in Evanston, Illinois in Mathematics, Applied Mathematics and Education.

[1]Note: Opinions expressed are those of the author and not necessarily those of the National Science Foundation.

PRINCIPLES AND PRACTICES:
GENDER-DISAGGREGATED DATA ABOUT PARTICIPATION IN UNITED STATES SCIENCE AND ENGINEERING

Data on education and labor force participation have been collected and reported separately in the United States for women and men for a long period of time. Nevertheless, the amount of the data available, and the usefulness of resulting reports for reviewing practice and for formulating policy, continue to change. New issues related to the collection and presentation of information on gender differences for the development of policy continue to arise. The reasons for gender differences are becoming more apparent as additional causal factors underlying differences are identified and studied. This review of collection practices and practical problems in obtaining and reporting gender-disaggregated data for science and engineering in the United States is intended to help those examining policies related to gender.

The paper first outlines the institutional context in the U.S. for the collection and reporting of information on science and technology because this structure affects the practical implementation of the principles that are reviewed. It then examines the instruments of data collection presently in use to collect gender-disaggregated data; considers the means of obtaining these data from various respondents; reviews alternative presentations of data in tabular formats; and discusses guidelines for the interpretation of results.

Out of the details of practice, several distinct principles emerge. The principles do not fit together neatly, nor coincide with the processes of collection and reporting. Yet these three principles are so important to the intent of the paper that they are presented here initially, to be reinforced and illustrated later throughout the discussion of procedures. While the details of practice vary with national circumstances, these "lessons learned" can be considered more universal, and hence should be considered by anyone interested in improving the availability (and influence in policy discussions) of gender-disaggregated data. These principles apply to both collection and presentation of data.

- First, understand the policy issues involved.
- Second, maintain objectivity and quality standards in the data collection agency or unit.
- Third, disaggregate data to the greatest extent possible.

Collection and Reporting of Science and Technology Data in the United States

The U.S. has a decentralized statistical system: that is, the authority for collecting and reporting data by the government is distributed across several government agencies. The sizes of the statistical units vary in staff and budget.

The responsibility for collecting and disseminating information about science and technology has been assigned to the Division of Science Resources Studies (SRS) of the National Science Foundation (NSF). SRS is within the programmatic agency responsible for promoting science and technology in the U.S. through support of education at all levels and through the support of basic research. SRS, the group responsible for data collection and reporting, regards itself as both a part of the NSF insofar as its focus is concerned, but also as a member of the federal statistical systemCa group of units across the federal government with analogous responsibilities in various subject areas.

Operationally, this means that SRS operates with numerous and frequent interactions, and a variety of formal agreements, with other Federal and State statistical units. These units include the Bureau of the Census (the nation's largest, housed in the Department of Commerce), the Bureau of Labor Statistics, the National Center for Education Statistics in the Department of Education, and data collection offices within the Immigration and Naturalization Service. Another type of tie links us with governmental units that transfer funds to support the collection of data but are not themselves statistical units. SRS has formal arrangements of this sort with the Department of Energy, the National Institutes of Health, the National Aeronautics and Space Administration, and the National Endowment for the Humanities.

The placement of the division of SRS within the NSF is an advantage as SRS addresses its responsibility to provide information on science and technology. The unit is close to those concerned with developing policy on these topics. In the case of NSF, this is the National Science Board. Hopefully, this proximity works to serve the policy makers as well as the data collectors. This closeness would not be as likely in a more centralized statistical system. [It is appropriate to note that Dr. Malcom, who is also speaking at this conference, is a member of that Board, is well known to many of the SRS staff. Her ideas are shared with those designing and implementing surveys and analyses.]

If an organizational structure is not in place that facilitates access to persons making policy and asking for information, it is important to establish that access. The first principle in developing data to address gender-related issues is to **listen to the policy makers in order to understand the issues**. For those who are aggressive in maintaining such access, the listening becomes a dialogue. Out of the dialogue may emerge more creative ways of serving the policy makers. As specific surveys are noted below, we can examine examples of changes to questionnaires that have resulted from these interactions.

SRS employees deal directly with staff in other cooperating statistical agencies. Several kinds of working arrangements link agencies together. While the formal ties are known to and endorsed by the top management of the agency when exchanges of money or formal collaborations are involved, frequent interactions between staff and programs occur across similar levels without clearance or prior approval. While this structure may sound organizationally cumbersome, in practice it offers several advantages. As participants in the federal statistical system, those at working levels discuss procedures and follow standards that assist them in maintaining quality and integrity as statistical units. The networking across agency lines contributes to principle two cited above, to **maintain the objectivity of the data-collection or reporting group.** This principle is particularly important in presenting data.

While retaining identity as a statistical agency, the staff of each agency in a decentralized system is then in a position to serve the focused interests of its parent agency. In the case of SRS, this means accepting the responsibility to provide the nation with the most complete picture possible of science and technology information. To fulfill this responsibility SRS conducts several surveys, makes arrangements to acquire data from other agencies, jointly funds data collection by some of the agencies mentioned, and publishes data and analyses resulting from its own and others' efforts, including work from those outside of the federal government. A central unit in the government, the Office of Management and Budget (OMB), acts to provide oversight of all statistical activities. Their jurisdiction includes a review and formal approval of all data collections by federal agencies. As part of its review, it considers possible overlap of surveys and encourages cooperation where feasible. It also considers the burden of responding for those asked to provide data.

Data Collection Instruments

Several surveys collect information about participants in science and engineering activities in the U.S. Disaggregation and reporting of data by gender is standard procedure for many of the basic surveys of educational participation. These surveys, some conducted by the Department of Education and some by SRS, track enrolment in educational institutions at undergraduate or graduate levels, and formal outcomes of education (e.g., completion of higher education degrees). Various surveys identifying characteristics of persons participating in or completing educational levels, and characteristics of persons in the workforce, also routinely identify the gender of respondents. Demographic characteristics of persons completing the PhD degree, and the work experiences of persons completing bachelor's, master's, and PhD degrees in science and engineering are the subjects of several surveys. Data from surveys conducted by other agencies are used to complete the NSF portfolio of available information.

The surveys collect information from two types of respondents: institutions and individuals. In most all cases, the surveys are voluntary; that is, there is no legal requirement that a respondent must supply the requested information. As a result, an important aspect of obtaining data of high quality is taking steps that will help obtain a satisfactory response rate, set at 80 percent by OMB as a minimum for government surveys if results are to be published.

Institutional surveys. Several steps contribute to high response rates for institutional respondents. These include (1) involving representatives of respondents at early stages in the survey-planning process; (2) providing advance notification that information will be collected; (3) demonstrating value to the institution from maintaining the information; and; (4) showing the usefulness to the institution of access to similar information from other peer institutions.

Early involvement of potential survey respondents lets those planning the surveys understand the record systems at institutions. Many records are now maintained electronically, although it is typical for respondents to vary widely in the sophistication of their record systems. It is also important to know, for example, what information is maintained at institutions as administrative records. For example, most institutions of higher education maintain records of student enrollees that include gender and data of birth, as well as level of enrolment, so that these items may be requested and provided with little effort. Of particular interest to those concerned with gender-related issues may be additional information that would help analysts interpret basic data. Such factors as demographic characteristics, student support, or transcript data on courses completed may be important to data analysts examining causes of gender differences.

The early involvement of respondents in decisions about data collection also provides advance notification when new items are being requested. Advance word is particularly appreciated when information is kept in electronic files because of the need for reprogramming. An item of information kept on a basic data file can be tabulated easily. Records of the gender of enrollees have been kept electronically from the outset for most electronic systems.

A third factor affecting the willingness of institutions to supply data voluntarily is the value of having access to comparable information from other institutions. Understanding others provides benchmarks for measuring one's own performance. A central agency can maintain high response rates by providing this information back to respondents at no cost. The goodwill generated from "data sharing" can be substantial.

Staying tuned to the issues plays an important role in planning data collection. Expansion of a straightforward survey of enrolments provides an example. Since the mid-1970s, SRS has conducted a survey of graduate students in science and engineering who are enrolled in all colleges and universities in the country. The survey was originally established to provide the agency with counts of students receiving financial support from NSF. It was designed to include a measure of the number of women receiving financial assistance from each of the primary funding agencies. When issues of enrolments by racial/ethnic groups became important to the study of equal access to graduate education and the careers that graduate education made possible, a section of numbers of students in each of several broad racial/ethnic groups was added. More recently, within the last five years, it has been realized that gender issues are related to those of race/ethnicity. The survey was expanded to include this break out. Before changing the survey, responding institutions were asked if the information could be provided.

Collecting data to allow for maximum disaggregation facilitates data use. Users of data are often interested in detailed data related to such factors as science and technology fields, or in institutions where the education is received. In the case of the graduate student survey, the reporting units of reporting are so small (individual academic departments at universities), that the survey has made possible comparisons of financial support for graduate students across disciplines and by gender. The roles of institutions in serving particular population groups thus may be examined easily.

Surveys of Individuals. To obtain high response rates on surveys of individuals, at least two factors have been shown to be useful. First is the guarantee to the respondent that any information provided will be held in confidence and used for statistical purposes only. That is, the identity of the individual will not be revealed. Laws governing the collection and access to data about individuals restrict the sharing of such information, across agencies or to any outside party. In fact, access to all of our data on individuals is carefully controlled. Those wishing to use data sets containing records of individuals must sign agreements regarding the handling of the records and analyses resulting from their tabulations; violations are punishable by law.

A second factor contributing to high response rates is the placement of questions regarding potentially sensitive items. Usually those asking about personal characteristics of respondents. Such factors as marital status, number of dependents, the presence of a disability that limits activity, or need to choose a job based on family situation, have been shown to be important in analyzing gender differences. Research into survey responses has shown that persons are more willing to provide information about themselves if the instrument has done a good job of securing their support for the data requested. In other words, if they have been able to identify with the issues addressed by the instrument, such as satisfaction with their work, or a discussion of their work assignments, they may then be more willing to provide a profile of themselves that includes such items. This factor is especially important as researchers and policy makers identify issues that may have an impact on gender differences in science and engineering participation.

Content. Additional variables not immediately seen as related to gender issues may nonetheless be important to the examination of the causality of gender differences. Data from both institutional surveys and surveys of individuals are important. In the case of institutional surveys, such factors as full- or part-time enrollment status, and discipline field of study or completion may differ by gender. Data from individuals that are important to analyses may include salary and type of employer as well as those variables already identified.

Data Presentation

In data reporting as well as in collection, the principles presented above can contribute to more widespread uses of data on gender in science and technology.

Tables. Tables can be designed to present results highlighting a particular aspect of the data, such as comparisons of women and men, changes over time, and distributions across discipline areas. As principle one indicated, the data collector can **utilize a knowledge of the issues to design tables that illuminate, rather than mask, the differences in question**.

For example, in the case of time trends, parallel columns in the same table, showing data for men and women may make a point more easily than would separate tables for men and women. An example, in this case showing academic degrees earned in physics, is attached as Table 38. The presentation makes it easy to contrast the numbers of awards for men and women as well as notice the differences in time trends for the sexes. At the level of bachelor's degrees, the awards to men are declining, while they are generally still increasing for women. Even so, men earned more than four times the number of degrees as women in the latest year available.

The information content of the data may also be expanded by combining data from multiple sources, such as population counts and earned academic degrees. The number of degrees in science and engineering fields related to the population of an age group representative of the age group for that degree level provides a measure of participation that "corrects" for differences in population size. An example is offered in Table 56, attached.

Text. Offering words that summarize the results reported in tables may present particular challenges. Yet it is at this point that the data collectors have perhaps the greatest potential for serving the needs of the policy makers. Principle two applies here: words must be chosen that keep the presentation of the information above reproach. **The objectivity of the information should not be questioned by any of those debating its significance.**

The responsibility of the data collector to provide information, including qualifiers that indicate confidence levels that can be ascribed to the data while not taking the next step to policy recommendations, is key. Such questions as Is progress fast enough? Is more possible? What range of differences is acceptable?, are not answered in SRS publications. A data collector should pass the information to the policy maker, but not assume the role of offering judgements on the information.

Examples of discussions of data are offered in the *Women, Minorities, and Persons with Disabilities in Science and Engineering* and *Science and Engineering Indicators* reports. These reports do not recommend policies or programs to implement, but they are used by individuals or organizations that do. Either changes over time or differences by groups can be highlighted. Making reports interesting while presenting only the facts can be a challenge.

> On the mathematics [standardized test], scores for both sexes have risen during the decade since 1984. Nevertheless, in 1994 females continued to score considerably below males, the gap narrowing only slightly over the decade. Women scientists and engineers hold fewer high-ranked positions in colleges and universities than men. . . . Part of this difference in rank can be explained by age differences, but differences in rank remain even after controlling for age.
>
> *Women, Minorities and Persons with Disabilities in Science and Engineering: 1996.* NSF 96-311

Sidebars in Reports. It is possible to extend the amount of information to include more evaluative or judgmental information while preserving objectivity and integrity by using the presentation device of sidebars that acknowledge an outside source of information. Sidebars can also be used to present data from more limited studies (as opposed to, say, national surveys). In this respect, sidebars can permit a focus on **disaggregated information on topics where it may be of particular importance**. For example:

> In 1993, graduate and undergraduate physics students provided information on the educational environment of physics departments nation wide (Curtin et al. 1995). In additional, physics professionals conducted site visits to find ways to improve the climate for women in physics departments (Dresselhaus et al., 1995). The project found that, Athe existing climate

for women in physics departments adversely impacts their progress in attaining a satisfactory career goals, . . . identified a number of factors that create a poor climate, . . .[and] suggested ways to address them and remove them.

Women, Minorities and Persons with Disabilities in Science and Engineering: 1996

Summary

Agencies or organizations collecting and reporting information on gender differences in science and technology have many opportunities to increase the use of such data by carefully designing data collection instruments, working to achieve high response rates, and choosing presentation formats carefully. Sharing of Aeffective practices@ and experiences can help all those interested in having data on gender used to influence and inform change.

Table 1. Physics degrees awarded, by degree level and sex of recipient: 1966-95

Year	Bachelor's			Master's			Doctoral		
	Total	Men	Women	Total	Men	Women	Total	Men	Women
1966	4,608	4,384	224	1,949	1,869	80	995	976	19
1967	4,733	4,466	267	2,111	2,015	96	1,248	1,216	32
1968	5,045	4,749	296	2,088	1,993	95	1,338	1,313	25
1969	5,535	5,213	322	2,259	2,139	120	1,349	1,317	32
1970	5,333	5,004	329	2,205	2,047	158	1,544	1,507	37
1971	5,076	4,733	343	2,194	2,042	152	1,625	1,577	48
1972	4,645	4,322	323	2,035	1,876	159	1,505	1,467	38
1973	4,268	3,955	313	1,755	1,642	113	1,458	1,408	50
1974	3,962	3,625	337	1,662	1,526	136	1,206	1,155	51
1975	3,716	3,354	362	1,577	1,453	124	1,169	1,111	58
1976	3,544	3,156	388	1,451	1,319	132	1,087	1,043	44
1977	3,420	3,062	358	1,319	1,193	126	1,030	975	55
1978	3,330	2,961	369	1,294	1,171	123	929	884	45
1979	3,338	2,939	399	1,319	1,184	135	993	928	65
1980	3,397	2,963	434	1,192	1,074	118	862	808	54
1981	3,441	3,009	432	1,294	1,179	115	906	844	62
1982	3,475	3,014	461	1,284	1,128	156	912	844	68
1983	3,800	3,317	483	1,370	1,208	162	928	869	59
1984	3,921	3,361	560	1,535	1,341	194	982	915	67
1985	4,111	3,550	561	1,523	1,333	190	980	889	91
1986	4,189	3,578	611	1,501	1,277	224	1,078	978	100
1987	4,324	3,629	695	1,543	1,300	243	1,137	1,030	107
1988	4,103	3,492	611	1,681	1,428	253	1,172	1,058	114
1989	4,347	3,705	642	1,739	1,448	291	1,161	1,060	101
1990	4,193	3,514	679	1,819	1,523	296	1,265	1,135	130
1991	4,245	3,575	670	1,725	1,441	284	1,286	1,144	142
1992	4,107	3,435	672	1,834	1,539	295	1,403	1,236	167
1993	4,080	3,403	677	1,781	1,463	318	1,399	1,230	169
1994	4,005	3,295	710	1,952	1,655	297	1,548	1,373	175
1995	3,836	3,161	675	1,826	1,535	291	1,479	1,297	182

NOTE: See section A, "Technical Notes," for specific fields that are included in this field of

Table 2. Science and engineering bachelor's degrees awarded, per thousand 22-year-olds in the U.S. population: 1966-95

Year	Total			Men			Women		
	22-year-olds(thousands)	Science & Engineering degress	Degrees per thousand	22-year-olds(thousands)	Science & Engineering degress	Degrees per thousand	22-year-olds(thousands)	Science & Engineering degress	Degrees per thousand
1966	2,814	184,313	65	1,411	138,679	98	1,403	45,634	33
1967	2,777	199,832	72	1,393	149,045	107	1,384	50,787	37
1968	2,747	226,597	82	1,378	165,200	120	1,369	61,397	45
1969	3,761	262,189	70	1,894	189,272	100	1,867	72,917	39
1970	3,495	284,230	81	1,757	204,528	116	1,737	79,702	46
1971	3,510	294,357	84	1,759	209,318	119	1,750	85,039	49
1972	3,511	306,459	87	1,762	216,422	123	1,749	90,037	51
1973	3,655	321,085	88	1,839	225,090	122	1,817	95,995	53
1974	3,757	326,230	87	1,892	223,652	118	1,865	102,578	55
1975	3,863	313,555	81	1,944	210,741	108	1,919	102,814	54
1976	3,970	309,491	78	1,996	205,570	103	1,975	103,921	53
1977	4,056	303,798	75	2,041	198,805	97	2,015	104,993	52
1978	4,119	303,555	74	2,072	195,888	95	2,047	107,667	53
1979	4,285	303,162	71	2,158	193,247	90	2,127	109,915	52
1980	4,275	304,695	71	2,142	191,215	89	2,133	113,480	53
1981	4,277	306,792	72	2,143	190,977	89	2,134	115,815	54
1982	4,270	315,023	74	2,143	193,624	90	2,127	121,399	57
1983	4,347	317,571	73	2,186	194,380	89	2,161	123,191	57
1984	4,269	324,284	76	2,151	199,150	93	2,119	125,134	59
1985	4,212	332,273	79	2,125	203,402	96	2,087	128,871	62
1986	4,167	335,405	80	2,111	204,743	97	2,056	130,662	64
1987	4,015	331,526	83	2,033	199,981	98	1,981	131,545	66
1988	3,817	322,482	84	1,939	191,549	99	1,878	130,933	70
1989	3,731	322,821	87	1,898	189,338	100	1,832	133,483	73
1990	3,670	329,094	90	1,873	189,082	101	1,797	140,012	78
1991	3,734	337,675	90	1,904	189,328	99	1,831	148,347	81
1992	3,865	355,265	92	1,970	195,779	99	1,895	159,486	84
1993	3,880	366,035	94	1,972	200,315	102	1,908	165,720	87
1994	3,607	373,261	103	1,836	202,284	110	1,771	170,977	97
1995	3,402	378,148	111	1,731	202,217	117	1,871	175,931	94

NOTE: Details may not sum to totals due to rounding.

SOURCES: Tabulations by National Science Foundation/SRS; data from Department of Education/National Center for Education Statistics: Survey of Degrees and Other Formal Awards Conferred, and Completions Survey; and Bureau of the Census

GENDER IN INTERNATIONAL S&T STATISTICS AND INDICATORS

Gunnar Westholm

Abstract

This presentation describes different issues of science and technology (S&T) data by gender as experienced by some of the largest international agencies: the Organisation for Economic Cooperation and Development (OECD) with Headquarters in Paris, Eurostat (the Statistical Office of the European Commission - EC) in Luxembourg and the United Nations' Educational, Scientific and Cultural Organisation (UNESCO) in Paris. It discusses the recommendations for the collection of gender data in the main international guidelines/manuals and also why such indicators (with the exception of education statistics) have not yet received the same attention as other kinds of international R&D (research and experimental development) and S&T statistics; in fact, this is due less to specific difficulties of collecting the gender data proper than to problems of international comparability due to varying concepts and coverage of the underlying statistical populations and, for many years, to rather low policy interest.

Some of the international guidelines (the UNESCO "Recommendation", the OECD "Frascati" and the OECD/Eurostat "Canberra" Manuals) are presented, together with a discussion of the principal conceptual problems of international comparisons.

Biographical Note

Gunnar Westholm worked as an administrator in the Economic Analysis and Statistics Division (EASD), Directorate for Science, Technology and Industry (DSTI) of the Organization for Economic Cooperation and Development (OECD) in Paris. Mr. Westholm has worked in most areas of internationally comparable R&D/S&T statistics and indicators. In areas such as: methodological developments/manuals, data collection and data base management, data analysis, diffusion, evaluation. His specialities in recent years were human resources devoted to S&T; university/academic R&D personnel and expenditures; bibliometrics and other «output indicators» for the higher education sector; and R&D/S&T resources in non-OECD Member countries.

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GENDER IN INTERNATIONAL“S&T” STATISTICS AND INDICATORS

1. Introduction

This presentation will describe different issues of science and technology (S&T) data by gender as experienced by some of the largest international agencies: the Organisation for Economic Cooperation and Development (OECD) with Headquarters in Paris; Eurostat, the Statistical Office of the European Commission (EC) in Luxembourg; and the United Nations' Educational, Scientific and Cultural Organisation (UNESCO) in Paris. It will discuss the recommendations for the collection of gender data in the main international guidelines/manuals. It will also discuss why such indicators, with the exception of education statistics, have not yet received the same attention as other kinds of international R&D (research and experimental development) and S&T statistics. This is in fact due less to specific difficulties of collecting the gender data proper than to problems of international comparability due to varying concepts and coverage of the underlying statistical populations and, for many years, to rather low policy interest.

Some of the international guidelines (the UNESCO Recommendation, the OECD Frascati and the OECD/Eurostat Canberra Manuals) will be presented briefly together with a discussion of the principal conceptual problems of international comparisons.

2. General Overview/Background

There is now increasing interest in the participation of women in the S&T/ R&D workforce both in the already industrialised countries (typically Members of the OECD) and the industrialising world, but not necessarily for the same reasons. Right or wrong - in a number of the most industrialised countries there were worries, some years ago, that mismatches would be coming up towards the end of the century between the demand for and the supply of R&D/S&T personnel, notably in some of the most dynamic, high-tech sectors. Here, women were considered part of the nations' potential, but often hidden, resources of highly qualified personnel as, for instance, illustrated in the series of publications *Women and minorities in science and engineering* of the National Science Foundation (NSF) in the United States.

In the industrialising world, the need for scientists and engineers in general but also for technicians was, and of course still is considered essential for the development of the national economies as a whole.

In the United States and in several other OECD Member countries, there is also ongoing debate on the role of women in S&T activities but more seen from the point of view of equal opportunities between genders. There are many other activities or occupations than S&T where women are still under-represented, but interest is essentially focussing on the S&T sector, possibly given that, notably at national level, much statistical evidence by gender is available to back up the discussions, such as, for instance, education data (both on students and faculty staff).

In the industrialised world, female students today frequently represent more than half the new entrants to tertiary (higher) education studies and they often constitute the majority of people graduating from universities. Nearly everywhere, these shares have grown steadily since the early 1980's (see for instance the UNESCO statistics).

There are, however, still great variations between the choices of male and female students in terms of disciplines (fields of study). A number of recent reports show that female students still typically choose to study, graduate and look for jobs in the "soft sciences" (social and human sciences) whereas their male colleagues appear to give preference to the "hard sciences" and related professions (such as engineering, the physical sciences, etc.). This is well summarised in the report *Education at a Glance - OECD Indicators 1997*:

> "*....Although women are more likely than men to earn first university degrees...women are far less likely than men to earn degrees in mathematics and computer science and in engineering and architecture"*.

This, of course, is a very broad generalisation, with more and more exceptions, and there is certainly a clear tendency that these discrepancies are decreasing.

Analysing education statistics (notably on personnel employed in universities and other institutions of higher education), other studies show that - also in countries where the principle of "equal opportunities" is by now more or less taken for granted - women still are seriously under-represented in S&T fields, and this still more so the higher they get into their teaching and research careers.

Even in disciplines where women are by now more numerous than men, both in absolute and relative terms, they seldom - at equal qualifications - reach the highest positions of the hierarchy (such as full professorships). When this occurs - they are frequently nominated to "less secure" (non-permanent or lower-status) posts than men. There are also indications showing that women often receive lower salaries (including fringe benefits etc) for eaqual work than their male colleagues. This can only be explained to some extent by the fact that many women S&E's are still relatively young and may therefore be in positions of less responsibility and corresponding levels of remuneration.

Depending on the countries, there are a number of reasons why this gender imbalance (even discrimination) still persists in S&T careers; this situation is likely to change only very slowly over time, given that the lead periods for modifications in educational and occupational structures are long.

These historical, traditional, sociological, philosophical (and perhaps even religious) factors will be discussed by a number of other participants of this meeting and I shall, therefore, concentrate on the essentially statistical/quantitative matters (unfortunately rather technical), which are probably much easier - and certainly less controversial - to handle than the above qualitative issues.

The gender approach has never become a hot topic in international R&D/S&T statistics and indicators work, with the notable exception of education statistics. Even if there are a number of theoretical recommendations for data collection by gender in the principal R&D/S&T manuals, this has resulted in only very limited practical follow-ups. Until recently, work centred on resources devoted to R&D (expenditures and personnel) though the R&D work-force only represents a small fraction of total S&T personnel.

Gender issues were, on the other hand, discussed at OECD seminars on a number of occasions in the 1980-1990s. However, this was within the framework of other aspects of human capital of S&T policy-interest, such as the ageing and the mobility of the R&D/S&T work-force or forecasting the need for and the supply of R&D personnel. Earlier, in the 1960s and 70s, there was also discussion of "brain-drain/brain-gain". A separate *ad-hoc* study on women in S&T was, however, undertaken at the OECD in 1988-90 (see 4.3.5 below). These meetings never gave rise to any systematic collection of gender data.

It is only during the last two-three years that more consistent efforts have been launched by OECD and Eurostat to collect head-count data for stocks and flows of human resources devoted to S&T (HRST) and related variables, including gender, following the adoption of the *Canberra Manual* (see 4.3.3 below).

Other groups at the OECD, such as the Directorate for Education, Employment, Labour and Social Affairs (DEELSA) also closely follow the evolution of the role of women in the economy, but perhaps more so for sectors where women are typically over-represented and frequently low-qualified, such as in health and social services.

It is, however, worthwhile mentioning that, in 1997, the OECD hosted an international and very high-level conference, in partnership with IBM, on the theme "*Women entrepreneurs in small and medium enterprises - A major force in innovation and job creation"*. This meeting attracted a far wider audience and participation than most of the "traditional" S&T policy meetings (see.4.3.6).

A first symbolic effort to take women more into consideration was when, perhaps some fifteen years ago or so, the terms "R&D manpower" in the *Frascati Manual* were systematically replaced by the expression "R&D personnel".

With a view to preparing the above Manuals and seminars, inventories were undertaken of relevant data collected in Member countries. It appeared that more gender data than originally expected was available at the national level. Much of this information, however, did not meet OECD quality standards of international comparability and was never collected or issued to the general public, for instance due to problems of incompatible classifications, etc.

3. The Coverage of S&T

3.1 General

Before going into deeper discussions let us try and agree on what we mean by "science and technology" (as an activity, as groups of fields of science or sectors of employment...), by "S&T personnel", by "science and technology statistics and indicators" and, then, finally discuss the main sources for the same data.

An indicator could be defined as a set of statistics, arranged to answer a specific question, "ring a bell" or give an "early warning".

3.2 S&T as an Activity - the UNESCO *Recommendation*

The basic definitions for international use of Scientific and Technological Activities (STA) and their subgroups are given in the "*Recommendation concerning the International Standardization of Statistics on Science and Technology",* (referred to as *recommendation*) adopted by UNESCO in 1978.

The STA are defined in the *Recommendation* as:

> *"systematic activities which are closely concerned with the generation, advancement, dissemination, and application of scientific and technical knowledge in all fields of science and technology. These include such activities as R&D, scientific and technical education and training (STET) at broadly the third level, and the scientific and technological services (STS)."*

The definitions of R&D, STET and *STS* (and relevant sub-classes) are shown below.

3.2.1 Research and Experimental Development (R&D)

R&D is defined as:

> *"...any systematic and creative work, undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this knowledge to devise new applications..."*

The *Recommendation* suggests a further breakdown of the R&D into Scientific Research Activities, in their turn broken down by:

- *Scientific research activities in the natural sciences, technology, and the medical and agricultural sciences;*
- *Scientific research activities in the social sciences and the humanities*

and, furthermore, discusses and defines a breakdown of these activities by

- *Fundamental research;*
- *Applied research, and*
- *Experimental development*

All the above definitions of R&D activities are directly based on the guidelines of the OECD *Frascati Manual*.

3.2.2 S&T Education and Training (STET)

S&T education and training (STET) at broadly the third level is defined in the *Recommendation* as:

> *" ...all activities comprising specialized non-university higher education and training, higher education and training leading to a university*

degree, post-graduate and further training, and organized life-long training for scientists and engineers. These activities correspond broadly to ISCED levels 5, 6 and 7."

It is recalled that ISCED is the "International Standard Classification of Education" (UNESCO 1976 and revision 1997). On the one hand, ISCED presents a description of levels of education (where levels 5 to 7 refer to higher education), and, on the other, a classification by fields of study. The latter list is frequently used as a proxy for fields of science or disciplines (see 3.3).

3.2.3 Scientific and Technological Services (STS)

The "Scientific and Technological Services" are defined by UNESCO as:

"... activities concerned with research and experimental development and contributing to the generation, dissemination and application of scientific and technical knowledge."

Nine STS classes are specified below. Note that this list goes back to the late 1970's and no longer really reflect recent developments in the economy, such as for instance information, computers and communication services and other high-tech areas.

" (i) S&T services provided by libraries, archives, information and documentation centres, reference departments, scientific congress centres, data banks and information processing departments;

(ii) S&T services provided by museums of science and/or technology, botanical and zoological gardens and other S&T collections (anthropological, archaeological, geological, etc);

(iii) Systematic work on the translation and editing of S&T books and periodicals (with the exception of textbooks for school and university courses);

(iv) Topographical, geological and hydrological surveying; routine astronomical, meteorological and seismological observations; surveying of soils and of plants, fish and wildlife resources; routine soil, atmosphere and water testing, the routine checking and monitoring of radioactivity levels;

(v) Prospecting and related activities designed to locate and identify oil and mineral resources;

(vi) The gathering of information on human, social, economic and cultural phenomena, usually for the purpose of compiling routine statistics, e.g population censuses; production, distribution and consumption statistics; market studies, social and cultural statistics, etc.;

(vii) Testing, standardization, metrology and quality control; regular routine work on the analysis, checking and testing, by recognized methods, of materials, products, devices and processes, together with the setting up

and maintenance of standards and standards of measurement;

(viii) Regular routine work on the counselling of clients, other sections of an organization or independent users, designed to help them to make use of scientific, technological and management information. This activity also includes extension and advisory services organized by the State for farmers and for industry but does not include the normal activitites of projects planning or engineering offices;

(ix) Activities relating to patents and licences; systematic work of a scientific, legal and administrative nature on patents and licences carried out by public bodies.

3.3 S&T as Fields of Study/Fields of Science

"Science and Technology", besides being a group of activitites where people are working, is also the denomination of areas in which people are studying with a view to formally qualifying for diplomas, grades, certificates at various levels. The ISCED classification list is expressed in terms of **fields of study** and is essentially used to break down education at all levels by disciplines, in particular tertiary (higher) education, but ISCED is also used as a **fields of science** classification for other kinds of S&T activities, such as academic research, bibliometrics, etc.

The ISCED classification consists of some 19 broad categories of fields of study grouping around 125 more detailed programmes. With the 1997 revision of ISCED, besides some changes concerning "levels" and new types of educational institutions, the fields of study list has been updated to more take into account new or emerging multi-disciplinary activities.

In the OECD international R&D surveys of expenditures and personnel, an ISCED-based fields of science list is used as the basic classification for the Higher Education (HE) and the Private Non-Profit (PNP) sectors. Unfortunately, the detail of this breakdown is limited to six major groups only: the natural, engineering, medical and agricultural sciences (NSE), on the one hand, and the social sciences and humanities (SSH), on the other. This is a shortcoming which seriously hampers the utility of such data for detailed international comparisons, especially since a number of countries do not even supply such macro-data when responding to the surveys. Several countries use their own and much more detailed (though closely linked to ISCED) lists for national purposes.

There is no unanimous approach between countries as to what is understood by "science and technology". This is broadly a matter of the inclusion or the exclusion of the SSH. Some countries strictly limit their S&T concept to cover only the NSE (see above), generally excluding all the SSH. Elsewhere, for instance in the German-speaking (and Scandinavian) countries, the S&T coverage is much broader. Here, the concept of "Wissenschaft" (= science) fully takes the SSH into account. The United States have adopted an intermediate concept of "Science and Engineering" (SE) which consists of the NSE plus some of the social sciences but excluding the humanities.

In the early days of the R&D statistics, UNESCO systematically collected data for the full set of NSE plus SSH whereas OECD limited itself to the collection of NSE. At the request of the

Member countries who did not want to supply different data sets to the two Organisations, OECD coverage was extended to also include the SSH in the middle of the seventies. One consequence was that the former R&D staff category of "technicians" (implying some kind of technical employment) was renamed "technicians and equivalent staff".

4. Scientific and Technical Personnel

4.1 General

There are a number of broad concepts in use in national and international reports and publications for discussions of human resources devoted to S&T. They are frequently used as synonyms for one another but, if we examine them more carefully, we have to realise that there are large variations as to their coverage. For instance, the following denominations (and acronyms) are often used in the public debate (with "personnel" as a synonym for "manpower" - and *vice-versa*):

- " Highly Qualified Manpower" (HQM)
- " Scientific and Technical (or Technological) Personnel" (STP)
- " Scientific and Engineering Personnel" (SEP)
- " Scientific, Technological and Engineering Personnel" (STEP)
- " Scientists and Technologists"
- " Highly Skilled Personnel"
- " Qualified Scientists and Engineers" (QSE)
- " Highly Qualified Technological Manpower" (HQTM)
- " Academic Level Researchers and Teachers"
- " Research and Technological Development Personnel" (RTD)
- " Research and (Experimental) Development Personnel"
- " Human Resources devoted to S&T" (HRST)

Among the above classes, there are only three which appear to be backed up by internationally adopted definitions: the STEP (in UNESCO's *Recommendation*), the "Research and Development Personnel" (in the OECD *Frascati Manual* and the *Recommendation*) and the HRST (in the OECD/Eurostat *Canberra Manual).*

4.2 The UNESCO Approach to S&T Personnel (STEP)

4.2.1 Basic Definitions and Recommendations

A certain number of definitions related to different categories of the STEP are found in the UNESCO *Recommendation*, together with criteria for the classification of persons to various sub-groups. It should be noted that many of these definitions and recommendations consist of a combination of occupational and educational criteria which, in practice, have been difficult to apply. When drafting the OECD/Eurostat *Canberra* manual (see below) on the measurement of total stocks and flows of human resources devoted to S&T (HRST) a major effort was made to clearly separate the occupational and the educational criteria (expressed in terms of ISCO and ISCED respectively), even if a number of cross-references to the two classifications had to be made with a view to explaining possible linkages between occupation and education

"Scientific and technical personnel" is defined in the *Recommendation* as:

> ... *"the total number of people participating* directly *in S&T activities in an institution or unit and, as a rule, paid for their services. This group should include scientists and engineers, and technicians (SET) and auxiliary personnel..."* (defined below).

4.2.2 Detailed Definitions of STEP Categories

UNESCO suggests that, in the first round, S&T personnel data be collected for:

- *(a)* Full-time scientific and technical personnel (FT)*; i.e. "personnel who devote almost all their working-time to S&T activities";*

- *(b)* Part-time scientific and technical personnel (PT)*; i.e. "personnel whose working time is shared between S&T and other activities", and*

- *(c)* Full-time equivalent (FTE)*: "measurement unit representing one person working full-time for a given period; this unit is used to convert figures relating to the number of part-time workers into the equivalent number of full-time workers. Data concerning personnel should normally be calculated in FTE, especially in the case of scientists and engineers and of technicians".*

The Recommendation then defines three principal categories of S&T personnel and suggests specific criteria for their classification to the respective groups. It should be stressed that these descriptions refer to **S&T personnel** and are slightly different from those of the **R&D personnel** (see 4.3.2).

The three *STEP* classes are:

Scientists and engineers *" (who) comprise persons working in those capacities, i.e. as persons with scientific or technical training, who are engaged in professional work on S&T activities, administrators and other high-level personnel who direct the execution of S&T activities".*

Persons should be classified in the scientists and engineers category if they have either:

(I) "completed education at the third level leading to an academic degree, or

(ii) received third-level non-university education (or training) not leading to an academic degree but nationally recognized as qualifying for a professional career, or

(iii) received training, or acquired professional experience, that is nationally recognized as being equivalent to one of the two preceding

types of training (e.g. membership of a professional association or the holding of a professional certificate or licence)".

Technicians *" ... comprise persons engaged in that capacity in S&T activities who have received vocational or technical training in any branch of knowledge or technology, in accordance with the following criteria:*

(I) that they have completed the second stage of second-level education. These studies are in many cases followed by one or two years' specialized technical studies, which may or may not lead to a diploma;

(ii) that they have received three or four years' vocational or technical education (whether leading to a diploma or not) following completion of the first stage of second-level education;
(iii) that they have received on-the-job training (or acquired professional experience) that is nationally recognized as being equivalent to the levels of education defined under (i) and (ii) above."

Auxiliary personnel *"comprises persons whose work is directly associated with the performance of S&T activities, i.e. clerical, secretarial and administrative personnel, skilled, semi-skilled and unskilled workers in the various trades and all other auxiliary personnel".*

4.2.3 STEP Variables Suggested for Data Collection

The personnel of S&T institutions should, following the UNESCO *Recommendation*, be classified according to six categories, one of which (f) is "by sex" (gender):

(a) By the work they are engaged in and their qualifications (three groups of personnel are identified: scientists and engineers, technicians and auxiliary personnel- see above)

(b) By level of education and by field of study, determined in accordance with ISCED (for the scientists and engineers and the technicians but not for the auxiliary personnel*).*

(c) By occupation, in accordance with the ISCO (the International Labour Office's " International Standard Classification of Occupations " (ctd)

(Note that ISCO was revised in 1988 and that linkages between the old and the new versions of the Classification are hard to establish, notably for the principal categories of S&T personnel).

(d) By number, in full-time (FT) and part-time (PT) for the category of scientists and engineers (see above);

(e) By nationality, for scientists and engineers and for technicians (merely showing nationals separately from non-nationals);

(f) By sex, for all categories of S&T personnel;

(g) By age, for scientists and engineers and for the technicians (with age groups recommended).

Later in the *Recommendation* UNESCO also defines what is meant by the Scientific and technical manpower potential for which two categories are identified:

(The) "Total stock of qualified manpower comprises the total number of persons with the necessary qualifications for personnel in categories of "scientists and engineers" and "technicians", regardless of economic activity (production, S&T activities, the professions, no gainful employment, etc.), age, sex, nationality or other characteristics, present in the domestic territory of a country at a given reference date", and

(The) "Number of economically active qualified manpower comprises the total number of persons with the necessary qualifications for personnel in categories of "scientists and engineers" and "technicians" who are engaged in, or actively seeking work in, some branch of the economy at a given reference date".

4.3 S&T Indicators Work at the OECD/Eurostat

4.3.1 General

In the field of methodological developments for the measurement of R&D and S&T activities, the OECD is a recognised world leader. Already in the early 1960's, S&T - and particularly R&D - were recognised as significant factors for economic growth. This pushed the OECD to start preparing conceptual guidelines for the collection of data for use in national and international policy studies, models and reviews. The first draft of the so-called *Frascati Manual* (FM) on the measurement of financial and human resources devoted to R&D was published 1964, followed by practical data collection work. A fifth revised version of the FM was issued in 1993/1994.

The subsequent revisions of the FM reflect new experience gained from earlier R&D surveys. They also take account of recent revisions in the international classifications on which many of the standard definitions are based (i.e. SN, ISIC, ISCO and ISCED).

For many years, work concentrated on "input" series of R&D but interest gradually increased in statistics describing the "results of R&D" ("output" indicators) and led to the preparation of a number of other manuals in the "Frascati family". To date, the S&T Manuals on the following page have been produced by the OECD Directorate for Science, Technology and Industry (DSTI).

Work is currently underway on manuals defining "high", "medium" and "low-tech" industries and goods, and on the measurement of " intangible investments" (to which, amongst other things, R&D and innovation, software developments, reorganisation work, staff training costs, etc belong). Other technical guidelines, without having the direct "Frascati status", have been issued, for instance on the use of bibliometric data series and the use of advanced manufacturing technology as indicators of S&T. Among the above "handbooks", only the *Frascati* and *Canberra* guidelines deal with matters of human capital. The other manuals are essentially devoted to S&T expenditures. The two manuals will be presented in more detail below.

Developing S&T manuals draws on two different approaches. In so far as possible, use should be made of already available and operational definitions, internationally adopted classifications and existing data series. This is the case, for instance, for the *"Patents*", the "*TBP*" and the "*Canberra*" manuals. The guidelines here suggest how to use these already available data for S&T policies, even if the underlying statistics had originally not been collected for the purpose of S&T analysis. For other manuals, such as the *Frascati* and *"Oslo*" manuals, completely new conceptual frameworks and definitions had to be set up. These were tested via experimental pilot surveys and first analytical efforts, which revealed a number of methodological problems which served for subsequent revisions of the definitions.

OECD Manuals on the Measurement of S&T Activities

Type of data	Title
Research and development	Proposed Standard Practice for Surveys of Research and Experimental Development ("Frascati Manual" 1993)
Research and Development	Main Definitions and Conventions for the Measurement of Research and Experimental Development (R&D) (A Summary of the Frascati Manual 1993)
Technology Balance of Payments	Proposed Standard Method of Compiling and Interpreting Technology Balance of Payments Data ("TBP Manual" 1990) (1)
Innovations	OECD Proposed Guidelines for Collecting and Interpreting Technological Innovation Data ("Oslo Manual" 1997) (2)
Patents	Using Patent Data as Science and Technology Indicators ("Patents Manual" 1994) (1)
Human Resources	The Measurement of Human Resources Devoted to S&T ("Canberra Manual" 1995) (1) (2)

1) Dealing mainly with the problems of classifying and interpreting existing information
2) Together with EC/Eurostat

4.3.2 R&D Personnel - the "*Frascati Manual*"

4.3.2.1 Definitions

UNESCO's approach for measuring S&T personnel was discussed under 4.2 above. This section will deal with that of the R&D personnel**,** as presented in Chapter 5 "*Measurement of Personnel devoted to R&D*" of the *"FM*" (the basic definition of R&D as an activity, common to the OECD and UNESCO, was indicated in section 3.2.1).

The "*FM*" defines the initial coverage of R&D personnel as:

> *"All persons employed directly on R&D should be counted, as well as those providing direct services, such as R&D managers, administrators and clerical staff".*

The *FM* recommends two approaches for classifying the R&D personnel: one **by occupation,** the other **by level of formal qualification**. Both are linked to the principal United Nations classifications, respectively *ISCO* and *ISCED*. Some Member countries collect R&D personnel data according to both series whereas others have opted for one or another, though frequently considering that there is general correspondence between different categories of occupation and levels of education.

The following three categories are defined in the *FM* for the breakdown of R&D personnel **by occupation:**

Researchers (RSE *" ...are professionals engaged in the conception or creation of new knowledge, methods and systems, and in the management of the projects concerned".*

(Remark: Postgraduate students engaged in R&D should be considered as researchers).

Technicians and equivalent staff *" ...are persons whose main tasks require technical knowledge and experience in one or more fields of engineering, physical and life sciences, or social sciences and humanities. They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods normally under the supervision of researcher. Equivalent staff perform the corresponding R&D tasks under the supervision of researchers in the social sciences and humanities".*

Other supporting staff "*include skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects".*

Compared to the definitions of S&T personnel in the UNESCO *Recommendation* (see 4.2), an effort has been made in the FM to avoid the confusion between educational and functional criteria to define the occupation categories.

The following five classes are recommended for the classification of **R&D personnel by level of formal qualification** (regardless of the field in which they are qualified):

- Holders of university PhD level degrees (ISCED level 7 upper part)

- Holders of basic university degrees below the PhD level (ISCED level 7 lower part and level 6)
- Holders of other post-secondary diplomas (ISCED level 5)
- Holders of diplomas of secondary education (ISCED level 3 and below)
- Other qualifications

4.3.2.2 Other FM Recommendations

Like the *Recommendation*, the *"FM*" recommends that priority should be given to measuring R&D personnel by full-time equivalence (FTE), notably in terms of person-years, but its most recent version also recommends, in stronger terms than the preceding ones, a measurement by head-counts. The FTE data is considered to give a better description of the total R&D effort whereas the headcount approach is the most appropriate for collecting additional information on the R&D personnel, such as age, **gender** or nationality or for purposes of forecasting (even "nowcasting"). The headcount series are also more suitable for comparisons with other statistical series with the individual as the statistical unit, such as population, labour force, (un)employment and education data.

Among additional breakdowns for the R&D personnel, the FM recommends that the following types of data should be collected on a headcount basis:

- researchers (or holders of university-level degrees) by field of highest qualification;
- technicians (or holders of post-secondary degrees and diplomas) by field of highest qualification;
- researchers (or holders of university-level degrees) by age, **gender,** national origin, length of service, etc.

The recommendations in the FM for collecting data by gender, for instance, are limited to the category of researchers (and equivalent personnel) only whereas the UNESCO recommends such data collection for all categories of personnel.

4.3.2.3 Surveys

For many years, the regular OECD R&D surveys were launched at two years intervals. In recent years, surveys are increasingly made on a rolling basis and countries report (even partial) data as soon as it is available, frequently on magnetic support.

Until recently R&D personnel data was only collected in FTE and with **no distribution by gender**. In the most recent R&D questionnaire (January 1998) OECD also requests information on " head-counts", however still without any disaggregation by gender. On the other hand, UNESCO is now introducing the gender concept in its draft (March 1998) statistical questionnaire on R&D, both for the R&D head-count and R&D FTE series.

Countries only report " raw data", i.e. no " derived" series, in their responses to the surveys. All conversions of these " raw data" into indicators, such as for instance percentages of GDP' or other economic variables for expenditures or ratios of the total labour force for R&D personnel, and calculations of growth rates, conversions into a common currency, etc. (as a rule to the United States dollars, using *purchasing-power parities -ppp's*) are centralised to the Secretariat of the OECD, thereby assuring that identical procedures for calculations are used for all participating countries. In some cases, however, the OECD undertakes adjustments of the national data, with a view to increasing international comparability.

4.3.2.4 Data Series Available - Publications

OECD currently maintains one of the world's largest R&D databases - however with no data what-so-ever by gender. Reasonably good personnel (FTE) series are available from the late 1960's/early 70's onwards, both for national totals and broken down by FM sectors of performance/employment (i.e. government, industry, higher education and private non-profit sectors) and according to some sector-specific sub-classifications.

As mentioned, only FTE personnel data has been collected by OECD from Member countries where, as a rule, both head-counts and the corresponding FTEs are surveyed (the former series being essential for the calculation of the latter). Gender being a typical head-count variable, it is not very realistic to disaggregate the FTE figures this way.

The principal R&D/S&T statistics and indicators publications of the OECD are the following:

"Main Science and Technology Indicators (MSTI)" - a data set which is issued twice yearly on paper and on diskette. The latter's contents is available on the OECD on-line system *("OLIS")* and via the general OECD web site = *"http://www.oecd.org*" or that of the Directorate for Science, Technology and Industry (DSTI) = **"***http://www.oecd.org/dsti/***".** The *"MSTI"* database includes some 89 R&D/S&T indicators of R&D expenditures and personnel (still no gender!) and some "output" indicators (patents, TBP and high-tech trade).

"Basic Science and Technology Statistics -BSTS", published every two years on paper and annually on diskette. The BSTS presents detailed country-by-country annual historical series on R&D expenditures and personnel, patents and TBP (also included in the CD-ROM "*OECD Statistical Compendium*").

There are, furthermore, a number of other statistical publications with specific reference to industrial R&D expenditures and employment (still without any information on gender).

4.3.3 S&T personnel - the "Canberra Manual"

4.3.3.1 Background

The need for information on a broader S&T personnel concept than R&D was increasingly felt in the 1980's in the OECD area. Even if it was admittedly difficult to forecast both the demand for and the supply of highly qualified personnel, there were worries of upcoming shortages towards the end of the century. These worries were based on demographic factors, such as the ageing of the S&T workforce and subsequent foreseen massive faculty retirement, and a simultaneous fall in the numbers of the youth cohorts who traditionally constitute the source of "new blood" into universities.

The expected falls in student numbers were, however, to a large extent, compensated by continued growth in overall enrolments to higher education, largely explained by increased participation of women. There were also some more subjective reasons for this general concern, with signs of reduced interest in S&T subjects and careers among younger students more attracted by non-S&T activities, such as business, banking and real estate, i.e. careers offering higher salaries, better working conditions and perhaps higher status than S&T.

Following a number of high-level policy recommendations, a first exercise was launched by the OECD Secretariat together with the European Commission (Directorate General XII and Eurostat) to design a statistical framework and a methodology for the collection, interpretation and analysis of data on human resources for science and technology (" *HRST*" - this new acronym was specially coined for this exercise) with a view to preparing another manual of the "Frascati family". Efforts were made to incorporate best national and international practice in the guidelines.

A comprehensive pilot "inventory" was undertaken of existing experience and HRST personnel data sources in the OECD/EC Member states; this inventory showed that, in principle, all the countries would be in a position to report detailed HRST data (including on gender) to international surveys. Greatest possible use was made of the main standard international classifications (*ISCED*, *ISCO, ISIC* and *SNA)* to structure the contents. The development work of the manual was performed in cooperation with a number of national experts on S&T indicators and with other OECD, EC, ILO and UNESCO units to take account of their experience and interests.

4.3.3.2 *"HRST*" Definitions/General Methodology

The *"HRST*" are broadly defined as

> *"...people who fulfill one or other of the following conditions:*
>
> *a) successfully completed education at the third level in an S&T field of study;*
>
> *b) not formally qualified as above, but employed in a S&T occupation where the above qualifications are normally required"*

This approach is similar to that used by UNESCO but structured differently. The "core HRST" will consist of persons both qualified and employed as *HRST*, but there will likewise be the categories of persons qualified as *HRST* but not so employed and persons employed as *HRST* but not so qualified.

From the outset, there were different opinions as to whether only " scientists and engineers (S&E)" should be covered. It was, however, decided that also "technicians" should be included in the *HRST*. Note that the concept of a "scientist and/or engineer" - frequently used as both an occupation and a qualification - is not very clear already at the national level and still less so for international comparisons.

The recommendations for levels and fields of study are based on "*ISCED"* and the coverage and breakdowns by occupation are in terms of "*ISCO-88"*. Unfortunately, the "*ISCO-88"* is still far from implemented in individual countries and most available data series are still based on its earlier version ("*ISCO-68")* or on national classifications. It is, furthermore, quite difficult to establish a direct key between the two "*ISCO"* versions and this is notably true for the categories in which we are particularly interested from the *HRST* point of view.

The basic framework for *HRST* distinguishes between **stocks** and **flows**.

*"An **HRST stock** can be defined as the number of people at a particular point in time who fulfill the conditions of the definition of HRST"*

*"**HRST flows** can be defined as the number of people who do not fulfill any of the conditions for inclusion as HRST at the beginning of a time period but gain at least one of them during the period (inflow) as well as the number of people who fulfill one or other of the conditions of the definition of HRST at the beginning of the time period and cease to fulfill during the period (outflow).*

There is also a definition of ***internal flows*****:** *" ...people who are part of the HRST stock, some of whose characteristics change during the time period concerned without, however, losing the essential characteristics for inclusion in HRST".*

Examples:

- "*HRST stock*" : the number of PhDs in a country on a given date;
- *"HRST flow"* : the number of people graduating from a university in a given year;
- *"internal flow"* : people who change jobs within their sector or achieve a higher "*ISCED"* level qualification.

The three **principal breakdowns** recommended for *HRST* data collection are
1) by formal qualification *(ISCED*); 2) by occupation *(ISCO*) and, 3) by labour force status (all discussed at length in the relevant sections of the *Canberra Manual).*

The *Canberra Manual* also discusses " Other variables of interest for *HRST* analysis"**,** notably " **Personnel characteristics**" with **gender** in the first place, together with age, national origin (and ethnicity, probably influenced by the NSF publications on women in S&T).

The interest in **gender** is justified in paragraphs 202-203:

“ 202. Women have traditionally had a low representation in many fields of S&T, particularly in the applied sciences, engineering and technology. Men, on the other hand, have typically been attracted to particular specialisations like engineering. Data on gender in stocks and flows and in the education pipeline may be useful to examine detailed participation rates and will show the potential rate of improvement of participation. They will assist analysis of the stages where women's' representation starts to fall away, e.g. at entry to higher education. Such data are also extremely important when measuring pools of under-utilised resources and considering the effectiveness of equal opportunities policies and programmes.

203. It is recommended that, wherever possible, HRST data should be subdivided by gender”

With a view to an improved understanding of the status and the conditions of the general “ *HRST”* workforce - including gender - the *Canberra Manual* recommends the collection of **contextual data** affecting the HRST system as a whole and, furthermore, a number of **variables specific to *HRST***. The former group could include demographic data (including population projections), overall numbers and trends in the education system, overall employment levels and characteristics and vacancies. *HRST*-specific information of interest is, for instance, data on unemployment of *HRST*, salaries, retirement ages, training and retraining and public attitudes to S&T.

As a follow-up to the *Canberra Manual*, Eurostat has prepared detailed theoretical/technical amendments on the measurement of *HRST* stocks and flows.

4.3.3.3 HRST Surveys and Data Collection

With a view to testing the new *Canberra* guidelines on HRST stocks, it was decided to have them applied on the Labour force statistics (LFS) already available at Eurostat, thus avoiding to launch another survey in the EC states. Unfortunately, the results of the exercise were not very conclusive. These statistics, though in principle harmonised to be internationally comparable, are based on sample surveys, grossed up to full-scale. Much of the specific details of interest to HRST - such as gender - had got lost during the grossing-up exercises. Therefore, Eurostat took the initiative (and managed to persuade the OECD to participate) to a first pilot survey in Member states. Most countries based their responses on their own labour force surveys, with the exception of some of the Nordic countries which extracted the information from special registers of highly qualified personnel. More detailed - but less comparable - data were obtained through this survey. The quality of the Eurostat LFS data having considerably improved during the last five-six years, another extraction exercise will shortly be launched with the hope of finding more detailed *HRST* information (including gender).

4.3.3.4 Publications

Eurostat published the results of the above analysis of the LFS in the second issue 1997 of its report “ *The Statistics in Focus*”, however without any data on gender. This information being available in the Eurostat databases, special extracts have been supplied for different analytical projects of the European Commission. There are also a few short paragraphs and graphs on gender participation in S&T in the EC "European Report on Science and Technology Indicators 1994".

No HRST data have been published by the OECD as yet.

4.3.4 Education Statistics and Indicators

4.3.4.1 General

From what has been said above, it is clear that the S&T statistics available so far at international level do not at all meet the needs for gender-disaggregated information. Such information, however, appears to be available in quite a few individual countries but has never been systematically compiled for international analysis. It is, therefore, from the educations statistics that the best information still has to be drawn. Data by gender is one of the basic variables for all these statistics. The main purpose is to publish internationally comparable statistics but, since there are no identical national education systems, there are still problems. Countries do not always allocate individuals to the ISCED levels the same way, both at levels 5 and 6/7. There may also be problems with the classification by field of study (notably concerning multi-disciplinary studies).

4.3.4.2 Methodology

Work on education statistics at the OECD is under the responsibility of the Directorate for Education, Employment, Labour and Social Affairs (DEELSA) and notably its attached Centre for Educational Research and Innovation (CERI). They have in recent years been strongly involved in improving the quality and the international comparability of education statistics and in the development of education indicators. As mentioned below, there is close cooperation between UNESCO, OECD and Eurostat for the collection of education statistics. The definitions and methodologies have, over time, become more and more harmonised.

UNESCO's data collection on education is essentially based on the terms and definitions of another "*Recommendation*" going back to 1978 concerning the international standardisation of educational statistics and on the Organisation's own classification ISCED.

At the OECD/CERI, systematic methodological work on education statistics and indicators started later than at UNESCO. In 1991, following a series of international conferences and intensive efforts of topic-oriented " networks", the General Assembly on International Education Indicators issued a "*Handbook*" with a view to developing tools for education policies and planning. Each of these " networks", representing specialists from several countries, had been assigned a specific domain for guidelines covering various quantitative and qualitative aspects of all ISCED" levels of education, from the " Kindergarten" to tertiary education. The 1991 "*Handbook*", backed up by a series of more recent, technical supplements, still constitutes the principal OECD methodology in the field of education statistics and indicators. Also see "*Making Education Count - Developing and Using International Indicators*" (OECD/CERI 1994).

4.3.4.3 Surveys (UNESCO/OECD/Eurostat)

For a number of years, education statistics for all levels of national education systems have been collected from Member states using a common UNESCO/OECD/Eurostat questionnaire *(" UOC3")* (sometimes including also agency-specific requests). This means that all the basic data published in their international publications have originally been supplied from national sources.

4.3.4.4 Data Series Available and Publications

The following (tertiary level) series, common to the three Agencies, are of specific relevance to HRST and issued in their respective publications:

- students by sex, age and ISCED levels 5/6/7;
- students at the third level by sex, field of study, and ISCED levels 5/6/7;
- students graduating by sex, field of study, and ISCED levels 5/6/7;
- new entrants at the third level by sex, study time and type of institution;
- new entrants at the third level by sex, field of study and ISCED levels 5/6;
- number of types of institution at the third level;
- number of teachers at the third level by sex, work time and type of institution.

Eurostat has (since 1990/1991) also assembled data for the European Union countries on:

- number of students by sex, study time and type of higher-level institutions;
- foreign students at the third level by sex, country of origin and region.

Recent UNESCO education statistics are notably found in the " *UNESCO Statistical Yearbooks"* (latest issue 1997) and the " *World Education Reports"* (latest issue 1995).
With a view to improving the status of international education statistics, the UNESCO Division of Statistics in July 1997 issued a very pertinent publication " *Gender-Sensitive Education Statistics and Indicators - A practical guide - Training material for workshops on education statistics and indicators"* with a view to sensitising producers and users of the importance of gender-sensitive data, to clarifying concepts and methods and to offering practical ideas and guidance to policy makers and managers of education in favour of gender equity.

The principal OECD/CERI publications (containing statistics, indicators and analysis) are the " *Education at a Glance - OECD Indicators"* and " *Education Policy Analysis"* reports (latest issues for both 1997). Matters of gender are well represented in these reports and also in " *Literary Skills for the Knowledge Society*", published by the OECD in cooperation with Human Resources Development Canada (latest issue 1997). The latter reports build on analysis of data on skill levels from the International Adult Literacy Surveys (IALS).

4.3.5 The OECD Study on Women in S&T (1988-90)

Following a workshop in 1988 on the theme " *Assessing the Availability of and Need for Research Manpower*", organised in response to concerns of upcoming near- and medium-term shortages of skilled personnel, a programme was launched at the OECD/DSTI, with support from the US National Science Foundation, to examine possible counter-measures. It was suggested that - rather than trying to reduce the demand - more efforts should be given to dealing with possible policy measures of increasing the supply of such personnel, notably by examining past, current and potential participation of women in the S&T work-force.

An impressive volume of (essentially education) statistics was gathered from some three-quarters of the Member countries. It was soon found that absolute comparisons between countries, at a given moment in time (" snapshots"), were less suitable for analysis than longitudinal studies (trends). A first analysis showed that, during the 1980's, women's' participation in S&T had increased everywhere, sometimes at quite high rates (though starting from very low), however with large discrepancies between countries. This concerned all variables of the S&T system: increasing female enrolments in higher education in general and in S&T fields of study in particular, in degrees awarded to women and in S&T employment. There were, however, in some countries, also first signs of decreasing growth rates or levelling-offs in enrolments and graduating.

Specific attention was given in the study to matters of (temporary or definite) withdrawals of women from their HE sector studies, and notably to drop-outs in the S&T fields of study.

An inventory was also undertaken in the study of different types of programmes in Member countries, and at various levels of the S&T and education systems, to promote the attraction to and the retention of women in science and technology fields.
The materials, drawn from a large variety of sources, covered the whole age span from pre-primary school to practising and even retired S&E's.

The following is a selection of attraction and retention programs identified in the study:

Pre-primary school level:
- reduction of gender-biased distinctions in child activities
- promotion of natural science and technology curiosity
- technical nurseries
- practical information

Primary school levels:
- science and technology classes
- gender neutral teaching materials and physical environment
- pedagogic techniques and scientific and technical materials
- teacher-parent communications
- teacher training in mathematics and science
- male/female teacher balance
- science exhibits
- science and technology centres, museums

Secondary and upper secondary school levels;

- obligatory mathematics, science and engineering
- special mathematics and science classes
- information on S&T opportunities and careers
- discussions with practising scientists and engineers
- visits to laboratories, design and production installations
- conferences and courses to promote higher education choices
- introductory courses to undecided students
- parent-student-teacher meetings
- financial aid (student support mechanisms)
- remedial S&T courses
- second and third opportunities to obtain mathematic and scientific qualifications
- communications and entertainment featuring S&T
- integration of social/gender awareness with S&T studies
- teacher training and instructional materials
- unisex (female) study groups and classes
- counselling activities - sex-stereotyping avoidance
- technical apprenticeships
- part-time study
- creation of female mentor support groups
- vocational programs
- minimum quotas in all study tracks
- technical employment assistance

Post-secondary school education:

- financial support (scholarships, loans, grants...)
- creation of female/male support groups
- female study groups
- workshop and laboratory experience
- teacher training
- part-time and short course studies
- encourage male interest in normally female pursued studies
- role models
- labour market counselling
- introductory courses
- information and related materials

Advanced higher education:

- financial support (loans, grants, fellowships..)
- flexible study/work/family care activities
- social and psychological encouragement
- research mentor counselling activities
- promotion of labour market possibilities
- elimination of abuse
- female participation in selection processes
- equality of facilities and human resource use
- creation of temporary research positions
- university associations for female researchers

Employment:

- transparency in selection criteria and of decision-making
- non-prejudicial assignments
- promotional opportunity
- recycling from non-traditional occupations
- leadership and management opportunities
- flexible and part-time work
- equality of remuneration
- organisation representation
- professional society involvement and publication
- examination of male colleague sexist behaviour
- internship programs
- in-service training
- networking female professionals
- child-care facilities
- changes in organisational practices
- recruitment of women
- updating courses
- job-sharing
- re-insertion into professional practice
- affirmative action (legislative and judicial) initiatives

This report gave rise to a number of internal discussions at the OECD and in Member countries, but it was finally decided that (in spite of its evident policy interest) it did not meet the traditional quality standards of OECD documents. It was, therefore, not released for " general distribution".

4.3.6 The OECD Conference on " Women Entrepreneurs in Small and Medium Enterprises" (1997)

As mentioned above, the OECD in 1997 hosted an international conference, in partnership with IBM, on the theme " *Women entrepreneurs in small and medium enterprises - A major force in innovation and job creation"*. It brought together members of government, senior policy makers, small business entrepreneurs, academics and other experts. The main objective of the meeting was to increase the understanding about the economic and social contributions of women entrepreneurs in OECD, developing and transition (former Soviet-block) economies and stimulate the exchange of experience. The meeting was structured around a number of workshops addressing the role of women in the business environment and in technology, globalization and international trade, management, finance and markets.

A common concern was highlighted by all the workshops: the need for comprehensive, internationally comparable quantitative and qualitative data on gender (women) and their involvement in commercial and industrial activities, in innovation and in the creation of new enterprises and jobs. In spite of the lack of such statistics, a number of very interesting features were reported. The following is extracted from the first (draft) chapter of the forthcoming synthesis report (see below):

“ Women-owned SME’s are reported to be growing at a faster rate than the economy as a whole in several OECD countries; however, the removal of a number of obstacles would allow their potential to be fully tapped”

“ Collecting information and statistics on women business owners should be an integral part of the ongoing data collection on SMEs”

“ Data are often incomplete...and partly because of historical factors or civil liberties, it is difficult to obtain national statistics on income and wealth by gender.”

“ Raising the visibility of and awareness about the economic and social role of women entrepreneurs and their businesses requires data and statistics”.

“ In the United States... in the last few years the number of firms created and managed by women has grown twice as fast as those set up and managed by men”

“ There are many indications of the growing importance of women-owned SMEs in OECD and non-OECD countries”.

“ Women in the transition economies are increasingly turning to entrepreneurship”

“ The great majority of businesses run by women are in the service sectors”.

The synthesis report of the Conference is in the pipe-line and expected for publication in the course of March 1998. The complete list of the meeting papers will be made available on Internet <*http://www.oecd.org/dsti/sti/smes/act/papers.htm*>*,* also in March.

5. Statistical Sources of Data for the Analysis of HRST

A separate section of the *Canberra Manual* (Chapter 7) is devoted to international and national sources which are or may be relevant for the measurement of HRST. As repeated on several occasions above, the current status of existing international series is (with the exception of education statistics) not very suited for detailed analysis, notably of gender issues, and there is, furthermore, no centralised system for collecting such data at the international level.

Both OECD and Eurostat manage permanent and regularly updated bases of **contextual data** of use for analysing *HRST* stock and flows, such as:

OECD:
- quarterly and annual labour force statistics;
- annual national accounts: employment by kind of activity;
- main economic indicators: earnings, disputes, jobs, hours of work,
- industrial structure statistics; employment, employees, wages and salaries;

Eurostat:
- general statistics, economy and finance, population and social conditions;
- regional statistics.

The education statistics available in international data bases were indicated in section 4.3.4.4 and R&D personnel statistics under 4.3.2.4 above.

Among other international sources should also be mentioned the Eurostat Labour force statistics (for EU Member states and selected other countries).

A number of regular national data collection exercises of potential use to *HRST* and gender analysis are carried out in most OECD countries, some of which also maintain specific (administrative and other) registers, containing, for instance, information on completed degrees/educational attainment of individual persons.

HRST information at national level may be drawn from censuses of population, household surveys, annual employment/labour force and education surveys**.** Other kinds of *HRST* data may be found in migration statistics, national earnings surveys and via specific *ad-hoc* surveys.

An increasing number of countries have also undertaken cohort or longitudinal studies following the professional careers of groups of *HRST* over long time periods.

6. Proposals for Future Work

The main conclusion of this paper concerning gender is that the world-wide international organisations, such as UNESCO and the OECD, have done reasonably good work in the field of education statistics and indicators but that much remains to be done concerning other (types of) S&T statistics and indicators, such as R&D and various kinds of employment statistics. S&T activities are recognised factors for economic growth, social development and environmental well-being already in the very short and still more so in the longer term. Increased involvement of women in S&T is essential to reach such goals. To this end, more factual information is needed to back up solid S&T policies.

With a view to improving this situation, the APEC as a Government and the PECC as a non-governmental regional organisation, have increasingly important roles to play. The quality of the work of the Human Resource Development Task Force is already recognised worldwide.

It is clear that statistics and indicators work in the APEC/PECC should, in so far as possible, become a permanent activity with permanent staff and permanent resources. This is essential for the setting up and the maintenance of databases in a long-term perspective. These databases should not be limited to personnel (gender) data but should cover the whole spectrum of S&T/R&D and education statistics and indicators and preferably also be closely linked to other kinds of policy-relevant statistics (such as industrial and demographic data series).

It is recalled that some very preliminary initiatives of shedding light on the S&T status of the Region have already been taken by APEC/PECC with their small "*APEC/PECC S&T Profile"* publications which, however, still are in need of further development and improvements.

Indicators work - notably at international level - should be professional and backed up by clear "rules of the game" engaging all partners involved. Political decisions have to be taken with a view to defining and examining the optimal use of scarce resources. The basic question, of course, is: who should do the job? Should a new " statistical group" be created or could the task be confined to one or another of the APEC Member states or economies which already possess recognised competence and experience in the area of R&D/S&T and education statistics and indicators?

Whatever decision will be taken concerning future work, cooperation with UNESCO appears to be essential. Like the APEC, UNESCO's activities are world-wide and so are, of course, the issues of gender equity. UNESCO has laid the base for the theoretical framework and is currently showing increased interest in gender policies. APEC and UNESCO, furthermore, have a number of features in common. Their memberships include countries in the " Third World" where gender issues certainly are more at stake than in the industrialised countries. UNESCO is probably also in a position to draw on the close cooperation for future work of other UN agencies with similar socio-economic objectives.

Abbreviations/Acronyms

APEC	Asia-Pacific Economic Cooperation
EC	European Commission
EUROSTAT	The Statistical Office of the European Commission
FT	Full-time
FTE	Full-time equivalence
HE	Higher education
HRST	Human Resources devoted to Science and Technology
IALS	International Adult Literacy Survey
ILO	International Labour Office
ISCED	International Standard Classification of Education
ISCO	International Standard Classification of Occupations
ISIC	International Standard Industrial Classification
LFS	Labour Force Statistics
NSE	Natural Sciences and Engineering
NSF	National Science Foundation
OECD	Organisation for Economic Cooperation and Development
PECC	Pacific Economic Cooperation Council
PNP	Private Non-Profit (sector)
PT	Part-time
R&D	Research and (Experimental) Development
S&E	Science and Engineering
S&E	Scientists and Engineers
S&T	Science and Technology
SET	Scientists, engineers and technicians
SME	Small and Medium Enterprises
SNA	System of National Accounts
SSH	Social Sciences and Humanities
STS	Scientific and Technological Services
STEP	Scientific and Technological Personnel
STET	Scientific and Technological Education and Training
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organisation

GENDER, SCIENCE AND TECHNOLOGY: PERSPECTIVES AND PROSPECTS FROM UNESCO

Dr Tony Marjoram

Abstract

The application of science and technology is the most important factor in industrial, economic and social development. Women play an important but under-represented role in science and, especially, in engineering and technology, and their contribution to economic development could be more significant. Shortages of human resources in engineering, science and technology are considered to be a major constraining factor to economic development. Many countries realize that and, in addition to promoting gender equity and equality, are promoting the entry of women into engineering, science and technology to address this situation.

Another constraint that then becomes apparent, especially in developing countries, is the need for better quantitative and qualitative information regarding women in engineering, science and technology. There is a particular need for improved sex-disaggregated data and associated gender analysis regarding women in science and technology in terms of primary, secondary and tertiary education, career choice, entry and professional development. Without this, educational and employment planners and policy makers cannot address the situation regarding the "leaky pipeline" of women into and within engineering, science and technology.

These issues are the focus of this paper. Particular reference is made to the SE Asia-Pacific region and the perspective, activities and prospects from UNESCO in gender, science and technology. There is specific reference to the development of UNESCO "Toolkits" of information and learning/teaching materials. The paper concludes with an emphasis on the need for co-operation and support from governments, national and international agencies.

Biographical Note

Tony Marjoram has been a Programme Specialist in the Engineering and Technology Division of UNESCO in Paris since October 1997. In this position he is responsible for the UNESCO UNISPAR programme in university-industry cooperation, aspects of solar and renewable energy, and the management of issues relating to women, engineering and technology. From 1993 to 1997 he was Programme Specialist in Engineering, Technology and Informatics at the UNESCO Regional Office for Science and Technology in SE Asia, based in Jakarta. Tony was the Dyason Senior Research Fellow specialising in technology for development at the University of Melbourne, Australia, from 1987 to 1993. Prior to this he was the Director of Technology at the Institute of Rural Development at the University of the South Pacific, where he worked extensively on issues related to women, technology and development.

GENDER, SCIENCE AND TECHNOLOGY:
PERSPECTIVES AND PROSPECTS FROM UNESCO

1.0 Gendered" knowledge

Science and technology are the development of knowledge regarding the natural and human worlds and the application of this knowledge. Engineering, science and technology are not distinct entities, but part of a related spectra of activity. Similarly, the "informal" system of indigenous and traditional knowledge and "formal" system of modern science and technology are alike, although the social relations of knowledge production and distribution have changed with the shift from community to state and corporate activity. The dominant world view of the late twentieth century is primarily constituted and provided science and technology. This, however, is accompanied by increasing concern regarding environmental, cultural and, more recently, the gender impact of S&T that have arisen since the 1960s.

The transition from traditional and indigenous knowledge to modern science and technology in the "age of reason" since the 17th century has lead to a more mechanistic and positivistic outlook, and the marginalisation of traditional and indigenous knowledge. Simultaneously, the marginalisation of women in science and technology has also taken place, and S&T have become increasingly dominated by men. This quantitative shift in the gender relations of S&T has been accompanied by a qualitative shift in scientific knowledge itself, which has become "gendered" (Harding, 1987; Wajcman, 1991). Science and technology, and scientists and technologists, are often perceived as "nerdy" or "geeky", characterised by a mechanistic, quantitative approach (distinct from a "female" approach focusing more on holistic, qualitative relations).

A gender dimension is also revealed in the way that men relate to technology as "toys for the boys" (Marjoram, 1990). While advertising for domestic appliances is directed at women, advertising for cars is directed at men. Most scientists and technologists are men, and the archetypal image of a scientist is a man in a white lab coat, which is also how most children draw scientists. The generally low participation rate of women in S&T around the world reflects the quantitative and qualitative shift in the gender relations of science and technology.

2.0 Differential Effects and Impacts

Science and technology also has differential effects and impacts upon men and women. These considerations raise such questions as "science by whom?", "science for whom?" and "science for what?" (Harding and McGregor, 1995). Women are the main users of many of the products of modern science and technology. Much of the advertising for household appliances (the "appliance of science") in such areas as domestic technology, for example, is directed at women. The primary users of technology in the office and light industry, particularly in textiles and small manufactured goods, are also women.

Women face many of the direct and indirect effects and impacts of scientific and technological change, leading to restructuring, de-skilling and re-skilling in their employment and domestic situations. While the load of housework, still largely the responsibility of women around the world, may be eased by domestic appliances, these are accompanied by increase financial burdens. Greater efficiency may follow technological change in the office, but so also may increased pressure and stress. In developing countries technology transfer and industrial development creates low-cost jobs mainly for women.

3.0 Science and technology in development

The importance of science and technology in development, especially the application of S&T and engineering, is generally acknowledged. Countries of the SE Asia Pacific region are particularly cognisant of the important role of engineering and technology in their past, present and future development.

At the same time, most countries around the world, and in the Asia-Pacific region, acknowledge a general shortage of human resources, especially in engineering and technology. In the United States, for example, there is a shortage of software and hardware computer engineers which is constraining development of the computer industry, and urgent need to develop or access expertise in these areas. Various initiatives have been attempted to promote human resources development in engineering, science and technology.

Many countries also acknowledge the under-representation of women in science and, particularly, in engineering and technology. Girls are less exposed than boys to science and technology, and fewer girls and women stay in with science subjects at secondary level. Fewer women go into S&T subjects at tertiary education. This picture is slowly changing, to the extent that in some countries girls are surpassing boys in secondary science and are better at teamwork in S&T. The entry and participation of women in the "formal system" of modern science and technology around the world remains low, however.

4.0 Women in science and technology – the "Leaky Pipeline"

Modern S&T present a "chilly climate" and "leaky pipeline" for women (Harding and McGregor, 1995). Despite efforts to counter this situation, women continue to face a "glass ceiling" regarding professional and career opportunities and development. The visible and invisible barriers that constitute the "leaky pipeline" relate to the entry into and professional development within science and technology of women begins with the toys given to boys and girls, continues in the home and the primary, secondary and tertiary education system, into employment. Women then run into "glass ceilings" in the workplace and laboratory, in the S&T professions and in S&T management, decision-making and policy formulation (Harding and McGregor, 1995).

Boys and girls have different socialisation regarding science and technology. Fewer girls are interested in science and technology in primary and secondary education and fewer go on to study S&T at tertiary level, where the leakage continues. Although the percentage of women entering S&T courses at universities has increased, reflecting policy interventions to promote this, it appears that an increasing number of women subsequently transfer out "hard-core" science, technology and engineering subjects into "softer" areas such as the biological sciences. Further leakage occurs in the workplace and professions, where further visible and invisible barriers and "glass ceilings" are encountered by women. Of those that enter S&T and related professions, many drop out to have a family and choose not or are unable to reenter work. Of the women that go into science and technology, only a trickle make it into S&T management, decision-making and policy formulation.

4.1 Re-plumbing the pipeline

Although the situation is improving, further gender-relations and perceptual changes are required to enhance the flow of women into and within the pipeline of S&T. The participation of women in science and technology, the gendered perception of S&T and the effects and impacts of S&T on women are interconnected. Questions regarding the gendered perception of S&T and the effects and impacts of S&T on women should be addressed to promote the participation of women in science and technology.

Attention to promote a less "gendered" image and perception of S&T includes an emphasis on increased gender awareness regarding S&T in childhood socialisation, primary and secondary education. At tertiary level attention is required to enhance the curriculum and presentation of S&T to facilitate the entry, retention and participation of women, particularly in the "hard" sciences, technology and engineering.

The entry, participation and professional advancement of women in S&T will be promoted by an enhanced gender image of S&T and removal of visible and invisible barriers and "glass ceilings". Actions to promote gender equity and the improvement of the environment regarding recruitment, training and development, retention, promotion and career development, equal pay and working conditions for women in S&T include, for example, the development and application of tools, strategies, policy interventions and legislation. Support for re-entry into the workforce and career continuity regarding maternity and child care would help overcome the second level "mommy track" for lawyer-mothers in the US. Professional associations should support this process. Although much of the required perceptual shift regarding women, science and technology mirrors broader attitudes toward women subject to generational change, policy initiatives will facilitate this process.

To promote understanding and actions relating to the "leaky pipeline" there is a particular need for improved sex disaggregated data and gender analysis regarding the participation of women in science and technology, especially in developing countries. As Harding and McGregor observe - "no data, no visibility; no visibility, no priority" (Harding and McGregor, 1995). Interest in this area is increasing, in conjunction with such regional bodies as APEC.

5.0 International Activity in Gender, Science and Technology

5.1 The Gender Working Group of the UN Commission on Science and Technology for Development

The Gender Working Group of the UN Commission on Science and Technology for Development (UNCSTD, which later became the UNCSTD Gender Advisory Board) was convened from 1993 to 1995. The goal of the Gender Working Group was to make recommendations regarding gender, science and technology for country actions at the national level and to the UN Economic and Social Council (ECOSOC) regarding reforms within the UN.

The Gender Working Group, with the assistance of UNIFEM, produced a review of UN agency activities in the field of gender, science and technology (UNIFEM, 1994). While many agencies had a commitment to gender, and others to science and technology, the review found that there is a lack of emphasis on gender, science and technology, that issues relating to gender, science and technology in UN agencies have not been integrated into agency activities and that cooperation between UN agencies and NGOs in gender, S&T is weak. The review also found that activities regarding women, science and technology were conventional, with little emphasis on the promotion of women in S&T.

A second study to review UN agency commitments and initiatives regarding gender, S&T was commissioned by the Gender Working Group (UNIFEM, 1994). The study recommended that the UN should review policy to include gender, S&T, prioritise the recruitment of women into S&T positions, incorporate gender analysis into project and programme activities and evaluation, and strengthen interagency and NGO cooperation in gender, S&T. In a further study, the Gender Working Group reported that rural development projects generally benefited men more than women (UNCSTD, 1995a).

In their final report, the Gender Working Group noted that key issues in gender, science and technology related to gender inequity in education and careers in S&T and the gender specific nature of development and technological change (UNCSTD, 1995b). The Gender Working Group proposed a series of seven Transformative Actions:

- gender equity in S&T education,
- removal of obstacles to women to careers in S&T,
- make S&T more responsive to the needs of society,
- make S&T decision-making more gender aware,
- S&T should relate better to local knowledge systems,
- ethical and gender issues should be better addressed by S&T,
- improve gender-disaggregated data for S&T policy makers.

To address the above key findings at the national level, the Gender Working Group formulated a Declaration of Intent, which identified six goals to promote gender equity in S&T:

- ensure basic education for all,
- equal opportunity to advanced training and professional development,
- gender equity in S&T institutions,
- gender equity in organisation and application of S&T,
- gender equity in access to S&T information,

- recognition of local knowledge systems.

The proposed Transformative Actions and Declaration of Intent of the Gender Working Group report were endorsed by ECOSOC. All governments were invited to subscribe to the Declaration and establish ad hoc committees to formulate national action plans for the implementation of the Declaration.

5.2 Fourth World Conference on Women

The "Fourth World Conference on Women, Action for Equality, Development and Peace", was held in Beijing in September 1995, together with an NGO Forum. The Beijing Conference produced a Declaration and Platform for Action - a policy document endorsed by UN member states to promote the advancement of women. While there is no specific section on science and technology in the Platform, the document contains numerous references to gender, S&T (see UNIFEM "yellow book" analysis). The NGO Forum featured a pavilion organised by the Once and Future Network (OFAN), a network of over 40 international NGOs active in the field of gender, science and technology.

6.0 Gender, Science and Technology at UNESCO

UNESCO publishes the “World Science Report” and the 1996 edition of the report had a special section on “The Gender Dimension of Science and Technology” (UNESCO World Science Report 1996). This section was presented by the Director General of UNESCO at the Fourth World Conference on Women, Action for Equality, Development and Peace, held in Beijing in 1995.

UNESCO is active in the field of women and gender, engineering, science and technology mainly through the Science Sector and the Unit for the Status of Women and Gender Equality (WGE). The Data Collection and Analysis Section of the Division of Statistics are responsible for statistics and indicators, with a focus on education. Activities are organised from UNESCO headquarters in Paris and from field offices around the world. Two important international meetings in this area are the World Conference on Higher Education, to be held in Paris from 5-9 October 1998, and the World Science Conference, to be held in Budapest from 26 June – 1 July 1999.

At UNESCO headquarters, Science Sector activities are undertaken in the basic sciences, engineering and technology, environmental sciences, hydrology and the Man and the Biosphere Programme. The overall emphasis is to improve women's access to scientific and technological education, training and careers.

In the Science Sector a focus of interest is the special project on “Women, Science and Technology”. This project promotes research into women in S&T and activity to promote women in S&T. Specific activities include international and national workshops and meetings, the development of international and regional partnerships and the award of prizes to promote women in S&T. Prizes include the Kalinga, Javed Husain, Carlos J. Finlay and Héléna Rubinstein awards for women scientists. The Héléna Rubinstein foundation, for example, presents four awards worth $20,000 every 2 years to women from four different regions who have made their mark in the fundamental and applied sciences. Partners in this activity include OECD, TWOWS, GASAT and ICSU. The Unit for the Status of Women and Gender Equality also awards the Marie Curie medal in honour of Marie Sklodowska Curie (for the work of Marie Sklodowska Curie, see Pnina Abir-Am, World Science Report).

The 1999 World Science Conference in Budapest will present an opportunity to address the continuing marginalisation of women in scientific careers and of women's perspectives in the formulation of science policies. Prior to the Conference the special project, "Women, Science and Technology" will organise several regional meetings in Africa, Latin America and Asia to consolidate women's collective initiatives (for the special project, see UNESCO Women, Science and Technology).

In engineering and technology, activity to promote women and gender issues is included in the three main programme areas of solar and renewable energy, university-industry cooperation and engineering education. The World Solar Programme, 1996-2005, supports a women and gender dimension in research, development and implementation of activities in the promotion of renewable energy sources, especially solar energy.

As part of the activity to promote university-industry cooperation, a new initiative focuses on combined information, learning and teaching materials in the form of UNESCO Toolkits in Women, Engineering and Technology. Three Toolkits are planned in the areas of "Gender, Science and Technology", "Gender-Disaggregated Data for Engineering and Technology" and "Women and Small-Scale Technology". The outline contents of each UNESCO Toolkit are as follows (see appendix 1 for further information):

- Introduction
- Background Issues
- Policy, Planning and Strategy for Action
- Practical Activities
- Case Studies - Success Stories, Lessons Learnt and Best Practice
- Follow-through: Monitoring, Evaluation and Bench marking
- Further Resources and Reference Materials
- Contacts and Links

In environment and sustainable development, UNESCO offers fellowships to young women scientists within the framework of its four major intergovernmental programmes: Man and the Biosphere (MAB), the International Hydrological Programme (IHP), the International Geological Correlation Programme (IGCP) and the Intergovernmental Oceanographic Commission (IOC). UNESCO also provides opportunities for young women to access specific scientific fields of study such as marine science, ecology, geology, biology and hydrology. UNESCO's geology programme, which covers 140 countries, supports women scientists as project leaders.

The Hydrology Programme works with women to develop and improve the water resources of their communities. This programme has a pilot project on "Women and Water Resources Supply and Use". Launched in 1996 through a series of regional workshops and national case studies, this project aims at improving the quality of life of women and their communities by facilitating women's participation in water resources management. The project also encourages and facilitates the formulation of regional and national policies in collaboration with other international organisations (UNESCO Hydrology).

The Man and the Biosphere Programme (MAB) strengthens women's capacities in the conservation and development of Biosphere Reserves in the he Women and Biosphere Reserves Management project. In the Mananara Biosphere Reserve, Madagascar, the South-South/MAB financed a project for the construction of a "house" for the women of the reserve that functions as a meeting hall for women's associations, a training centre and a handicrafts exhibition place (UNESCO MAB). Similar activities are being developed in the context of the Coastal and Small Islands (CSI) programme.

The Data Collection and Analysis Section of the Division of Statistics has a particular interest in gender-disaggregated statistics and indicators relating mainly to education, but including science and technology in the educational sphere, in such areas as technical and vocational education. Particular publications of interest include training material for workshops on education statistics and indicators designed to sensitise producers and users of statistics in education to the importance of gender sensitivity, clarify concepts, methods and techniques and offer practical guidance regarding gender disaggregated statistics (UNESCO Gender Sensitive Statistics).

The work and methodology of the Data Collection and Analysis Section of the Division of Statistics in the field of education, science and technology is discussed by Westholm (Westholm 1998). This links to other international activity carried out by organisations such as OECD (see the Frascati Manual, Oslo Manual, Canberra Manual; refer to Westholm 1998), the World Bank, APEC and ASEAN.

It is interesting to note that the development of statistics and indicators at UNESCO will be promoted by the proposal for a "UNESCO Institute of Statistics". It is to be hoped that this proposed institute would also promote the development of gender disaggregated data in engineering, science and technology.

7.0 Gender, Science and Technology in Southeast Asia and the Pacific

Gender, science and technology has not been a particular focus of attention in SE Asia and the Pacific. An international symposium on the participation of women in S&T development and transfer was held in Bangkok in 1992 (Approtech-WISE, 1992). In the area of gender, science, technology and change in SE Asia, a study on impact of computerisation on office workers (Ng and Munro-Kua, eds., 1994a) was followed by a workshop on "New Technologies and the Future of Women's Work in Asia" held in Kuala Lumpur in 1994 (Ng and Munro-Kua, eds., 1994b).

7.1 Regional Secretariat for Gender, Science and Technology in Southeast Asia and the Pacific

One particular activity in the SE Asia Pacific region that deserves mention is the establishment of the Regional Secretariat for Gender, Science and Technology in Southeast Asia and the Pacific, to be based in Jakarta, Indonesia. The Regional Secretariat will cover ASEAN (seven member countries at the approval of the proposal - Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam), plus the neighbouring countries of Australia, China, Fiji (for the Pacific islands), Japan, Republic of Korea, New Zealand and Papua New Guinea.

- As a follow-up to several major meetings on gender, science and technology in the region, this Regional Secretariat of the Gender Advisory Board of the UN Commission on Science and Technology for Development (UNCSTD)(UNCSTD 1995) is being established as a joint activity between UNESCO and the Indonesian Institute of Sciences (LIPI). Financial support is provided by the Netherlands Government. One goal of this Regional Secretariat is the development and promotion of gender disaggregated data in engineering, science and technology in the region (through the development of national and regional database of gender, science and technology). Other functions include:

- promoting the establishment of national committees or their equivalent in gender, science and technology;

- promoting regional cooperation through networking between national committees on gender, science and technology;

- facilitating and promoting the regional exchange of information and experience;

- promoting regional cooperation in studies on the differential impact of the rapid progress of science and technology and their application to development on women and men in a variety of sectors affecting the majority of women, especially in low-income groups.

Activities will include:

- consultation on the establishment of Focal Points or National Committees for Gender, Science and Technology;

- workshops to identify major programme areas to be undertaken by each country;
- training and workshops on information packaging and networking;
- exchange of information and experience on gender, science and technology;
- promotion and facilitation of the development of national and regional database of gender, science and technology.

This activity in the Southeast Asia Pacific region follows the "International Workshop on Women and Technology in Southeast Asia and the Pacific", coorganised by UNESCO and LIPI and held in Jakarta in January 1996 (UNESCO Jakarta 1996). Attended by over 70 women from eleven countries of SE Asia and the Pacific, this was the first international meeting on women and gender, S&T to follow Beijing. The three themes of the workshop were the participation of women in S&T, the development and application of technology to promote the advancement of women and the effects and impacts of scientific and technological change upon women. Conclusions and recommendations of the workshop relate mainly to strategic actions regarding the three themes of the workshop. The main recommendation of the workshop was the establishment of a Regional Secretariat for Gender, Science and Technology for SE Asia and the Pacific.

In view of the (then) upcoming APEC Summit in Manila in November 1996, this workshop also recommended the organisation of a meeting to promote issues relating to women and gender, S&T for the APEC Summit in Manila in November, 1996. To address this recommendation, a "Strategy Workshop on the Positioning of Gender, Science and Technology Issues for the November 1996 APEC Summit in Manila" was organised and held in Jakarta in March, 1996 (Strategy Workshop 1996). This workshop brought together over 20 participants from 7 economies of the region to present economy profiles and discuss strategic actions for the Manila summit to promote issues for the APEC Summit. The workshop endorsed the establishment of the Regional Secretariat for Gender, Science and Technology and associated network in SE Asia and the Pacific.

Following the recommendations of the strategy workshop the Network of Women Senior Leaders from the APEC Region held a conference on "Gender, Trade and Investment Liberalisation, and Economic and Technical Cooperation for Sustained Growth and Equitable Development" in Manila in October 1996 (Network Conference 1996). This conference was attended by nearly one hundred women leaders from the public and private sectors, academia and NGOs from the region. The conference was designed to introduce gender issues into the APEC Action Program and focussed on the three APEC themes of human resources development, industry, science and technology and small and medium enterprises. The conference proposed that APEC:

- develop policy dialogue regarding knowledge gaps and gender themes,
- identify and ameliorate negative impacts of change on women,
- promote sex-disaggregated databases and indicators,
- better integrate gender issues into policies, programs and projects,

- strengthen gender initiatives regarding the three APEC pillars of trade and investment liberalisation, facilitation and economic and technical cooperation.

The conference produced a "Call to Action" for APEC leaders to recognise and integrate gender as a cross-cutting theme in APEC, develop partnerships to identify mechanisms to achieve this and offered the women senior leaders network as a partner in the development of the APEC vision, goals and action agenda. The "Call to Action" also urged that the gender dimension be continued into APEC Summits being held in Canada in 1997, Malaysia in 1998 and Auckland in 1999. The "Call to Action" was received for presentation to the 1996 APEC summit by President Ramos.

Participants acknowledged the role of UNESCO in helping establish the Women Senior Leaders Network and looked forward to continued UNESCO participation in the network and its activities. UNESCO regards liaison with the network as important in the development of women and gender activities in the APEC region, and in the development of UNESCO cooperation with APEC. Several developments have arisen from the APEC Summit in Manila. These include an expert group meeting on the collection and gender-analysis of sex-disaggregated data and indicators in the region initially proposed to be held in Manila in October, 1997 (the present meeting). This activity connects well with existing initiatives of ASEAN and UNESCO.

7.2 Science and technology indicators in SE Asia

Activity to develop science and technology indicators in SE Asia has been developed by the ASEAN Secretariat, in conjunction with UNESCO. The first of a series of reports published by the ASEAN Secretariat under the ASEAN Medium Term Programme for Science and Technology. Priorities in this programme include the need to establish an ASEAN technology information network to link centres of excellence, universities, research and development institutions to share information relating to R&D, business development, technology transfer and R&D expertise. The main goal is to enable ASEAN member states to respond better to the changing R&D and technology-intensive business environment. The first step in the establishment of this network is the development by the ASEAN Committee on Science and Technology (COST) of the ASEAN Science and Technology Management Information System (ASTMIS). Activity carried out under the ASEAN ASTMIS project was funded under the ASEAN-UNDP ASP-5 programme, for which UNESCO acted as the main contractor to provide advisory consultant services.

The first major output of the ASTMIS project is the publication of the “Science and Technology Indicators in ASEAN” report (ASEAN 1997). This was the first systematic study and report on S&T indicators in the ASEAN region (Brunei Darussalam, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. The report reviews data on S&T indicators in selected ASEAN member countries (the study and report focused on Indonesia, Malaysia, Philippines, Singapore and Thailand – the study was conducted before the economic crisis in the SE Asia-Pacific region; Vietnam was not yet a member), provides an overview of the status of S&T in ASEAN, recommends procedures for the development of S&T indicators in the region and suggests possible new indicators.

ASEAN member countries have adopted different approaches and emphasised different types of S&T indicators in their national statistics. The data are limited, but permit some useful general observations regarding the state of scientific research and, to a lesser extent, technological development in the ASEAN region. The available data focus mainly on financial and human resources for R&D.

The report found significant differences in S&T systems, strengths and priorities in ASEAN member countries, in such areas as basic science and engineering, agricultural sciences, medical and health sciences, social sciences and humanities. Much of the variation in the pattern of R&D in ASEAN member countries is explained by their stage of industrial development. Most ASEAN countries remain very dependent on foreign technology, mainly from Japan, Europe and North America.

The report noted that, although national S&T systems are generally small in international terms, there was a very high growth rate in national R&D expenditures (GERD) in some countries, particularly in Singapore and the Philippines, where it exceeds 20%. National R&D expenditures in all ASEAN member countries grew substantially faster than the OECD average in recent years, similar to the fastest growing OECD countries. Private sector R&D expenditure is also growing strongly at around 20% per annum in ASEAN (albeit from a small base in some ASEAN countries), compared to the OECD average of 4% per annum. Public and private sector R&D focused on the agriculture and food industries, with most business R&D expenditure focusing on high technology industries.

The report concluded that quantitative S&T indicators are important in monitoring national and ASEAN strategies for S&T, assisting in priority-setting and Bench marking with other countries. The report made several recommendations, the most important being the need to develop S&T indicators, standardise definitions and classifications and extend coverage of S&T systems, especially of human resources and the technological capacity and performance of industry. Further general suggestions and recommendations by the present author included the need for the increased disaggregation of data relating to women and gender, S&T and the usefulness of bench marking in the SE Asia Pacific region to include comparative data for other countries of the region.

8.0 Concluding Remarks

The overall goal of activity and initiatives in gender, science and technology is to promote consideration of gender issues and participation of women in science and technology – to warm the chilly climate and repair the leaky pipeline to create a more conducive environment. Promotion of the participation of women in S&T should include support regarding the recruitment, training and development, retention, promotion and career development, re-entry and equal conditions for women in S&T.

Expanded activity regarding the definition, standardisation, collection and gender analysis of sex-disaggregated data is urgently required. Such activity would benefit from increased co-operation between and support from organisations such as UNESCO, the World Bank, OECD, APEC, EC/EU and other international and regional organisations, multilateral and bilateral donors, governmental agencies and NGOs. It should be hoped, for example, that the proposed UNESCO Institute of Statistics would develop a particular interest in activity relating to the collection and gender analysis of sex-disaggregated data in engineering, science and technology.

The gender dimension regarding the effects and impacts of the introduction of new technology also requires further research and the development of a gender-aware approach to the study of S&T, as part of a greater awareness regarding the role of technology in development planning and projects. This would help overcome the constraint of "no data, no visibility; no visibility, no priority" for women in S&T. This would also help surmount visible and invisible barriers to women in S&T, develop a gender-aware approach to the study of S&T and hopefully make S&T more gender-aware.

The Regional Secretariat for Gender, Science and Technology in SE Asia and the Pacific, based in Jakarta, will serve an instrumental role in the development of the gender dimension in indigenous knowledge and modern science and technology in the SE Asia Pacific region. This Regional Secretariat should be supported to promote gender equity and the empowerment of women in S&T in the SE Asia Pacific region.

The recommendations and “Call to Action” of the Network of Women Senior Leaders from the APEC region conference on "Gender, Trade and Investment Liberalisation, and Economic and Technical Cooperation for Sustained Growth and Equitable Development" should also be followed-through and developed.

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APPENDIX 1

UNESCO TOOLKITS IN WOMEN, ENGINEERING AND TECHNOLOGY
UNESCO Toolkit on Gender, Science and Technology

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UNESCO Toolkit on Sex-Disaggregated Data for Engineering and Technology

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The Need for Objective and Subjective Indicators in Gender Statistics

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Abstract

Indicators of women's status and development have relied on simple census statistics. These indicators are affected by the economy's overall social development which often masks the extent of gender disparity within the economy. Objective statistics need to be put in context to assist meaningful interpretation and cross-cultural comparison of the data. Objective indicators are further limited in their ability to explain gender disparity related to subjective factors such as roles, attitudes, stereotypes and values. Statistics on these subjective factors and their trends would help to target socio-cultural roots of gender inequity. Relevant findings from the Baseline Survey on Equal Opportunity on the Basis of Gender in Hong Kong and other research studies are cited as examples of subjective indicators useful in understanding the participation rates of women and men in scientific and technological education and careers.

Biographical Note

Fanny Cheung is the first Chairperson appointed to head the newly established Equal Opportunities Commission in Hong Kong. She was trained as a psychologist with a B.A. from the University of California, Berkeley, and a Ph.D from the University of Minnesota. Prior to her appointment to the Equal Opportunities Commission in May, 1996, she was the Dean of the Faculty of Social Science and a professor in Psychology at the Chinese University of Hong Kong. She also founded the Gender Research Programme at the Chinese University in 1985. Ms. Cheung's research interests include gender roles, violence against women, personality assessment, and psychopathology. She has co-organized a number of international and regional conferences and workshops on psychology, mental health, and gender. She has authored/co-edited 7 academic books and manuals. and published over 80 journal articles book chapters, monographs. and conference proceedings internationally and locally.

THE NEED FOR OBJECTIVE AND SUBJECTIVE INDICATORS IN GENDER STATISTICS.

1. Objective Indicators

Common indicators of women's status have relied on simple census statistics which reflect the overall socio-economic development of the economy. Such indicators often include birth rate, infant mortality rate, maternity mortality rate, life expectancy, educational level, and labour force participation. These objective indicators are confounded by the socio-economic status of the economy and do not reveal gender disparity which resurfaces when resources are limited.

International reports comparing women's status have taken these objective indicators to establish the relative standing of countries. For example, the 20th Report of the Population Crisis Committee (1988) used indices in five areas:

1. Health - Percentage of female infants, mortality rate women of child-bearing age women, female life expectancy, and sex differential of life expectancy.
2. Marriage and Children - Adolescent marriage and fertility, contraception and number of sons and daughters, male/female ratio in loss of spouse.
3. Education - Enrolment in primary and secondary school, female teachers in secondary schools, enrolment in university, sex ratio in illiteracy.
4. Employment - Female labour force participation, self-employed women, professional women, male/female ratio in labour force participation.
5. Protection of Social Equality - Political and legal equality, economic equality, equality in marriage and family.

On the basis of these indices, Hong Kong ranked above average compared with other countries, and among the more favourable in Asia. Similarly, the United Nations Development Program's *Human Development Report* (1994) calculates the Human Development Index (HDI) of all nations on the basis of objective indicators like average life expectancy, adult literacy, years in school, and purchasing power. The overall index would rank Hong Kong as number 24 in the global comparison. However, if these indicators are adjusted by the male/female differential, then Hong Kong's ranking would be lowered to the 30th position. The HDI for women was 68% of that for men.

The use of these overall indicators often masks the disadvantages experienced by women. Economic development in Hong Kong in the past two decades has enabled both women and men to enjoy free and compulsory education for 9 years, better health care, and more employment opportunities. Despite these socio-economic conditions, women still lag behind in terms of earnings, political participation, and leadership positions. Without reference to gender disparity in these objective indicators, comparison between countries on the basis of indicators which are not disaggregated by sex may not reveal the actual status of women in those countries.

2. Descriptive Gender Disparity

Statistical data provides an objective description of the facts. It does not explain the reasons for the gender disparity or whether the differences constitute discrimination. Interpretation of statistical data needs to be put in context before cross-national as well as within-nation gender comparisons are made.

The 1991 Hong Kong census data (Census & Statistics Department, 1991) on adult population tertiary educational attainment by field of study, for example, may indicate the gendered segregation in higher education. It can be clearly demonstrated that there is an overwhelming male dominance in all fields of science an technology. The male/female ratio (female = 100) in construction, civil and structural engineering was 732; the ratio in electrical and electronic engineering was 714; that in mechanical, marine, production and industrial engineering was 615 (Table 1). In terms of occupational segregation, women are under represented in the administrative and managerial categories in which the male to female ratio in 1991 was around 4 to 1.

Likewise, women's wages were also found to be lower, even though the wage differential did decline from 1981 to 1991. The ratio of women's median wage relative to that of men in 1991 was 0.77. Compared to the ratio of 0.69 in 1981, this reflects an improvement in the earnings gap. On the other hand, in view of the important role of science and technology in future economic development, the disproportional gender distribution is going to pose greater disadvantage to women.

Without detailed analysis of the data and consideration of related contexts, these gross differences mask the underlying factors associated with the composition of the labour force (Westwood, Ngo Leung, 1997). For example, the gap is larger for those in the higher income categories, for those over the 35 age groups, and for married women. Single women at the beginning of their occupational path are relatively more competitive. Analysis of earnings ratio by number of years of working experience further shows that women with three years or less working experience tend to have the most favourable earnings ratios. These decline for women who stay longer in the labour market. (Mak & Chung, 1997).

This descriptive data suggests that family responsibility arising from marriage and fertility contributes to the unequal earnings between men and women. They may be corroborated by studies on division of domestic labour which show that irrespective of the occupational status of the wife, she still bears the major burden of household chores and emotional labour (Choi & Lee, 1977; Equal Opportunities Commission, 1997). However, objective indicators are not able to uncover the attitudinal aspects which underline the disparity. For example, men and employing organizations may argue that women are not the breadwinner of the family and their wages are considered supplementary (Cheung, Wan & Wan, 1994; Westwood et al., 1997).

Similarly, the descriptive figures on male dominance in science and technology do not explain why girls are not entering into these fields. Other research studies have pointed to the role of socialization, teacher bias, and gender stereotypes instead of aptitude or abilities (Cheung, Lai, Au, & Ngai, 1997). These subjective factors help us to understand the underlying issues in gender disparity and inequality in opportunities. However, the results of these studies are not reduced to indices which are selected to assess the status of women.

There is a need to incorporate these subjective factors in gender statistics.

3. The Need for Subjective Indicators

Multiple objective indicators involving gender comparison serve to describe the situation of women. These indicators do not necessarily reflect the attainment of gender equality for women. The status of women may deteriorate when there is an economic downturn, or when resources become limited. Discrimination may be hidden while women ride on the coattail of economic development, but becomes more apparent in times of retrenchment. For example, the fall in earnings ratio even for single women in Hong Kong in 1991 coincided with the contraction of the manufacturing sector and the process of economic restructuring (Mak & Chung, 1997). The underlying attitudes toward the secondary role of women's work surface in such times when it is often found that lower wages are offered to women than in boom times.

It may be argued at the same time that gender differences in the objective indicators are based on self-selection or choice rather than on discriminatory practices. For example, on the basis of objective data, it would be difficult to allege that the differential streaming of boys and girls into different subjects, and the under-representation of women in the field of science and technology are the result of discrimination. The gender differential has to be interpreted in the context of the pay structure of gender-segregated jobs, as well as the reasons for the gender segregation.

Studies in Hong Kong show that through formal and informal channels, children learn explicit gender roles in schools and are streamed in school subjects along gender lines (Cheung, Lai, Au, & Ngai, 1997). Biases in channelling by teachers and lack of role models may account for gender differences in subject preferences. The school practice of excluding girls from Design & Technology classes and boys from Domestic Science classes are justified by school administrators on scheduling convenience and tradition (Volk & Yip, November 1997).

A survey on secondary students' attitudes toward technology (Volk & Yip, November 1997) sheds more light on the subjective aspects of the gender segregation. The survey found that boys are more likely to have a computer at home, choose a technical profession, and have taken a technical subject in school. In terms of attitudes, boys have more interest in technology and being in a technological profession, are less likely to perceive technology as difficult, and have more positive views about the consequences of technology and the inclusion of technology in the school curriculum. These attitudes are associated with the students' experience of having taken a technical subject in school and their intention to choose a technological profession.

These studies are able to tell us more about the underlying reasons for gender differences and point to areas where changes may be directed.

3.1 Subjective Indicators Studies

Studies of subjective indicators should be conducted in addition to objective indicators to provide a more comprehensive picture on women's status. An example of such a study is the Baseline Survey of Equal Opportunities on the Basis of Gender in Hong Kong 1996-1997 (Equal Opportunities Commission, 1997). The aim of the survey is to establish baseline indicators reflecting equal opportunities and discrimination on the basis of gender, including subjective perceptions and objective indicators, and to develop a set of core indicators which will be useful for future comparison. The content areas covered in the survey include public perception of gender roles and stereotyping, access to education, inequality in the family and at the workplace, opportunities for community participation, and subjective experience of gender discrimination.

Some of the results of the Baseline Survey are relevant to access to equal opportunities in science and technology for girls. For example, it is found that gender stereotyping is still entrenched, especially in the media. Perception of feminine roles tends to be traditional and negative. In the area of education, a more encouraging outlook is noted. Respondents who are married and have children report that they spend about the same amount for boys and girls in education-related expenses. The female respondents have similar expectations in educational attainment as men; for the 16-24 age group, women even have a significantly higher educational expectation than men. However, women still perceive a slight parental prejudice against their education.

The development of core indicators in these content areas enables comparison among the indicators and trend analyses in later years. The Equal Opportunities Commission intends to conduct a similar survey every three years to gauge trends of social change. These indicators are preliminary and need to be further refined. In the long run, we should think in terms of internationally standardized methodologies to provide global comparisons on both objective and subjective indicators of the status of women.

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TABLE 1. Sex Ratio of Adult Population Tertiary Educational Attainment by Field of Study, 1991 Census

Field of Study	Ratio(female=100)
Arts, Fine Arts	88.0
Humanities and Social Science	103.0
Pure Mathematics and Natural Science	235.1
Teacher Training and Education	43.1
Accountancy and Secretarial Skills	65.0
ss Administration and Financial Management	125.2
Computer Studies	288.5
Medical and Health Related Studies	70.1
Architecture and Town Planning	477.6
Construction, Civil and Structural Engineering	732.3
nical, Marine, Production and Industrial Engineering	615.0
Electrical and Electronic Engineering	714.3
Textiles and Clothing Technology	133.9
n and Miscellaneous Industrial Technology	145.3
Law	227.5
Mass Communication and Documentation	78.0
Other Programmes	111.8

(Westwood et al., 1997, p.65)

Women in the Reformed New Zealand Science Environment

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Abstract

The size of the scientist occupational class in New Zealand is small and the management of science has undergone radical reform over the last decade. Human resource figures for Crown Research Institutes suggest that the size of the pool of scientists has increased and that women have increased their relative participation by a small margin. However, anecdotal remarks hint that women's perception of their situation in S&T careers is far from ideal. While employment conditions have become more flexible, the funding and conduct of research has become less flexible. The major reform has been a change to a science provider/funder split and contestable bidding to a set of defined national strategic objectives. Post-reform surveys suggest a profound effect on most scientists' morale and career paths. Anecdotal evidence points to a differential effect on women, resulting in problems with retention of qualified women within the science occupational area. Suggestions are made for obtaining alternative streams of information on career aspirations and actual experiences of women scientists already working within their chosen fields of endeavour.

Biographical Note

Ellen Förch trained as a marine biologist and worked for 10 years as a squid fisheries scientist. She was awarded a Winston Churchill Fellowship in 1988 and used this to further her international involvement in squid research. After the birth of her two children, she changed focus and concentrated on in bibliographic work. She became involved in a children's science museum while completing a further post-graduate qualification in Museum Studies. When her youngest child reached school age she took up full time work again as a Programme Manager in the New Zealand science funding agency, the Foundation for Research, Science and Technology. Subsequently she has worked as a Research Manager for the Open Polytechnic of New Zealand. More recently she has carried out science policy work for a variety of government and other agencies. She is currently Manager of Environmental Monitoring with the Hawkes Bay Regional Council, one of 12 New Zealand Regional Councils.

Women in the Reformed New Zealand Science Environment

Setting the Scene - the New Zealand Nation

The population of New Zealand is a little over 4 million. The size of the employed workforce is 1.69 million. This includes all full and part-time workers over the age of 15. Women constitute 44.6% of this workforce. Since 1991 the total number of jobs has increased, but part-time jobs have increased by more than the number of full-time jobs. In 1997 the Ministry of Research, Science and Technology (MoRST) published the most up to date figures relating to employment in the Research and Development sector in New Zealand. The figures are reproduced below. In the table, CRI refers to Crown Research Institutes, and FTE to full-time -equivalent.

Table 1: Full-time equivalent Research and Development (R&D) personnel, by occupation, and workplace 1995/96 (MoRST 1997)

Note: Universities not surveyed in 1996

Occupation	Gender	Business R&D FTE	CRI's R&D FTE	Government R&D FTE	Total R&D FTE
Researchers	M	1306	1035	112	2453
	F	274 (17%)	276 (21%)	74 (40%)	624 (20%)
	Total	1580	1311	187	3077
Technicians	M	549	869	53	1470
	F	274 (33%)	565 (39%)	31 (37%)	870 (37%)
	Total	823	1434	84	2341
Support Staff	M	207	410	19	636
	F	218 (51%)	499 (55%)	41 (69%)	758 (54%)
	Total	425	909	59	1394
All	M	2062	2313	184	4559
	F	766 (27%)	1341 (37%)	146 (44%)	2253 (33%)
	Total	**2828**	**3654**	**330**	**6812**

Women outnumber men in R&D support staff. This is not unexpected since women dominate the clerical and service occupations. Women are under-represented among technicians in business sectors relative to Crown Research Institutes. However, considering the overall numbers of women in the workforce (44%), and the lack of information on the size of the potential pool of recruits, the gender disparity is not a cause for serious concern. Nevertheless, as is shown in Table 3, the distribution of female technicians over different disciplines is very uneven also and this may be of concern.

When all women in R&D are considered together, they form 27.1% of those working in business R&D, 36.7% of Crown Research Institute workers, and 44.2% of R&D workers in Government Departments. These figures represent increases of 2.9%, 3.3% and 5.8% over equivalent figures for 1993/94. Note that women form only 20.3% of all researchers and women researchers are least well represented in business (17%), followed by Crown Research Institutes (21%) and Government sectors (40%). This paper focuses on the largest research sector with its relatively new structures, the nine Crown Research Institutes established in 1992 and the researcher category of their workforce.

A Brief History of Recent Science Reforms

For several decades prior to the late 1980's, the principal scientific research organization in New Zealand was the Government's Department of Scientific and Industrial Research (DSIR). This Department consisted of a number of Divisions, each operating largely independently of each other, and each largely free from close overall political direction. Investment in private R&D was low in New Zealand and links between DSIR and industry were variable in their frequency, responsiveness and effectiveness. Other Government departments also maintained research facilities - notably Ministry of Agriculture and Fisheries and the Ministry of Forests. University research was generally carried out part-time by teaching staff funded through the Education portfolio. Devine (1997) suggests that problems with the science structures of this period included:

I. a lack of accountability
II. a reluctance to ensure the transfer of advances to industry,
III. cumbersome bureaucratic structures and high management overheads
IV. difficulties with obtaining capital expenditure for equipment
V. isolation through lack of travel opportunities

In the late 1980's large cuts to science funding (around 30%) and reform of the entire Public Sector in New Zealand led to a large reduction in the numbers of permanent positions in science, improvements in financial reporting structures and the establishment of performance indicators.

After extensive debate and a series of investigations by Government Committees and Panels, a contestable science funding system was established in 1990. Funding was channelled through the Public Good Science Fund, administered by a separate, politically insulated entity, the Foundation for Research, Science and Technology (FoRST). FoRST was to contract for the provision of scientific and technological research to address national strategic directions and research priorities defined by Government. The levels of funding and areas of national priority were set out in a series of "Output Class" documents. In 1992, the majority of the former Government research capability was distributed over ten new state owned, but commercially independent, "Crown Research Institutes" (CRIs). These organisations had their own government-appointed boards of directors and could choose to operate in any business or research sphere, both nationally and internationally. The Public Good Science Fund (PGSF) was their "major client". Currently 55% - 73% of the CRI revenue is still obtained from the PGSF contestable pool of around NZ$300 million per annum (see Table 2). Government Departments and Ministries maintain a small number of in-house researchers primarily to inform policy development and regulation.

Procedures connected with allocating the Public Good Science Fund have continued to evolve. The funding has moved from an annual cycle, with some research programmes receiving up to three years funding, to a system where applications are received every two years and some programmes may receive up to 6 years funding. Allied funds have been developed to support post-doctoral research, graduates working in industry, the development of alliance between business and research institutions (Technology for Business Growth Scheme), and excellent and innovative research which is not necessarily aligned with defined national research priorities and for which an immediate application may not yet exist (Marsden Fund).

The new structures, administration and orientation of research were so completely different from previous practice that the move to them is best described as a “revolution” rather than “reform”. Scientists’ lives and research were dramatically affected by the changes. The changes occurred at the end of a decade of uncertainty, restructuring, job losses and large funding cuts. The impact on an already demoralised science workplace was dramatic and largely unwelcome.

Surveys and past information

Up till this point I have been discussing the general impact of the reforms on the scientists, both male and female. But what was the effect on women ? Information is available, in an oblique sense only, from a small number of surveys which have been carried out on the science community.

Some of the earlier surveys which form valuable comparative material for this paper did not have the benefit of a database of scientists, or a good directory of R&D researchers. Comparisons are hampered by the differing aims of the surveys and the lack of comparable questions. The primary purpose of the surveys, except for a 1988 DSIR survey, was not to illuminate gender related issues, but rather to gauge New Zealand science morale, professional experiences and working conditions, as well as attitudes to science management in the post-reform science environment.

Warren report

The only located report on women in Government science prior to the reforms is based on a 1988-87 survey of women working in DSIR (Department of Scientific and Industrial Research). Janet Warren’s report was based on returns from questionnaires sent to all 672 female staff in DSIR and to a random sample of 101 male staff. Interpreting the survey results in terms of the experience of women scientists is often difficult because of the frequent pooling of results over all women (including non-scientific support staff).

NZAS survey

A survey was carried out after the majority of the science reforms by a science professional body, the New Zealand Association of Scientists (NZAS). The authors of this report (Berridge *et al*. 1995) recognized the limitations caused by the lack of a database of scientists and did the best they could under the circumstances. Their survey provides a snapshot of attitudes and opinions on the science reforms held by scientists in mid 1994. The authors noted that the survey was concluded just as the national budget signalled an end to funding cuts for science, and that the extent of demoralization identified in the survey did not reflect an improving situation. Responses were analysed for gender effects, although the questions were not specifically designed to elucidate any effects of the reforms on women.

The demographics of the NZAS survey respondents were similar to those receiving science funding i.e. younger and less experienced scientists were under-represented. Robinson(1997) commented that the actual age classes in CRI's probably reflect the redundancies that have occurred and the recruitment of young post-doctoral labour. Most redundancies occurred prior to transitions from Government Departments to CRI's. Since there was no suitable database of scientists at that time, the survey was conducted in three stages:

1. NZAS membership (334)
2. random questionnaires to members of Professional Societies generated from Royal Society lists
3. "Primary Production Group" scientists (1229)

The survey was circulated to 2569 scientists and 837 replies were received. Duplication and some non-active scientists were eliminated, reducing the number of responses to 713. Males formed 84% of the sample. These respondents were separated into CRI, University and "other" categories of science workplace. Berridge *et al*. (1995) estimated the size of the pool of scientists at about 4000.

Sommer Report (Jack and Diane Sommer 1997)

A database of scientists had been compiled by the Ministry of Research Science and Technology by the time the Royal Society and the Fulbright Program engaged Dr Jack Sommer to conduct a survey of New Zealand scientists and technologists. The Sommers' findings are based on a sample of 576 usable replies to 998 questionnaires. The questionnaires were sent to:

II. 1 in 5 sample of 2900 non CRI researchers (53.6% or 310 returned)
III. 1 in 4 sample of 1341 CRI researchers (73.5% response or 247)
IV. Separate 1 in 5 of NZAS members for comparison with earlier survey (67% of 300)

Socio-demographic characteristics of the population sampled for the Sommer report

The size of the total pool of scientists identified was around 4241, and it was estimated that fewer than 5% were likely to be missing from the population sampled. The qualifications of those sampled encompassed PhD MS, MD's, with about 80% of respondents holding a PhD or equivalent. Compared with other nations, respondents with post-doctoral fellowship experience are not numerous at 41.1% , with only 19.9% having held a post for 1 year, and 14% for 2 or 3 years. The largest grouping of respondents were employed in CRIs (43.6%) followed by Universities (38.7%). Of the survey respondents, 77.2% were male, and 22.8 % were female. Personal incomes were highest in mathematics, computer science and health sciences. Two-thirds of respondents with qualifications in biology, physics and earth sciences had lower personal incomes at under NZ$60 thousand. Average female incomes were less than those of males. The females were younger, which accounted for some of the income disparity identified. Also slightly less than half of females (47.7%) had worked in New Zealand for less than 10 years (compared with 28% for males).

Table 2 sets out staff sizes and total revenues of the remaining nine CRIs. The amount of research carried out in CRI's tends to be low in earth sciences, engineering, and social research, which are all strongly supported in New Zealand universities. Public health and medical research is a separate sector and funded by a separate agency (Health Research

Council). While the Sommers' report encompassed 9 CRI's, 6 Universities and several Research Boards, the present paper concentrates on the results recorded from CRI's, in order to examine that particular working environment for scientists.

Table 2: Crown Research Institutes staff and revenue 1996/97

1996/97	Abbreviation	Area of Research	Total staff	Total Revenue NZ$ million
NZ Pastoral Agriculture Institute	AgResearch	Pastoral, farming, animal health and breeding	900	88.3
National Institute of Water & Atmosphere	NIWA	Climate, marine, freshwater, fisheries	592	58.9
Horticulture & Food Research Institute	Hort	Horticulture	529	48.8
Forest Research Institute	FRI	Forestry, wood research	520	37.7
Landcare Research	LCR	Ecology, botany, biodiversity, soils	409	33.9
NZ Institute for Crop & Food Research	CRF	Crops, harvesting and Food technology	380	27.5
Industrial Research Ltd.	IRL	Engineering, physics, mathematics, industrial technology	373	41.9
Institute of Environmental Science & Research	ESR	Forensic, analytical chemistry, environmental research	360	26.4
Institute of Geological and Nuclear Sciences	GNS	Geology, earth sciences, nuclear sciences	260	24.5

Table 3: 1998 Figures for CRI's: Numbers and/or percentages of scientific staff who are women

Organization (refer Table 2)	Scientists %	Technicians %	PI /Programme Leaders - numbers	Objective leaders numbers	Trend in recent numbers of women	women as % of recent science appointments
AHD (part of AgResearch)	26%	55%	0	0	increasing	
NIWA	15%	21%	3/60 =5%	15 = 10%	All staff increasing 18% (1992) - 30% (1996)	30% scientists 51% of technicians
Hort	22.7%	47.5%	5 = 7%	27 = 15%	slight increase	
FRI	26/129 = 20.1%	92/125 = 73.6%	1+1 co-leader = 1.5%	10 = 8%	Women scientific staff were 50% (1993) - 64% (1997)	
LCR	13.4%	50.4%	8/55= 14%	16/163 = 10%	Senior women scientists increasing 11(1992) - 24 (1997)	40%
CRF	34%	66%	5/36 = 13.8%	N/A	N/A	37% (science)
IRL	9%	2%	1/46 = 2.2%	5/150 (3.3%) +6 equivalent positions = 7.3%	increasing	0-1%
ESR	not supplied					
GNS	2 + 6 post-docs	approx. 40-50%	(1) 0/42	2	possibly increasing	

How Has the Science Environment Changed for Women ?

When the size of the pool of women scientists in the CRIs is around 276 full-time equivalents (FTEs), spread over different institutions and disciplines, are any generalizations possible ? What have been the changes since 1988? What is the current environment for women scientists in CRIs?

Promotion and Career paths

There have been increases in the total number of all women staff employed in R&D. The DSIR employed 672 women in 1988, while the CRI's employed 1341 women in 1995/96.

Warren (1988) reports that scientists were promoted according to years of service, but that women and men with similar years of service were promoted at different rates. Warren suggested that there was gender discrimination, "For instance for the 7 women who had been employed as scientists in DSIR without broken service for more than 25 years, only one had been promoted beyond the 05 level. However, the large majority of male scientists with similar years of service has been promoted beyond this level. Almost a quarter has been promoted beyond the level of the highest graded woman."

Warren (1988) identified that requests for re-grading for promotion by females occurred less frequently than for males. Half of the males had requested re-grading, but less than one quarter of females had requested a re-grading. Interestingly, the re-grading success rate was about half for both male and female.

In DSIR, in 1988, a progression from technician to scientist or to management represented a change in occupational class and was a significant route for promotion. These changes were not frequent for females, with all female DSIR scientists starting as scientists, already armed with the appropriate qualifications. However, 8 men had managed the transition. In DSIR, while most women were interested or possibly interested in management positions, only 40% expected to be successful, 25% expected not to be successful, and the others were unwilling to predict the outcome. Men were less interested, but of those that were, only a small number did not expect to be successful.

This has changed. The CRI's all claim to promote on merit, not years of service. Most CRI's collect statistics on the distribution by gender over salary bands and some also collect information on the speed of promotion. With present day practices based on merit, it is considerably harder to demonstrate differences in treatment based on gender alone. The Sommers' report did not specifically address this area, although related questions showed little difference in perception between males and females. The current CRI practices vary between institutions, but promotion has not been raised as a problem during discussions with human resource (HR) managers or senior women scientists.

Changes in Employment

There have been significant changes to employment conditions and related policies since DSIR days. Most are not specifically targeted at women. Now that progression is based on performance rather than tenure, this change should begin to benefit the larger number of younger women. Equal Employment Opportunities (EEO) policies have been developed at all CRI's and although many have no special provisions for women, work flexibility has increased considerably. Joint employment with another organization, flexible working hours, or working from home are now possible. Glide time around core hours, maternity leave (without pay), sick leave to care for family, holiday programmes for school age children, and crèches or arrangements to assist with child care are now a normal part of the employment options for CRI staff . The advent of the Employment Contracts Act has meant that individual contracts can be negotiated with an employer, and obviously, the more in demand a particular scientist's skills are, the more likely they are to be able to negotiate a contract to their advantage.

Many examples of innovative and unusual working arrangements were mentioned during my conversations with Chief Executive Officers (CEOs) and HR managers. But all is not well, for despite changes in attitude, there are still some anecdotal reports of bullying, with affected women choosing to leave. Exit interviews do not reveal the problems as women tend to be positive in order to keep future options open. The level in the organization at which responsibility for EEO issues rests has not really been assessed. The impression I have gained is that it remains part of the plans at HR and Corporate level.

Discrimination and harassment

Discrimination and harassment were found to be an issue by Warren in 1986/87. 29% of women (173) thought they had been treated unfairly. The concerns were sexual harassment, occupational class status, and age. Warren recorded anecdotal instances such as a woman scientist told by female clerical staff that "women shouldn't be scientists - they take jobs from men" and male colleagues who referred to her as "a girl" in front of visiting scientists.

The NZAS survey for 93/94 noted that discrimination was identified in all groups in order of decreasing frequency, based on: age= gender> ethnicity= union affiliation> sexual orientation> political affiliation> religious affiliation. The NZAS survey records that 23% of all respondents had noticed discrimination on basis of gender (27% in Universities and 18% in CRI's) and 24% had noticed significant incidents of age discrimination. However, when female respondents were analysed separately, 49% had noted discrimination on the basis of gender (Berridge *et. al*. p.10). This is the single most significant difference between gender groups in the entire survey and did not evoke any further comment by the authors. It should be a cause for much more concern when nearly half the women scientist respondents have noted discrimination on the basis of gender.

However, in 1998, overtly discouraging remarks and obstruction seem to have largely disappeared from the managerial and cultural climate of CRI's. None of the senior women I have spoken to found it necessary to mention such actions or experiences. However, one CRI with increasing numbers of young qualified females in a previously exclusively male domain has mentioned an increase in sexual harassment complaints. The difference may be that legal complaint procedures have been developed over the last 5 years, and form an accepted part of employment in NZ.

Sommer concluded that "CRIs encouragement of women is less than for universities". This conclusion was reached because of the response to a question worded "Special efforts should be made to attract women into undergraduate science, maths and engineering studies". Differences emerged by field, age and gender. More women agreed with the statement (61.4% compared with 49.8% of men) and universities were more in favour (56.5%) than CRI scientists (46.1%). An alternative interpretation might be that low morale and a negative perception of job prospects may have influenced the response, rather than CRIs being less encouraging of women *per se*.

Affirmative action is not supported by most CRIs, with HR managers citing the discriminatory effect on other staff.

Staff support for science

In the Sommers' report, staff support for science is another area where male and female scientists seem to differ. Fewer than 10% of all respondents agree that the staff support for the conduct of science has increased, while 60% say that staff support has not increased. The level of disagreement increases with age, but overall, only 3.9% of women agreed compared to 11.4% of men. Given the skewed age distribution for women, this difference becomes even more significant. It is tempting to conclude that more of routine work falls to women and fewer support structures are available to women.

Job Security

A series of workshops held by the NZAS to discuss the results of the 1993/94 survey identified widespread job dissatisfaction as a result of the perceived destruction of career structure, lack of accountability by managers and boards, and the treatment of research as a commodity. These issues were explored in greater depth by the Sommers' report. Differences emerged in age response and institutional response, but few clear-cut differences emerged based solely on gender. Sommer (1997) also identified that CRI's are less optimistic about recommending a career in sciences, but men and women equally so.

The NZAS survey (Berridge *et al* 1995) gauged that overall job satisfaction had decreased over the years from 1989 - 94, and disproportionately so in CRIs . 76% of researchers in universities felt that their jobs were secure compared with only 36% in CRI's. The CRIs find it difficult to offer job security when the institutional funding is largely obtained through a contestable forum. Some areas of activity which are poorly supported by external funding need to be subsidised by the CRI . If the programme or staff member continue to fail to gain funding then initially the programme, and eventually the researcher, will need to be cut. Despite this commercial risk, the number of scientists has increased since 1992. The Sommers' report identified a gender difference in response to the problem of interruptions to science funding. These were identified as a major issue by 16.6% of men and 22.7% of women.

Tony Robinson (1995) was moved to suggest that, "There seems very little incentive at the moment for science graduates to enter a career in research. The 10-15 year opportunity cost, high level of creativity and specialisation required, and the low pay in their early years as a scientist can no longer be traded off for career security."

General Morale

Sommer identified the 5 major issues facing New Zealand scientists in 1996 as:
II Bureaucratic accountability management and red tape (CRI 27.7%, universities 13.5%)
III. Interruptions in research funding (men 16.6 %) (women 22.7%)
IV. Lack of public understanding of science and technology (14.4%)
V. Emphasis on funding applied research over basic research (11.8%)
VI. Over-politicization of research (8.8%)

On the subject of scientific discovery and serendipity - fewer women than men believe that scientific discovery is more a result of insight and circumstance than textbook methodological treatment (82.4% men versus 67.3% women). Sommer did not ask the questions that would have identified whether this difference in attitude is a result of a different type of science activity carried out by women. One of the largest employers of senior women scientists has suggested that they tend to make a name for themselves in areas requiring exacting manipulative work, complexity and extreme attention to detail i.e. hard work rather than serendipity ?

All scientists' support for the science reforms is low in both the NZAS and Sommers' surveys. All HR managers who responded believed that there was no differential effect of the science reforms on men as opposed to women. However, none analysed or kept figures on exit interviews or reasons for leaving the institutions. Anecdotal information does suggest differences in impact.

Differential effect of the science reforms

Given the prevailing climate of low morale amongst scientists, are equivalent responses to the reforms available to men and women? I believe that this is a question which deserves further investigation.

Conversations with senior scientists have raised anecdotal information which suggests that different choices are being made by women. A lot of women are feeling under extreme pressure in the now highly competitive environment. They do not wish to openly compete with their own workplace colleagues. Some are saying, "I don't need this" and opting to spend more time with family. Some women are choosing alternative careers e.g. environmental law, public relations. Some have turned down an offer of leadership because they do not wish to take on the additional stress and responsibility. It was raised in discussion that some women are in the fortunate position of having more choices than men. They are often not the sole breadwinner and often are more able to take up alternative careers and activities.

It is inevitable that the surveys have the shortcoming of only questioning those who remain in science and are able to respond to the questionnaires! In addition, since the focus of the surveys was not women in science, none of the questions identified the reasons for gender differences in response. What can be stated is that: women were more unhappy with the Government setting research agendas, more unhappy with interrupted research funding, and had experienced more gender discrimination. The appropriateness of the role of government in setting the "research agenda" roused strong feelings in women (with only 23% approving as compared with 40.6% of males).

Many of the general issues were more pronounced in the CRI's where the largest intake of new, younger scientists and women has occurred. Another demographic effect of the science reforms mentioned by a CEO is the pressure on older scientists (often men) to maintain their funding. This in turn creates difficulties for less experienced scientists (including relatively more young women) trying to break into funding. Men have larger research budgets to control than women, but again Sommer explains this as a result of gender age distribution. The Sommer survey established that a significantly greater proportion of men than women have served as principal investigators on PGSF grants (48.9% versus 29.5% of respondents). It would be interesting to see these figures adjusted to take account of age distribution, or perhaps more correctly, years of experience.

My own observations of the contestable funding system suggest that because of the skewing to younger ages for women scientists, women will be a disproportionately affected by CRI bidding practices. The contracted research situation carries no responsibility to nurture young scientists and no responsibility to encourage intellectual growth, risk and challenge in scientists relatively inexperienced in a particular area of research. This relates both to "new" scientists, but also to "new" research, and leads to stifling of innovation. The bureaucratic process of bid evaluation incorporates rigid views of "experience", "track record" and "ability to lead".

Since the bids are the lifeline for the CRIs, they have little alternative but to align themselves with the expectations of their major client and hence reduce their commercial risk. Some CRI managers have admitted that their Principal Investigators are proposed because of their high profile and superior track record, but that in reality the actual leadership and management of the research may fall to others with better skills in that area. In some cases these have been senior women scientists.

Funding experience

The relative success of women in attaining senior positions, as measured by becoming Principal Investigators (PIs) or objective leaders on PGSF bids, forms a convenient common measure across all CRIs. (Refer to Table 3). There are large differences in participation of women scientists and in the size of the pool within each CRI. Unfortunately, when broken down to this level, the number of women Principal Investigators becomes so small that each success or failure becomes an anecdote. It is also at this level that it is important to remember that these science leaders may not share any characteristics that necessarily relate to their gender (i.e. gender is not a significant attribute) and any attempt to generalize is unsupportable (see Gilbert 1996).

Figures from the Foundation for Research Science and Technology

- Women PIs in 1993 = 7.16%, 1996 = 9.5%
- Women comprise 11.4% of objective leaders
- There are 8 contracts held by women from the Private R&D sector
- Funding success of women led applications =59.8%, men led programmes = 69.7%
- Women led programmes are concentrated in: "Society and Culture"; Horticulture, Arable and other Food and Beverage"; Land and Freshwater Ecosystems"
- Universities have a higher % of women led programmes (20%) as compared with the CRIs (6.8%)
- Women have gained 31% of the post-doctoral fellowships
- The FoRST referee database has 10.5% women

Peer Review process needs more analysis

The NZ scientist in general is critical of the FoRST peer review process. Shortcomings mentioned are the small pool, competitive environment, and risk of loss of intellectual property and innovation. The Sommers' survey stated that "Women are very slightly more likely to agree than men to agree that peer review works well as it is, but scientists 45 yrs and over are more critical and only 5.8% supported assertion". 18.7% of Sommer respondents said that reviews are marred by cronyism, old boys networks and insider politics. Situations which engender these types of statements usually disadvantage women - however, this was not the perception of NZ women respondents in mid 1996. This is in sharp contrast with figures presented by Robinson (1995) for Australian scientists where "women were half as likely as men to agree that peer review works well as it is, and scientists in the 30 to 39 year old age group (where most of the women scientists were found) are especially critical of the procedure".

My own perception of reviewers comments on PGSF bids during my time as a programme manager at FoRST did not alert me to any differences in relation to gender. Rather, all younger or less "conventionally" qualified scientists were likely to be questioned and come in for greater scrutiny. All scientists venturing out of past areas of experience were stripped of their credibility and it was clear that overseas "big names" lent weight to programmes. During my campus visits, scientists raised issues which indicated general anxiety and dissatisfaction rather than gender based discrimination.

One CRI with a significant number of women-led programmes had not detected any recent evidence of discriminatory reviews and indeed had obtained some exemplary reviews. By way of contrast, another CRI had detected qualitatively different and harsher reviewer comments on all women acting as programme or objective leaders. This may be the result of the prevailing scientific cultures surrounding a particular discipline, but the assertions certainly deserve to be thoroughly investigated. The difference in reviewer comments related to issues of "ability to lead", "track record", "skills and experience". Men of similar or lesser experience and skill in those fields did not attract equivalent comments.

Figures from the PGSF for the funding success of women-led as opposed to male-led programmes differ (women 59.8% versus men 69.7% for the last funding round), but do not seem obviously discriminatory. There are senior women scientists on all of the PGSF Advisory Committees who could be expected to act as watch-dogs if such practice was occurring. Regardless of overall statistics, the effect of a perceived injustice or discrimination at this level appears to be devastating to senior women's morale and confidence. They feel that they have done everything they can, but their ability is still being questioned. The CRI concerned consequently appears to be facing a retention problem with women scientists, with some opting to leave science altogether.

Women in alternative roles

Human resource managers were asked to identify any special areas where women might be making a larger contribution, but none were identified by them. Nevertheless, anecdotal information suggests that there are stronger pressures on women to contribute in certain non-core activity areas. Discussions at a NZ Association of Women in Science Conference (1996), conversations with senior women scientists and conversations with senior male science managers mentioned certain expectations. "Any woman with a half decent personality is pushed in front of a camera and has to deal with the media". It was suggested that it is easier for a women to enter and progress in some "soft" areas than in the "hard sciences" e.g. policy, public relations, science editing, education, and high public appeal research. This was thought to be OK for some, but intensely frustrating for those who wished to progress in a particular scientific field.

Some "non-core" areas of scientific activity are not well supported by the PGSF. These include: international participation, national and international facilitation roles, technology transfer, client and user liaison, popular publications, educational and science promotional activities. These are all considered as overheads and charged against funding for science "outputs". Researchers (including women) operating in these areas are not likely to gain status, seniority or funding by doing so.

Women scientists and childbearing

The Warren report on DSIR women in 1988 (pre-Privacy Act) established that 31% of women have responsibility for children, rising to 65% of those between 35 and 44 years of age. Women in the sample tended to have small families. Most part-timers were responsible for children. 88 women (22% of respondents) indicated that they had delayed or decided against having children because of the effect on their careers. Of those, 40% were science technicians, 30% were scientists, and 17% executive or clerical workers. Only 2 males had indicated delay. 60% of women with responsibility for children considered it had affected their careers, 82% negatively. Only 27% of men with responsibility for children said it had affected their careers; 57% positively and 43% negatively.

The Privacy Act means that HR managers do not collect or disseminate information on employee's families. However, senior women scientists seemed very aware of who in their organization had children and who did not. Anecdotal evidence was that child-bearing had a serious impact on women's science careers, and that the majority of successful senior women scientists are childless. In one CRI 5 senior (married) women of childbearing age had chosen to remain childless, and in another only 2 out of 10 senior women had children. The highest proportion of senior women with children attained in any CRI was half of 10 objective leaders. Anecdotal information from CRIs suggests that senior women scientists have either delayed childbearing, entered their profession later in life (after coping with a young family) or avoided the full impact of family responsibility in some other way e.g. divorce without full child custody.

A survey by the Zoology Department of Otago University tried to identify why the proportion of students successfully completing a degree who were women declined as the level of degree increased from BSc to MSc to PhD. The interesting finding was that although there were a significant number of women academics on the staff, none of these women had children and so they consequently failed as role models in the eyes of younger women. These women academics did not have a lifestyle with which the female students could identify.

Statistics desired by HR managers

Statistics that interest HR managers revolve around the size of the present and historic recruitment pool. Their interest in existing staff experience and success did not come through strongly. Particular information needs mentioned were figures on:

II. number of women qualifying in relevant scientific disciplines
III. establishing whether the low numbers of women in senior positions has been driven by limited numbers with post-graduate qualifications and "experience suitable for senior positions"
IV. since senior scientists are at least 30-35 yrs old - what was the historic participation of girls 20 yrs ago
V. establishing whether, with equivalent length of service and qualifications, and all other things being equal, men are still paid more than women
VI. what have been the number of interruptions in careers for males and females, and after accounting for these, are women still under-represented in senior ranks ?

It was disappointing that CRI Human Resource managers appeared more interested in the recruitment into careers than in the retention and satisfaction of employees. Perhaps this is understandable, since recruitment statistics are easier to benchmark and measure performance against. None mentioned the surveys referred to in this paper nor any national statistics that have been collected on tertiary qualifications.

Summary and Recommendations

Although the participation of women in science has increased substantially over the last 10 years, there still appear to be serious obstacles to gaining senior positions. Removal of the cultural and structural barriers to progression, and enhancement of legal redress for discriminatory practices, has not solved all the inequities. With an increased number of younger women in NZ science, the challenge is to ensure that they are retained within their chosen profession and progress according to their skills and experience. Because in some fields their numbers are still very low, there is a responsibility on their employers to ensure that each individual woman's working environment is not a qualitatively different one from that of their male colleagues. This may require reaching beyond the conventional HR statistics to :

II. Investigate the effect of women's social responsibilities on their careers through alternative means
III. Collect information from departing scientists anonymously by a third party in order identify any gender based reasons or differential retention problems
IV. Obtain more qualitative information from in-depth interviews or focus groups to support

the NZ Government RS&T 2010 document which recommends gauging the morale of NZ scientists. One option would be to repeat the Sommers' report questions at regular intervals.

V. tailor questions in surveys so that they elucidate gender issues rather than just establishing a gender difference in response

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BEYOND STATISTICS

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ABSTRACT

Thailand has set up a National Committee on Human Resource Development in Science and technology to address the serious shortage of scientists and engineers, especially in the government/public sector. Several measures have been initiated, including national education reform. However, gender issues have yet to be integrated into policy formulation and planning. Statistics, based on limited study in 1995, revealed a somewhat gender-balanced workforce, including fellowships, within the Ministry of Science, Technology and Energy. The total female/male (F/M) ratios was reported to be 48/52, while at the senior level the F/M ration was 41/59, and 46/54 for fellowship students.

Analytical assessments indicated that women fared better in written competitive selection while men fared better when selection was based on interviews, including through consultative evaluations. Further detailed study revealed that certain key criteria favourable to men include credibility, visibility, leadership, personality, communication/presentation and vision. These findings indicate that career and staff development policy and programs must take into consideration gender difference in areas of potential, relevant training and development needs, as well as in working environment and support services. Unless gender-differentiated training and development needs are understood and appreciated, full human resource potential cannot be achieved. A shift of emphasis from "quantity" participation to ***quality participation*** *is necessary and much needed in the knowledge-based economies of APEC.*

BEYOND STATISTICS

1.0 INTRODUCTION

The growing participation and representation of women in economic development is one of the most remarkable developments in the APEC region, including particularly in Thailand. Women networking and information technology are among the key contributing factors to the increasing awareness of women's potential in addressing people- and environment-friendly economic cooperation. However, it has neither been satisfactorily proven nor recognized that a country's level of economic development is a reliable indicator of women's active participation in the national workforce, let alone of women's equal sharing of benefits. This is especially true in countries where statistics are not properly collected, analysed and interpreted. In the Asia-Pacific economic cooperation, it took more than nine years (from 1989 to 1998) for gender dimension to be formally integrated into the APEC process.

It is therefore very timely that the present meeting be organized as part of the efforts to effectively integrate, and illustrate, women's participation in, and contribution to, the development of the APEC's economies, individually as well as the APEC region as a whole.

2.0 Gender Dimension in Thailand's National Development:

2.1 A Brief Overview

Thai women have been and still are expected to be actively involved in economic and social activities in the development of the nation, as well as in fulfilling roles as wives and mothers within a supported extended family structure. As Thailand developed, especially during the past few decades, Thai women maintained that important economic role.

On average, sixty-seven per cent of Thai women actively participate in the workforce, ranking among the highest group in the Asia-Pacific region, and making up 47 per cent of the national workforce. In Thailand, women are particularly concentrated in agriculture and in industries such as electronics, textile and clothing and food which have been in the driving forces behind national development.

However, unbalanced development and achievement of benefits among men and women are not uncommon at the present time, especially at the lowered of the employment hierarchy. This occurs despite the full recognition of women in the constitution, and legislation which requires equal opportunity and equal pay. In urban areas, female manufacturing workers receive approximately 77 per cent of the wage of their male counterparts and 60 per cent in the service sector. In agriculture the difference is less drastic (but with low wages for both sexes), with women workers receiving 84 per cent of the male wage. As expected, Thai women do carry the double burden of housework, estimated to be, on the average, about 1600 working hours more per year than the men.

2.2 Statistics and Gender Issues

Since 1975, the year in which the United Nations held its first international women's conference, Thailand has formally launched a series of "women development" programs which has helped to strengthen Thai women's capacity and potential. These are based mainly on the concept of women being a disadvantaged group and playing traditional roles as wives and mothers first and supporting economic roles second. As such, no- or very little - attention has been given to the issue of **gender** relations, the role of men and women, at home and in the workplace. On this issue, it should also be noted that the word "gender" has no equivalent word in the Thai language, making it more difficult to communicate the subject effectively.

There is a need to be aware of, understand and, eventually, appreciate the gender issues in development policy formulation and planning involving girls' education. Likewise there is a need for supporting statistics and appropriate analytical tools. This can be exemplified by an example from the 1980s. Statistics indicated that the ratio of girls and boys at the primary and secondary school level of education were approximately 50/50 and 38/62, respectively. Analysts and planners in the Ministry of Education, which oversees national education below the level of university, concluded that girls were not encouraged to continue with higher education due to traditional beliefs. Later, however, when the statistics on the women/men ratio of university students were shown to be almost 1/1, more detailed investigation revealed that the reason for lower enrollment of girls in secondary schools was due to the long distances of most secondary schools from villages, while there Is a primary school in almost every village. There was also a lack of dormitories for girls, while boys could live-in at temples. "Gender" analytical findings indicated the need for appropriate policy on living accommodation for girls and boys.

3.0 Gender Dimension of Science and Technology Development:

3.1 A Brief Overview

Other than some inclusions in the national statistics, the gender dimension of the science and technology sector is relatively new in Thailand. We are still at a very early stage in the gender integration process in science and technology development. As generally recognized, one needs to be aware of new "knowledge", to be able to understand and, finally, to learn to appreciate the potential utilization of that knowledge before one can expect any change to be affected.

We are just beginning to be aware of women's contributions to science and technology development, especially in the public/government sector. This is partly due to the critical brain drain of the S&T manpower from the public sector to the private sector, especially during the past decade. As a result, the Ministry of Science, Technology and Environment decided to set up a National Committee on Human Resources Development in science and technology which is chaired by the Deputy Prime Minister. As part of this effort, sex-disaggregated data has recently been collected, initially, in the Ministry and later in other sectors including the private sector. Some of this data is included in this paper as appendices.

The 1996 data indicated that of the almost 3,500 total staff members of the Ministry, the male to female ratio was 108:100. At the senior levels, top 4 levels from division directors up, the ratio was 143:100. Future trends, based on statistics and numbers, point to a somewhat positive direction in terms of the proportion of women at these senior levels, including S&T policy makers. However, recent promotions did not follow such positive trend in favouring the promotion of women administrative officers in line for promotions. Instead, senior male officials from outside the departments were selected, indicating the need for critical analysis and study **beyond statistics** in such cases.

4.0 Critical Analysis Beyond Statistics: A Case Study from Thailand

The authors have undertaken a critical rapid study/assessment of these cases. Admittedly, this has some limitations. The study reveals some very interesting indicative findings that include factors of gender differentiation and preference in career development and training needs, such as

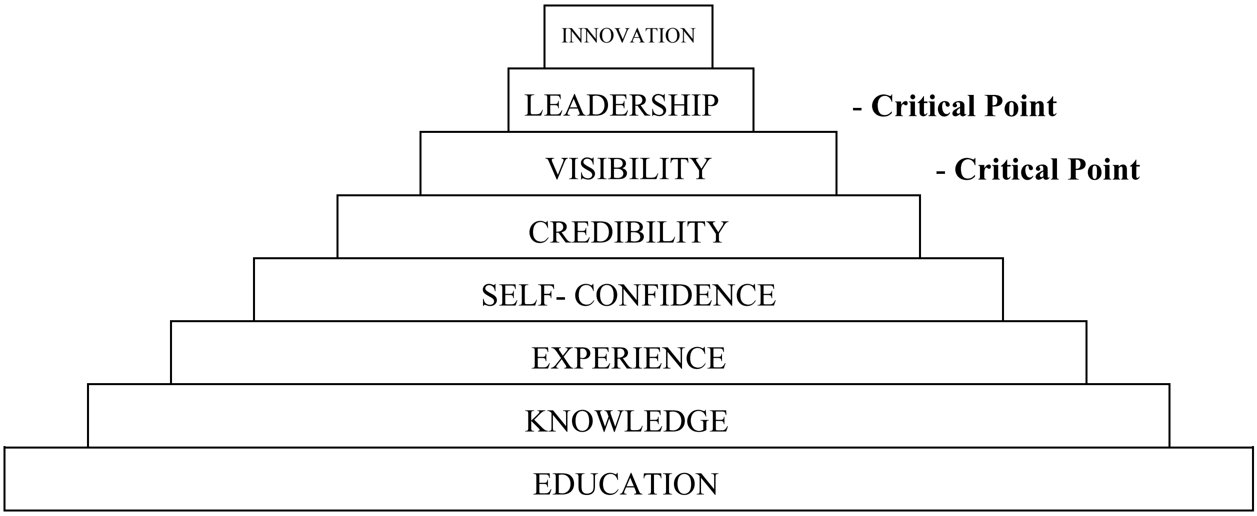
- Women in science and technology in Thailand need to be more visible in public. They also need more training in public speaking and leadership development.
- Women in science and technology could excel in research and development management, commercialization of technology and in science and technology policy formulation which facilitate upward mobility in industrial science and technology development.
- In these cases, it seems that it may be necessary to provide more options in career development, as well as to actively encourage and motivate women scientific and technological workers to explore new career path options.

It therefore appears that women's equality and critical mass in participation alone may not be enough. **In brief, there is a need to shift the focus from quantity participation to quality participation.**

Key qualitative criteria to be taken into consideration include knowledge and experience gained during employment, capability to build up self-confidence and credibility, image, increased visibility and leadership and, for industrial science and technology, innovative thinking and vision.

The above criteria are seen as some of the key contributing factors to upward mobility of women in science and technology. They are summarized in the following diagram:

Figure 1. GENDER DIFFERENTIATION IN UPWARD MOBILITY



5.0 Concluding Remarks

In Thailand, there is a growing trend toward female leadership, but a large number of women are still seen to be relatively timid and passive. This is partly due to language deficiency. However, leadership and effective presentation/communication can be developed and should be actively promoted.

Finally, in pursuing a more balanced leadership role for both women and men, it is essential to continue to maintain family- and society-sensitive female values and thoughts into the integration process of national and APEC regional cooperation.

TABLE 1: Number of MOSTEs Officials classified by Agencies and Sex in 1996
(Unit: person)

AGENCIES	MEN		WOMEN		TOTAL	Proportion of Men : Women
	No.	%	No.	%		
1. Office of the Secretary to the Minister	3	37.50	5	62.50	8	60:100
2. Office of the Permanent Secretary	35	44.30	44	55.70	79	80:100
3. Pollution Control Department	24	52.17	22	47.83	46	109:100
4. Department of Energy Development and Promotion	201	77.01	60	22.99	261	335:100
5. Department of Science Service	48	31.58	104	68.42	152	46:100
6. Office of the National Research Council of Thailand	41	30.60	93	69.40	134	44:100
7. Department of Environmental Quality Promotion	14	34.15	27	65.85	41	52:100
8. Office of Environmental Policy and Planning	46	42.20	63	57.80	109	73:100
9. Office of Atomic Energy for Peace	68	53.97	58	46.03	126	117:100
10. Thailand Institute of Scientific and Technological Research	100	57.47	74	42.53	174	135:100
11. National Science and Technology Development Agency	83	57.24	62	42.76	145	134:100
12. National Science Museum						just established
13. Waste Water Management Authority						just established
14. National Synchrotron Research Centre						just established
TOTAL	663	52	612	48	1275	108:100

Source: Office of Policy and Planning, Ministry of Science, Technology and Environment, September, 1996

women2

TABLE 2. Proportion of Women S&T Personnel of MOSTE in 1996 (Unit: person)

AGENCIES	Junior Officers			Senior Officers			GTOTAL			Men : Women
	M	W	Total	M	W	Total	M	W	GTotal	
1. Office of the Secretary to the Minister	3	4	7	-	1	1	3	5	8	60:100
2. Office of the Permanent Secretary	25	39	64	10	5	15	35	44	79	80:100
3. Pollution Control Department	16	20	36	8	2	10	24	22	46	109:100
4. Department of Energy Development and Promotion	184	58	242	17	2	19	201	60	261	335:100
5. Department of Science Service	41	91	132	7	13	20	48	104	152	46:100
6. Office of the National Research Council of Thailand	34	83	117	7	10	17	41	93	134	44:100
7. Department of Environmental Quality Promotion	10	26	36	4	1	5	14	27	41	52:100
8. Office of Environmental Policy and Planning	38	56	94	8	7	15	46	63	109	73:100
9. Office of Atomic Energy for Peace	49	47	96	19	11	30	68	58	126	117:100
10. Thailand Institute of Scientific and Technological Research	64	32	96	36	42	78	100	74	174	135:100
11. National Science and Technology Development Agency	57	56	113	26	6	32	83	62	145	135:100
12. National Science Museum										just established
13. Waste Water Management Authority										just established
14. National Synchrotron Research Centre										just established
TOTAL	521	512	1,033	142	100	242	663	612	1,275	108:100

Source: Office of Policy and Planning, Ministry of Science, Technology and Environment, September, 1996

TABLE 3. MOSTE's Senior Executives Classified by Level and Sex, 1996.

Unit: person

AGENCIES	LEVEL 11			LEVEL 10			LEVEL 9			LEVEL 8			GTOTAL			Proportion of Men : Women
	M	W	T	M	W	T	M	W	T	M	W	T	M	W	GT	
1. Office of the Secretary to the Minister			0			0			0		1	1	0	1	1	0:100
2. Office of the Permanent Secretary	1		1	2	1	3	2		2	6	4	10	11	5	16	220:100
3. Pollution Control Department			0	1		1	2		2	4	2	6	7	2	9	350:100
4. Department of Energy Development and Promotion			0	1		1	3		3	9	4	13	13	4	17	325:100
5. Department of Science Service			0	1		1		3	3	3	4	7	4	7	11	57:100
6. Office of the National Research Council of Thailand			0	1		1		2	2	5	5	10	6	7	13	86:100
7. Department of Environmental Quality Promotion			0	1		1	1		1	2	2	4	4	2	6	200:100
8. Office of Environmental Policy and Planning			0	1		1	3		3	4	8	12	8	8	16	100:100
9. Office of Atomic Energy for Peace			0	1		1	2		2	8	4	12	11	4	15	275:100
10. Thailand Institute of Scientific and Technological Research			0	1		1		4	4	32	30	62	33	34	67	97:100
11. National Science and Technology Development Agency			0	1		1	1	1	2	24	6	30	26	7	33	371:100
12. National Science Museum			0			0			0			0	0	0	0	just established
13. Waste Water Management Authority			0			0			0			0	0	0	0	just established
14. National Synchrotron Research Centre			0			0			0			0	0	0	0	just established
TOTAL	1	0	1	11	1	12	14	10	24	97	70	167	123	81	204	152:100

Source: Office of Policy and Planning, Ministry of Science, Technology and Environment, September, 1996

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Table 4. Number of MOSTE's S&T Scholarship Students Studying Abroad, 1990-1996

(Unit: persons)

PHASE / **GENDER**	**MEN**	**%**	**WOMEN**	**%**	**TOTAL**	**Proportion of Men : women**
PHASE I (1990 - 1995)	430	54.50	359	45.50	789	120:100
PHASE II (1996 -)	131	54.81	108	45.19	239	121:100
TOTAL	131	54.57	467	45.43	1028	120:100

Source: National Metal and Materials Technology Centre, Sept. 96

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Table 5. Proportion of Civil Servants Classified by Ministry and Sex

MINISTRY	Proportion of Men : Women
1. Office of the Prime Ministry	108 : 100
2. Ministry of Finance	135 : 100
3. Ministry of Foreign Affairs	152 : 100
4. Ministry of Agriculture and Co-operatives	269 : 100
5. Ministry of Transport and Communications	267 : 100
6. Ministry of Commerce	86 : 100
7. Ministry of Interior	235 : 100
8. Ministry of Justice	67 : 100
9. Ministry of Science, Technology and Environment	108 : 100
10. Ministry of Education	73 : 100
11. Ministry of Public Health	38 : 100
12. Ministry of Industry	174 : 100
13. Ministry of University Affairs	54 : 100
14. Ministry of Labour and Social Welfare	67 : 100
15. Ministry of Independent Public Agencies	87 : 100
TOTAL	128 : 100

Source: Women and Development, 1992: A Canadian International Development Agency Project managed by IRA Consulting Group Inc., Toronto, Canada

INCREASING THE PARTICIPATION OF WOMEN IN SCIENCE AND ENGINEERING RESEARCH

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Abstract

The Task Force on Women in Science and Engineering was established in 1995. Its mandate was to advise the Natural Sciences and Engineering Research Council (NSERC) of Canada on how to create an environment which facilitates and encourages greater participation of women in science and engineering research in Canada. To that end, the task force, first studied the background and context which would explain the low participation of women in these fields, in general, and proceeded to examine each of the Council's policies for potential gender bias. This was followed by a study of success rate for women and for men for each of NSERC's programs: scholarships, fellowships, awards, medals, and grants. A review of NSERC's Women's Faculty Award Program, the gender ratio on selection and standing committees, and on NSERC Council was done. Twenty-one recommendations were made covering all these aspects. New endeavours were suggested for women with young babies going to conferences, and for women having a baby during the tenure of an NSERC Scholarship for graduate studies. The great majority of these recommendations have already been implemented by NSERC in 1996/97.

Biographical Note

Monique Frize has a dual academic appointment as professor at Ottawa University and Carleton University in the Department of Systems and Computer Engineering. She worked as a clinical engineer for 18 years, initially at Hospital Notre-Dame in Montreal, and then as Director of the Regional Clinical Engineering Service in Moncton, New Brunswick, providing services for seven hospitals in the South-Eastern region. Dr. Frize was also Research Associate in the Faculty of Science and Engineering at University de Moncton and was the first Chair of the Division of Clinical Engineering for the International Federation of Medical and Biological Engineering. In December, 1989, she was appointed the first holder of the Nortel-NSERC Women in Engineering Chair at the University of New Brunswick. In 1995, she received the Second Historical Professional Achievement Award (jointly with Michael Shaffer) from the American College of Clinical Engineers, for her paper: "Clinical Engineering in today's hospital: Perspectives of the Administrator and the Clinical Engineer"

INCREASING THE PARTICIPATION OF WOMEN IN SCIENCE AND ENGINEERING RESEARCH

Background

To address gender issues at the research level, in Science and Engineering, it is essential to first examine the factors that contribute to limiting women's participation in the pool of researchers in these fields. In the engineering undergraduate programs in Canada, the enrollment of women has increased steadily at a rate of one percent per year, over the past decade, reaching a national average of just under 20 percent in 1995. The enrollment is slightly higher in computer science and in physics. However, this is far from the progress achieved in Faculties of Law, Medicine, Dentistry, and Veterinary Medicine, which have reached gender balance for some time. In Engineering, women are clustered in a few disciplines such as chemical, industrial, and environmental engineering, and their enrollment in mechanical, computer , and electrical engineering is currently half the national average (9-12 percent). Many of the well-paying jobs today are in these fields. Why is this message not getting through to young women, but quite clearly getting through to young men?

One factor contributing to the low interest of girls in the high tech sector arises from looking at the interaction of girls and boys with computers. A recent study of children of professionals and business persons in Nigeria shows that boys play substantially more than girls with computers (Ulomata, 1996) and both girls and boys agree that computer games to date have been mainly designed for boys: action, violence, adventures, all heroes are male characters, female characters are victims to be saved by male heroes. A few new games use violent female characters, but obviously that doesn't solve the problem! Girls say the games are not interesting because the characters are boring, that is, no story can be woven around them. Arcades and computer clubs are mostly frequented by boys.

According to David and Myra Sadker, in their book "Failing at Fairness" (1994), schools in America have provided much better opportunities for boys than for girls, except in single-sex schools for girls. Boys receive more attention, stimulation, and positive feedback on their participation. Girls are often rewarded for neatness and good behaviour. In a report entitled "Gender Socialization, New Ways, New World", Coulter (1993) describes how sexist attitudes and behaviours occur at home and at school from birth to adolescence. Many of the sexist attitudes are so ingrained, they have often become unconscious and unnoticed. The report includes advice for parents and teachers on how these practices can be eliminated.

Out-of-school science and engineering promotion activities can be used to peak the interest of young girls in science, mathematics, engineering and technology. However, to date, many of these programs have had a more positive impact on boys than on girls (Vickers et al., 1995). This study in British Columbia shows that the program which had the strongest impact on girls was a single-sex program called "Girls in Science". However, two other single-sex programs did not rate as well. In the mixed gender programs, boys responded more strongly than girls to: summer science and engineering camps, industrial tours, a high school camp for high achieving students (Shad Valley), and 'Science Olympics', a competitive science activity. Girls responded more positively than boys to public lectures, but equally to open houses and to presentations in schools by role models. This study shows how important it is to assess how the structure, content, and gender composition of the activities affects both sexes. Special efforts must be made to ensure that as many girls as boys participate and that activities and approaches must be interesting for both girls and boys. A gender-balanced participation can be supported by a policy and a well-designed marketing strategy.

Research reports different views as to whether boys have a natural tendency towards mathematics and science (the biological theory), or whether they are more stimulated and encouraged towards these disciplines (the socialization theory). A recent article in the Globe and Mail (November 3) stated that in Ontario (Canada), girls are doing better than boys in the mathematics provincial exams (by at least four percentage points) in several grades. However, in this study, 58 % of the boys believed they were good at math, while 46 percent of the girls thought they were. This shows boys to be 'over-confident' and girls to be 'under-confident' with respect to their abilities in mathematics. Building a positive self-esteem in girls will continue to improve their performance and true abilities and make them more confident to take-on studies that have been to date tagged as 'male domains'. As the number of young women entering in these fields grows, this may become a 'natural career choice'. Making women more visible and profiling their successes and achievements will help to build the image that women who choose these fields can do well.

Another factor that may affect the choice of a discipline is the attraction that women have for the life and health sciences; women represent half of the students in biology, in medicine, and over 90 percent in nursing. Associating the problem-solving aspect of engineering to subjects in the life sciences, and showing the human aspects and applications of these fields will help to redefine the image of what engineers and scientists do, and will succeed in attracting more young women to these careers.

Solutions to reach a gender balance in all of the disciplines are numerous. We need to destroy the stereotypes attached to some of the disciplines, particularly for electrical and mechanical engineering, by inviting women studying and/or working in these fields to talk about their work and choice of career to young students in school. This must start early, in elementary school. In secondary school, it is important to encourage students to keep their options open by selecting all the mathematics and science courses that they can, especially physics, chemistry, and advanced mathematics; it is also essential to have all boys and all girls take both home economics and technology/shop courses. This will help the students in two ways: opening avenues for entering high tech careers, and teaching them how to perform household chores and parenting duties.

Presentations should also be made to groups of parents, teachers, and guidance counselors, to engage their help in encouraging young women to consider all the opportunities, especially in the well-paid high tech sector. The importance of achieving economic independence and on choosing a partner as carefully as their career should be the other messages given to young people. There are many unfilled jobs in that sector of the economy and countries who encourage women to become knowledge-workers will do better than those who cannot meet the demand.

In the Workplace

Is the workplace a hospitable and equitable environment for women who have become engineers and scientists? This depends very much on who you work for. First, let's look at why women say they leave the engineering profession. Van Beers (1996), in a study of forty engineers (half women and men) in the Vancouver area, found that the reasons most often cited by women for leaving the profession were: The work ethic being too rigid and the lack of flexible work options; the existence of the 'old-boys' network; harassment; and not feeling a part of the decision-making process. The solution to these problems are well-known: Creating an atmosphere of openness in the way that business is carried-out, and eliminating back-room politics and hidden agendas from meetings where important decisions are being made; instituting fair hiring and promotion policies, and enforcing them; flexible work options will allow young parents to better balance their work and their time with family. To eliminate sexual harassment from the workplace, it is essential to provide education on what it is, and on how the firm will be dealing with cases that occur. Support from the top and training of all employees will go a long way in reducing this problem (Frize, 1995).

As for parental leave, this can be planned well in advance and creates much less disruption than sudden medical accidents. Women are usually quite healthy when expecting a baby and can stay connected with the office, from time to time during the leave, through communication technologies. It is now less unusual to see men take a parental leave once the infant is born. A recent survey by l'Ordre des ingenieurs du Quebec shows that 21 percent of men took a parental leave (personal communication). This was shorter than the one taken by women, but it is a positive change and a more equitable sharing of parental responsibilities. Felice Schwartz (1992), in her book *Breaking with Tradition,* compared the pattern of leaves of absence from work for women and men in the workplace in the USA, in 1962 and again in 1992. Schwartz shows that in 1992 both sexes opted for part-time work for a similar number of years: for women, this was taken during their mid-years; for men, towards the end of their career. She found that women often delay having children until their career is established. For the firm, retaining an employee (woman or man) who is fully trained is an asset to the company. In the UK, several case studies show that companies saved substantial sums of money by reducing turnover of their human resources (DTI, 1995) through providing more flexible work options.

Women in Science and Engineering Research

How many women have continued their studies to the doctorate, obtained a faculty position, and are doing research in these fields? Are women treated fairly? Do they stay and are they happy with their career and their life? Answers exist to the first two questions, but little research has yet been done on the last point.

The field of biology has the highest proportion of women completing a doctorate and, according to Sonnert and Holton (1996) in their large US study, it is the only field (in science and engineering) where women have achieved a comparable level of career success as men. In the other fields (chemistry, physics, mathematics, and engineering), the authors state that the 'glass ceiling' is real; that is, discrimination favours men's career advancement, even though both women and men selected for the study were all high achieving scholars. In all fields, there is a serious falling proportion of women choosing to complete higher degrees just starting out in their career. One major reason for this appears to be the belief that it is impossible to balance a family and work in academe or in a research career. The image of a single-minded individual pursuing ‘his’ work at the expense of everything else is still how people see researchers and scientists, and the criteria of excellence applied to recognizing such work reflect the reality of the image. This may partly explain why few women choose this avenue.

Are women treated fairly? A recent article examining the question of fairness in grants and post-doctoral awards in Sweden concluded that women are not treated fairly. The authors showed that men were over-rated; women were under-rated and needed 2.5 times more evidence of productivity than men to get an equivalent rating for a fellowship. The study shows that in a five-year period, women needed three more publications than men in journals like Science or Nature, or twenty more papers in journals like Radiology, etc.. (Wenneras and Wold, 1997). The pool of male and female candidates with doctorates applying for this award was nearly equal (44 % female/ 56% male, in biomedical research). The authors concluded that if this discrimination is a reality in Sweden, it is worrisome to think about how fair things are in other countries, since Sweden has been rated highly on gender equality by the United Nations.

In Canada, in 1995, a Task Force was created by NSERC (Natural Sciences and Engineering Research Council), a Granting Council, to examine the obstacles and potential biases that could limit women’s participation in research. The Task Force released a report containing 22 recommendations, all but one addressed at NSERC, and one addressed at the universities. The report is published on the internet (NSERC, 1996). Half of the recommendations were focused on issues of concern to women, and the remaining half on issues that would benefit both women and men. NSERC has already implemented a good number of these suggestions, which address policies, membership on committees, manuals, to name a few.

The situation reported in Sweden should encourage each APEC economy to review the success rate by sex for each of their research funding programs (scholarships, grants, post-doctoral fellowships, awards, and prizes). If the proportion of success is not equal for women and men, then the granting Councils should examine why this is occurring and how to remedy the situation. The NSERC report could serve as a model for many economies, thus allowing rapid progress to occur without having to re-invent the wheel.

Approaches and perspectives in science and in engineering have come from a homogeneous group for far too long. Moreover, there is currently a critical shortage of skills in several of these field. Including more women is the most direct, practical, solution to this crisis. At this critical time, the number of women entering engineering and science may grow steadily if some fundamental changes are made to the culture and the education process. The profession and its leaders have a choice: Will the values, attributes, approaches, and ideas that women bring to the field be integrated into the culture? If research and development (R&D) leaders begin to see how diversity will benefit the research community and our economies, then women will finally take their rightful place in the ranks. We will all be richer for it.

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APPENDIX

DATA AND STATISTICAL TOOLS FOR GENDER, SCIENCE AND TECHNOLOGY IN THE ASIA PACIFIC ECONOMIC COOPERATION

Background Paper for the
Asia Pacific Economic Cooperation
Experts' Meeting on Gender, Science and Technology,
10 - 11 March, 1998, Manila, Philippines

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LIST OF ACRONYMS

APEC	Asia Pacific Economic Cooperation
APPROTECH-Asia	Asian Alliance of Appropriate Technology Practitioners
GWG	Gender Working Group
HRD	Human Resources Development
S&T	Science and Technology
UN	United Nations
UN-CSTD	United Nations Commission on Science and Technology for Development
UNESCO	United Nations Education, Scientific and Cultural Organization
WISE-Thailand	Women in Science and Engineering Forum of Thailand
WLN	Women Leaders Network

EXECUTIVE SUMMARY

One of APEC's main goals is the promotion of growth and development in the region, mainly through the strengthening and creation of a completely open multi-lateral trading system. Central to this model of the region's development is the ability of member economies to participate effectively in a highly competitive trading atmosphere, thus maximizing mutual gains from free trade. This is predicated on the presence of adequately skilled pools of labour, especially in science and technology which have become increasingly crucial to the efficient performance of economies, and thus pivotal to their ability to compete globally.

In APEC, as in much of the rest of the world, women make up about half of the potential source of this skilled labour. However, evidence shows that women are under-represented in scientific and technological education, careers, decision-making fora, and research and development, especially in mathematics, physics and engineering. This under-representation of women in S&T epitomizes losses in potential contributions to S&T, and thus overall economic growth, which APEC can ill afford. The extent to which women are excluded from contributing to S&T in APEC reflects an effective limit on the region's ability to reach its objectives for enhanced competitiveness and development.

The need to redress gender imbalance in S&T has already been acknowledged in APEC. It can be enhanced by appropriate policy intervention whose accurate formulation, implementation and monitoring depend on the availability of sufficiently detailed and reliable gender-disaggregated data. Although some data on S&T is collected among APEC economies, there is, in general, a paucity of gender disaggregated data. S&T data is collected through a variety of mechanisms, including economy-wide censuses and surveys, as well as in professional associations. Data can also be gleaned from special reports and proceedings of relevant meetings. For the most part, these reports provide anecdotal information. There is a need for more systematic data collection and reporting efforts within APEC. On a global scale, UNESCO collected and reported gender-disaggregated S&T data for specific categories of S&T education and employment until 1996.

Policies to support gender balance in S&T can be aimed at increasing women's participation in S&T education, employment, decision-making fora, as well as research and development. These may include policies which improve women's access to S&T education and careers, as well as those which provide for more gender sensitive school and work environments. Useful data for setting strategic targets, and monitoring progress includes women's participation rates in all aspects of S&T, seniority in employment, and attrition and retention rates.

The APEC Experts' Meeting for Gender and S&T on 10 - 11 March, 1998 in Manila is designed to explore the issues above in detail, and to identify concrete data and policy needs for the promotion of women in S&T. The key outputs from the meeting will be practical recommendations and strategies for decision-makers in APEC concerning identified priorities.

DATA AND STATISTICAL TOOLS FOR GENDER, SCIENCE AND TECHNOLOGY IN THE ASIA-PACIFIC ECONOMIC COOPERATION

1.0 INTRODUCTION

1.1 Purpose of Paper

The Asia Pacific Economic Cooperation (APEC) Industrial Science and Technology Working Group will convene an "Experts' Meeting on Gender, Science and Technology" on 10 - 11 March 1998. In particular, conference participants will discuss key issues surrounding gender disaggregated data[1] for science and technology (S&T) in the APEC region: its availability, methods of collection and issues of coordination among economies, as well as policies which are relevant to the collection and use of gender disaggregated data in S&T. From these discussions will ensue specific recommendations for the increased participation of women in S&T, as well as a clear identification of ways in which data can serve to enhance policy formulation, implementation and monitoring.

Written in preparation for the meeting, this paper is intended to raise key issues pertaining to data for gender and S&T in order to stimulate thinking and discussion. As such, its scope is guided by the three key themes which will be addressed at the conference. These are specifically:

- "Existing Data": a review of existing data on the participation of women in S&T education, employment, and research and development in APEC;
- "Data Sources: Instruments in Use": an overview of data collection for gender and S&T in APEC economies, as well as in international agencies;
- "Statistics with a Purpose: Policy Making Within APEC Economies": an examination of case studies where policy actions facilitate access to S&T for women, and identification of the type of gender disaggregated data needed to support policies.

Much of the rest of this paper is organized around these three themes. The rest of section 1 presents the historical context and the rationale for considering gender-disaggregated S&T data. It highlights the reason why the collection and use of this data is important to APEC's objectives for developing and maintaining a competitive edge in the global economy.

Section 2 then reviews available data on gender, and S&T. It discusses briefly the available gender-disaggregated S&T data in education, employment, research and development, decision-making, as well as data on the gender-differentiated impacts of S&T.

Section 3 examines the collection of gender-disaggregated data for S&T within member economies and by other international agencies. It also notes the factors which may enhance or hinder the possible coordination of efforts for the collection of data among APEC

[1]In keeping with APEC publication guidelines, data will be used in the singular in this paper.

member economies.

The fourth section considers the linkages between policies and gender-disaggregated data for S&T. On one hand, policies which facilitate women's access to S&T are identified. On the other, the section reviews the kind of data needed for the development and monitoring of gender-sensitive policies in S&T.

Concluding remarks are contained in section 5. In particular, the section identifies some suggested outputs from the APEC Experts' Meeting on Gender, Science and Technology.

1.2 Historical Context

In convening this meeting, APEC joins past notable efforts which have raised the significance of gender in science and technology for the best use of an economy's human resources, and in particular, the importance of gender-disaggregated S&T data in the formulation of relevant policies for the increased participation of women in science and technology. Some examples of international fora which have made recommendations for gender, and S&T include the 1979 Vienna Programme of Action on Science and Technology for Development, the 1984 United Nations (UN) Panel of the Advisory Committee on Science and Technology for Development, as well as the three UN World Conferences for Women which were held in 1975, 1985 and 1995. Some of these recommendations, as well as others, are presented in appendix table A1.

In the Asia-Pacific region, the significance of gender and S&T have been recognised in several fora, including the Women Leaders Network (WLN), an inter-disciplinary informal network of women from APEC member economies. For example, at their 1997 meeting in Canada, the sixth workshop focused on "Promoting Women's Successful Participation in the Knowledge-Based Global Economy: Science and Technology Platforms". Subsequent recommendations for future action included:

- gathering disaggregated data on gender
- sharing best practices on gender in S&T
- promoting equal access of women to technical and vocational education
- providing 'enabling environments' for women in Science
- using gender-based analysis to measure and address differential impact"

APEC has also acknowledged the important role that women play not only in S&T, but in the economy in general. One example of this is the recognition of women's roles in the economy contained in the 1996 APEC Leaders' Statement issued after the Leaders' Summit. Indeed, even within APEC member economies, various efforts to champion gender concerns in APEC are underway. Three such examples outlined by Gibb (1997: p.38 - 40) are Canada's Interdepartmental Sub-Committee on Gender in APEC, the National Commission on the Role of Filipino Women in the Philippines, and the Thailand Chapter of the WLN.

1.3 Rationale for APEC's Consideration of Gender Disaggregated S&T Data

1.3.1 Gender in the Production of Science and Technology

One of APEC's main goals is the promotion of growth and development in the region, mainly through the strengthening and creation of a completely open multi-lateral trading system.[2] To this end, APEC has set goals for the achievement of free and open trade and investment in the region by the year 2020, the developed countries being required to achieve set targets by 2010.

Central to this model of the region's development is the ability of member economies to participate effectively in a highly competitive trading atmosphere, thus maximizing mutual gains from free trade. This is predicated on the presence of adequately skilled pools of labour. In particular, human resources with skills in scientific and technological disciplines have become increasingly crucial to the efficient performance of economies, and thus pivotal to their ability to compete globally. Indeed, the phenomenal successes in economic growth which were enjoyed by such APEC members as Indonesia, the Republic of Korea and Singapore during the eighties and early nineties have been attributed largely to their having sufficiently skilled human resource bases. As we move into the next millennium, economies' successes in the international markets will be determined increasingly by their endogenous abilities for S&T innovation.

In APEC, as in much of the rest of the world, women make up about half of the potential source of this skilled labour. However, evidence shows that women tend to be under- represented in scientific and technological education, careers, decision-making fora, and research and development. In particular, the number of women in the fields of mathematics, physics and engineering are extremely low.

This under-representation of women in S&T epitomizes losses in potential contributions to S&T, and thus overall economic growth, which APEC can ill afford. So long as women are effectively excluded from S&T education and careers, some of the best minds in APEC will be prevented from contributing to the region's economic growth, thus effectively limiting the extent to which the region can reach its objectives for development.

Furthermore, as long as the barriers which women face in S&T are not effectively addressed, much investment in education will be wasted as skilled and talented women continue to opt out of scientific and technological careers to work in other more gender-responsive environments.

APEC recognizes the importance of redressing gender imbalances in S&T. At the 2nd APEC Ministers' Conference on Regional Science and Technology Cooperation which was held in Seoul on November 13 - 14, 1996, ministers " ... affirmed the importance of enhancing the recruitment and retention of highly talented women in science and technology. Ministers identified the importance of removing barriers, and promoting the full contribution of women to S&T innovation and creativity as an essential element in meeting APEC's goal

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[2]See APEC Ministers' Declaration on Asia-Pacific Economic Cooperation, Seoul (1991);
APEC Leaders' Economic Vision Statement, Blake Island (1993); and APEC Leaders' Declaration of Common Resolve, Bogor (1994).

of achieving sustainable and equitable development."

Obtaining appropriate data is critical. APEC economies individually, and as a region, would benefit from the development of concrete policies and strategies to promote the gender-balanced participation of women and men in S&T. In order for these to be effective, they must be based on sufficiently detailed data. The establishment of benchmarks against which future efforts would be measured requires data. In addition, monitoring the implementation of subsequent action plans would also depend on the availability of adequate gender disaggregated data and indicators.

1.3.2 Gender in the Use of Science and Technology.

As APEC member economies pursue growth through the achievement of free trade, it is equally important to be cognisant of the implications of gender in the development and use of S&T.

There are numerous examples of the gender differentiated impacts of science and technology. For example, the more pervasive use of personal computers in the work environment has tended to displace secretarial staff, an important entry point for many women into the work force. Likewise, the increased use of automated telephone answering systems has replaced many receptionists, a job held predominantly by women. These cases are but a couple of examples which demonstrate how technology may exacerbate existing gender biases by reducing employment opportunities which are dominated by women, especially when alternative job opportunities are limited for them, unless they opt for non-traditional education and careers.

Other examples of gendered impacts can be seen in the health sector with reproductive technologies, in agriculture (Jiggins, 1986), as well as in manufacturing. In some of those, for example in the automotive sector, technological change may impact upon men much more than on women.

While it is not always avoidable, it is important to predict and where possible mitigate the negative social consequences of S&T development. This is especially critical in cases where these negative effects have a disproportionately larger impact upon already disadvantaged groups in society. An effective system of routinely evaluating scientific and technological innovations for their gendered impacts requires the establishment of policies, guidelines and strategies. For these to be accurate and effective, they must be based on reliable and sufficiently detailed gender-disaggregated data and indicators.

1.3.3 Data for Gender, Science and Technology

Clearly, sufficiently detailed and reliable gender-disaggregated data for S&T in APEC is needed in order to render the issue visible, and to underpin effective policies and strategies in the production and use of S&T. Although some data on S&T is collected among APEC economies, there is, in general, a paucity of gender disaggregated data.

2.0 DATA ON GENDER, AND SCIENCE AND TECHNOLOGY IN APEC

2.1 Data on Gender and S&T in Education

Gender-disaggregated data on education in S&T is perhaps the more frequently and systematically collected and reported than that for various categories of employment in science and technology. Typically, it is collected in the normal course of school enrolments, attendance and graduation. Also, UNESCO routinely reported these data up to 1996, hence there was an international mechanism which made this data available. However, despite the widespread collection of education data, it is not always reported and made available in a manner which is easily accessible or comparable. Gaps in information are very common.

Despite these gaps, evidence shows clearly that although the APEC region has achieved levels close to universal enrolment rates for primary school education, there are wide gender gaps in enrolments in S&T courses, especially for mathematics, physics and engineering courses. Table 1 shows the female enrolment rates for various courses at the post-secondary level for selected APEC economies. The pattern of lower enrolment rates for female students in science and technology courses is evident, as is the variability that exists among countries.

For example, data for Malaysia showed that women's university enrolments in technology studies at universities were about 10 per cent in 1992 (Merican, 1993:23). For sciences as a whole, the share of women with science majors in local universities ranged from 45 per cent to 49 per cent. These fields included science education and nursing, fields which are typically dominated by women. Likewise, Lin (1993:31) reported that for Singapore, only 14 per cent of graduates in engineering were women. The share for science graduations was a much higher 59 per cent.

These gender gaps indicate the presence of barriers for girls. These include cultural influences and gender-role stereotyping both within and outside the school system. More detailed discussion of the barriers which girls and women face in S&T education are contained in Asian Alliance of Appropriate Technology Practitioners (APPROTECH-Asia) and Women in Science and Engineering Forum of Thailand (WISE-Thailand) (1993), Canadian Committee of Women in Engineering (1992), Frize (1993) and Noble (1992). Similar findings on the disproportionate male and female enrollments in S&T education were reported by Megaw (cited in Barinaga: 1994) who surveyed 400 physics departments around the world. Megaw found that women were under-represented in all physics departments. However, there were differences among countries.

Table 1. **% Enrolment of Female Students for under- graduate and post-graduate university education in selected fields of study for selected APEC Economies.**

Economy	Level	Education Science	Humanities and Religion	Fine arts & applied arts	Natural science	Math and computer science	Medical science and health-related Studies	Engineering	Architecture
Australia	under-gd post-grad	76 67	69 63	- -	41 32	- -	68 67	11 10	- 29
Canada*	under-gd post-grad	74 66	64 51	67 61	44 28	30 22	72 56	12 12	32 27
Indonesia	under-gd	36	29	29	39	25	30	19	20
Japan	under-gd post-grad	58 37	64 38	65 50	18 10	20 10	37 13	3 3	- -
Malaysia	under-gd post-gd	58 58	56 35	46 -	45 41	49 31	55 34	15 13	31 21
Mexico	under-gd post-grad	65 53	57 49	44 49	59 36	41 22	54 33	16 16	37 23
New Zealand	under-gd post-grad	81 70	66 49	62 66	39 38	19 19	58 55	14 23	37 38
Philippines	under-gd post-gd	75 78	58 76	60 78	63 76	53 63	74 81	17 25	19 -
Republic of	under-gd	64	53	64	33	31	36	3	10

Economy	Level	Education Science	Humanities and Religion	Fine arts & applied arts	Natural science	Math and computer science	Medical science and health-related Studies	Engineering	Architecture
Korea	post-gd	40	35	72	23	23	23	3	8

Sources: Compiled from data in UNESCO *Statistical Yearbook, 1992 and 1993;* and UNCTAD, *Statistical Data Base on Gender, Science and Technology,* Geneva, July 15, 1994.

*The Canadian Council of Professional Engineers reported that for 1992, female student enrolments in undergraduate engineering programs was 17%, and that for post-graduate programs was 14%.

2.2. Data on Gender and S&T in the Work Place

Data on gender, and S&T in the work place has not been collected and reported to the same extent as for education. Although there is a growing body of data collected, much of it still remains anecdotal, and has not been aggregated as in education. Nonetheless, the data shows that although the number of women in science and technology careers has been increasing, women are still very poorly represented in S&T careers, especially in mathematics, physics and engineering.

For example, Merican (1993) reported that in Malaysia, less than 4% of engineers registered with the Institution of Engineering were women. Likewise only 2% of engineers registered by Petronas, the government-owned petroleum company, were women. These gender gaps are typically larger at higher levels of S&T education and employment due to attrition, a trend which Science (1993: 409) and Barinaga (1992: 1366 - 1367) call the “leaky pipeline”.

The under-representation of women in S&T is repeatedly observed across economies, although variations across economies are evident. Megaw’s study (cited in Barinaga, 1994) showed that while women constituted less than 5% of physics in Japan, Canada, and the United States, they exceeded 25% in Thailand, and the Philippines. Likewise, Ruivo (in Barinaga, 1994) noted that in Mexico, Argentina and Eastern Europe, 20 - 50 per cent of scientific researchers were women, while for highly industrialized countries, such as the United States and Western Europe, this figure was typically less than 10 per cent.

The data is too scanty to draw definitive conclusions as to why observed differences exist. Ruivo and other have alluded to differences in the “culture of science and technology” which varies from place to place, and influences such things as the status accorded to different S&T careers. She suggested that in some of the places where the presence of women in S&T is relatively high, the status and pecuniary rewards associated with these S&T research positions may be relatively low.

In research and development, there is some evidence to suggest that women receive smaller grants than do their male counterparts. Healy (Science, 1994) found that in the United States, although women’s success rates in competing for research project grants (RPG) from the National Institute of Health were equal, women received only 16% of the RPG funds. He noted that women requested on average, $30,000 less in funding than male applicants.

Women are also under-represented in decision-making in virtually all agencies dealing with S&T. These include the political arena at the ministerial and deputy ministerial levels, deans of faculties, principles of schools and science foundations and advisory boards. Harding and McGregor (1996:18) , and others have argued that “in order to affect change and contribute fully to science and technology, women must be present in critical numbers and at a critical level in decision making in S&T institutions, departments, advisory boards, development agencies and educational institutions”.

In reviewing the literature, it is instructive to note that although there are dissimilarities across economies, there are also many similarities in the problems identified as being critical determinants of S&T careers for women. A listing of these constraints is presented in Table 2.

Table 2. Constraints faced by women in S&T

Constraints in Science and Technology Careers
• limited access to critical information by women in science and technology because of the "old boys' network; • discrimination, harassment, and the glass ceiling in workplaces; • lack of linkage to grassroots knowledge and networks; • structure of science and technology institutions • gender stereotypes & sexist attitudes regarding perceived abilities in science courses, especially mathematics and physics; • gender stereotypes regarding career choices; • lack of educational and job opportunities; • double standards in assessing women in non-traditional occupations; • inequities in distribution of household and parental responsibilities; • lack of flexible work options.
Constraints in Research and Development
• institutional constraints; • discrimination, nepotism and sexism; • non-implementation of laws favouring women; • non acceptance of alternative work style; • family commitments, especially in single or female-headed families.

Adapted from: APPROTECH-ASIA and WISE-Thailand *Mainstreaming Women in Science and Technology*. Manila, 1993:6-7; and Van Beers and Frize (1997)

Although significant gaps exist in gender disaggregated data on S&T education and careers and decision-making, the largest gap is for quantitative data on women's unpaid work, especially that which occurs within the household. Although this data is difficult to obtain, it is important to include because it is frequently the competitive demands of household work which inhibit severely women's abilities to take advantage of career and sometimes educational opportunities in S&T. It is important to understand the interactions of paid and unpaid work if women (and men) are to be given the support needed to adequately balance these two dichotomies of their lives. This is especially true for women who still bear the larger portion of household responsibilities.

3.0 THE COLLECTION OF GENDER DISAGGREGATED DATA IN S&T

3.1 Who collects gender disaggregated data in S&T within APEC

Commonly, economies have statistical offices which collect a wide array of information through regular surveys and censuses. However, this data is not always disaggregated by gender, even though economies like Canada routinely disaggregate almost all social data by gender. Other sources of data and information include S&T professional associations, such as the Canadian Committee of Professional Engineers who collect and analyse data for engineers. Most available information on gender in S&T careers in APEC can be gleaned from special reports, some commissioned by the public sector, such as Canada's National Advisory Board on Science and Technology Report (1993), and "Women in Scientific Research in Australia" McPherson (1992); while others arise out of regularly published journals and magazines, such as the special issues of *Science* (March 1992; April 1993; March 1994) which were dedicated to exploring gender and S&T.

Other important sources of data on gender, and S&T are proceedings of meetings dedicated to relevant themes. Such examples include APPROTECH-ASIA and WISE-Thailand (1993), the proceedings of the conference on "Gender Equity in Education and Training: Meeting the Needs of APEC Economies in Transition" (1994), and the 1996 "Meeting of the Resource Group of Women Scientists and Technologists in Asia and the Pacific Region". For the most part, these reports provide anecdotal information. There is a need for more systematic data collection and reporting efforts within APEC.

Data collection agencies face a variety of constraints. Perhaps the most common of these is the lack of adequate funding for the collection of gender disaggregated data for S&T, reflecting the low priority accorded to the collection and use of this data. Hence, the number of surveys and other data collection vehicles dedicated to the collection and reporting of this data are few.

3.2 International Sources of Data on Gender and S&T.

Until 1996, UNESCO was probably the agency which provided the most extensive gender-disaggregated data on S&T education and careers. Other more limited efforts included those of OECD. Within APEC, the current data collection effort by the Human Resources Development Working Group is probably the most extensive in attempting to provide information on labour data which is disaggregated by gender.

The tables in the UNESCO Statistical Yearbook, broken down by gender, included:

- "education at the third level: graduates by sex, and by International Standard Classification of Education (ISCED) level and field of study"
- "scientific and technical manpower"
- "number of scientists, engineers and technicians engaged in research and experimental development"

There were also related tables on students and educational staff in general, in which data were broken down by gender. These included tables on first level education enrolment and duration; number of institutions and teaching staff by sex, statistics on secondary school education and area of specialization.

Typically, the tables contain wide variations in the reported entries. For example, Table 5.3 of UNESCO's 1992 Statistical Yearbook sought to report gender disaggregated data for "Scientific and Technical Manpower". Table 3 summarises the pattern of responses of the 64 respondents, demonstrating gaps and differences in reported information among the respondents.

Table 3. Pattern of Response for a table 5.3 of the UNESCO Statistical Yearbook, 1992.

Data Type	Number of Respondents
scientists and technicians, both by gender	28
scientists by gender, no technicians	17
scientists and technicians, no gender disaggregation	11
scientists, no technicians, no gender disaggregation	6
scientists without gender disaggregation, technicians broken down by gender	2
combined total for scientific and technical personnel , with no disaggregation	1

Although attempts were made to report data over specified time periods, the significant gaps observed in the data limit their usefulness in conducting extensive time series comparisons. Likewise, cross-sectional comparisons also have to be done with caution. Data were reported for different years in the same table. In addition, some variables may have been defined differently at source. For example, some entries reported data for "economically active manpower", while others reported that for "qualified manpower". The tables do give extensive explanatory notes, pointing out any significant variations among entries. Despite the potential problems which may be inherent with such data sets as the UNESCO statistics, they are still useful, especially when used in conjunction with other data, such as more detailed local or regional data.

The large number of gaps in data from the UNESCO tables suggest some very important lessons for any efforts which APEC may make towards coordinated efforts at collecting data. First, it is very important to gain the commitment of economies in order to have a data set which allows for comparisons, and provides opportunities for mutual learning. The more complete the data set, the more useful it will be to policy-makers seeking to ensure inclusiveness for gender in the production and utilization of S&T in the region.

Another lesson which can be drawn from the UNESCO data set for APEC is that compatible equivalent definitions, collection methodologies and reporting of data enhance the reliability of the collected data. Where reliability is absent, resources are spent compiling data which researchers, policy makers and advocates cannot use with confidence.

Finally, other international efforts could prove useful in dealing with the challenges associated with collection of data across economies. For example UNCSTD's meeting in Geneva (1997) which focused on common methodologies may be of relevance to APEC economies as they begin a common effort in gender disaggregated data collection within the region.

4.0 POLICIES AND GENDER DISAGGREGATED S&T DATA

A systematic and pervasive approach to redressing the gender imbalances observed in S&T requires policies aimed at promoting gender balanced participation in all fields of science and technology, as well as gender analysis of S&T impacts. Indeed, there are examples of such policies in some APEC economies, some embodied in such legislation as those related to gender equity in employment. In this section, we review the entry points for gender-sensitive S&T policies, and the data requirements for the formulation and monitoring of these policies.

4.1 Policies and Strategies in Education and Training

According to data from the UNESCO Statistical Yearbooks (1994), most APEC economies have near universal levels of education at the primary school levels, with a fairly gender balanced enrolment ratio. The highly skewed enrolments in S&T courses at the secondary and tertiary levels of education can be linked to the existence of gender biases in the educational and cultural systems which results in the streamlining of girls away from science and technology education. As noted, in section 2, the disparity is particularly pronounced for mathematics, physics and engineering courses.

Hence, policies are required to promote the balanced enrolment and retention of girls and boys in science and technology courses at all levels of the education system. Some of these policies should be addressed to the educators, promoting activities such as the training of teachers and staff in both formal and informal education, in gender sensitivity, which would allow them to better assist students in overcoming gendered barriers, as well as themselves in eradicating biases which may be inherent in their own actions.

Other strategies include direct incentives for girls, such as scholarships for university enrolments in particular S&T courses, mentorship programs, and internships for students in S&T working environments. Adult learning also provided important options for enabling women to enter fields of S&T. The APEC's Forum's Human Resource Development (HRD) Working Group's work on *Lifelong Learning* (Hatton, Michael, ed. 1997) provides seminal work which can be built upon.

4.2 Policies and Strategies for the Work Place

Many corporate policies exist which prohibit gender bias and discrimination in APEC economies. However, there is a need to strengthen those which specifically support the increased participation of women in S&T careers, thus striving for gender balance in those areas where women are under-represented. Such strategies can vary widely. They can include those directed at recruitment, such as guidelines for gender balance in interviewing techniques, as well as open advertising of vacant positions. Policies and strategies can also focus on retention, including promotion, training and capacity building, pay equity and re-entry, especially after maternal leave.

4.3 Policies and Strategies for Gender Sensitive Impact Analysis of S&T

In addition to policies and strategies for the promotion of gender balanced participation in S&T, policies which guide gender-sensitive evaluation of S&T are also required. The Gender Working Group (GWG) of the UN Commission on Science and Technology for Development (UNCSTD) conducted a two year study and documented numerous examples of gender-differentiated impacts of S&T. It is important to be able to evaluate new technologies for gender differentiated impacts. Tools for evaluation are available, and should be consistently applied within industries, as well as by public agencies. An example of this is seen in Canada where the federal agency responsible for women's issues, Status of Women Canada, has developed gender-sensitive evaluation guidelines, contained in *Gender Based Analysis* (1996), to help federal departments to implement mandatory gender-based analysis of tendered policies and legislation, including those for S&T.

4.4 Data Requirements for Policies

Whether it be in the school system or the work environment, policy should be based on accurate and reliable information. Thus policies designed to increase gender balance in university enrolments and retention in S&T courses must first correctly identify not only the extent of the imbalance, but also its causes. The first set of information will allow the setting of targets, while the latter determines the specific plans of action to be undertaken in order to reduce the gender imbalance in enrolment and retention.

Useful data for policy includes all that which highlights the gender disparities such as:

- enrolment rates for education as a whole and in each course, including math, physics, chemistry, at all levels
- school attendance rates
- school graduation rates
- progression from one grade to the next
- gender disaggregated enrolment and graduation rates for specific S&T disciplines at the secondary, and tertiary levels.

Not only does this data allow for the setting of priorities, but may also serve as useful indicators of the success of policy implementation over time. Similar gender disaggregated data for women's S&T careers include:

- share of employment in different S&T professions;
- share of membership in S&T professional associations;
- share of membership in S&T advisory bodies;
- position in hierarchy of S&T organizations;
- share of research funding for projects submitted by women;
- scholarships, fellowships, awards and prizes;
- remuneration for work, including salaries, bonuses and other benefits.
- gender representation at various levels of organizational hierarchies, including in

decision-making.
- rates of job displacement as a result of technology
- access to training

The relevance of any type of data, or information depends on the specific strategies chosen to implement policies. The relevance is reflected by impact on policy and its ability to render issues visible, and thus serve to underpin subsequent actions.

5.0 CONCLUSION

Informed policy intervention would facilitate the increased participation of women in S&T. Policy intervention is also needed to ensure the adequate evaluation of gendered impacts of technology, thereby providing an opportunity to avoid or mitigate negative impacts of S&T. However, effective policy intervention, as well as accompanying strategies must be based on sufficiently detailed and reliable data. For the most part, the data which is currently available tends to be sporadic and not uniformly defined, hence the value of APEC-wide coordinated efforts at identifying data needs, the collection of this information within economies, and the establishment of coordinating mechanisms to facilitate mutual sharing and learning and sharing of data, as well as policies and strategies which will utilise this data.

At the March 1998 "APEC Experts' Meeting on Gender, Science and Technology", a useful foundation will be laid if for the following categories:

- gender in S&T education (all levels)
- gender in S&T careers and unpaid work
- gender in S&T decision-making agencies
- gender in S&T research and development

The following questions could be answered:

- What are the priority areas on which attention should be focused?
- What are the policies which would enable improvements in gender-balanced participation in S&T, especially where women are under-represented?
- What gender disaggregated data is required to formulate and implement effective policy intervention, including specific strategies for execution?
- Who are the key stakeholders?
- What resources will be required to implement suggested policies, and where would these resources come from?
- In what kind of time frame would suggested policies and action plans be implemented?
- What are the monitoring tools (indicators and mechanisms for monitoring) which would be required to measure progress?

Finally, the participants at the meeting should consider possible coordinating mechanisms for data collection, analysis and use within APEC. These may include existing institutions which are suited for the coordinating functions, or may involve the establishment of a new APEC agency which has the mandate for coordination of APEC's S&T data collection and use. Again, resource implications for coordination should be identified and quantified.

These answers should form the basis of practical recommendations to decision-makers within APEC economies, including recommendations to APEC, those to individual economies, and those to associations and other agencies.

What this suggested list of tasks for the APEC meeting in March leaves out are the policy, and data implications of the gendered impacts of S&T. Although extremely important if developed technologies are to adhere to concepts of "equitable development", the two day meeting may be more fruitful if focus is placed on the "production" side of gender and S&T, leaving consumption issues to another forum. This should by no means suggest that consumption issues are not important, but is rather just a pragmatic response to limited time availability.

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APPENDIX TABLE A1. Previous Recommendations on Gender and Science and Technology

'79 Vienna*	'84 Adv. Committee on S&T for Development	'85 Nairobi	'91 Miami	' 95 UN Commission for Science and Technology for Development.	'95 Beijing Platform for Action
Rec. A3(g) ensure full participation in S&T development process Rec. D99(g) promote full participation of women in all groups for application of S&T	Rec. 30-35 facilitate women's participation on all S&T; Rec. 53: Use women's groups and women in S&T to deliver S&T to women's organisations; support women in S&T decision-making process. Rec. 54-77: Use women's groups in the selection, design and dev't of technology for women; re-training of technology-displaced women;	para. 191 & 192: Enhance women's science and technology skills and adapt technology to women's needs and relieve them of tasks. Para 204: Assess impact of technology development on women' s incomes, health & status. Para 206-208 increase women's access to information, and participation of women in all levels of communications policy and decision making. Para. 369 - increased training of women in audio-visual forms of information dissemination.	Pg. 22: Call for benign technology transfer with special stress on women & appropriate technology for their roles. Support communication strategies to disseminate appropriate technology to women. **'92 Rio** Art. 6.23: support indigenous people through education, economic and tech. opportunities Art. 34.3: Tech. Transfer to consider gender-relevant aspects.	- improve collection and sharing of gender disaggregated data. - provide same opportunities for education for both girls and boys; introduce new approaches to science and technology education. - promote gender sensitive work arrangements, improve decision-making for gender balance in S&T - find creative avenues for mutual learning and exchange between traditional and modern knowledge systems.	- improve women's access to technologies, information and technical assistance - improve women's access to science education and technical training - improve women's access to non-traditional employment - strengthen position of women scientists and technologists - improve women's participation in S&T decision-making and policy-making.

Sources: Gender Working Group of the UN Commission on Science and Technology for Development. *Previous Recommendations, 1975-1993*. 1994; and Women Leaders Network *Conference Proceedings Summary*, Ottawa-Hull Canada, September 13-16, 1997. "Session 6" and "Annex B".
* Full conference titles next page.

Conference/Document Titles which yielded "Previous Recommendations"

'79 Vienna: "The Vienna Program of Action on Science and Technology for Development". Report of the U.N. World Conference on Science and Technology for Development. 1979

'84 Adv. Committee on S&T for Development: Science and Technology and Women" Report of the UN Panel of the Advisory Committee on Science and Technology for Development. Geneva, 1984.

'85 Nairobi. The UN Forward Looking Strategies. (Second World Conference on Women). Nairobi, 1985.

'91 Miami. Women Environment and Development Organisation. *Women's Action Agenda 21*. Miami, 1991.

'92 Rio United Nations Conference on Environment and Development.

' 95 UN Commission for Science and Technology for Development. Gender Working Group of the UN Commission on Gender, Science and Technology. Ottawa, Canada. 1993-1995.

'95 Beijing Platform for Action: Report of the Fourth World Conference on Women, Action for Equality, Development and Peace. Beijing, 1995.

AGENDA

Agenda

Day 1: 10 March, 1998

8:00 Registration

8:15 Welcome: Amelia ANCOG (Philippines)

8:30 Opening remarks by the co-chairs: Monique FRIZE (Canada) and Aurora PEREZ (Philippines)

8:45 Keynote Speaker: William PADOLINA (Philippines)

9:15 Keynote Speaker: Marilyn WARING (New Zealand)
Why is gender an important issue in APEC S&T development?

9:45 Question Period

10:15 BREAK

PANEL 1: EXISTING DATA

This panel reviews existing data sources on the participation of women in science and technology in APEC.

10:30 Introductory Remarks: Co-Chairs

10:35 Shirley MALCOM (United States)
Education (students and educators)

11:00 Vivian CHENG (Hong Kong, China)
Participation of female students in science and mathematics

11:25 Young-Ock KIM (Republic of Korea)
Data on gender and science and technology in the work place: The Korean Case

11:50 Sjamsiah ACHMAD (Indonesia)
What are these statistics telling us? What is being left out?

12:00 Question Period

12:25 Concluding Remarks: Co-Chairs

12:30 LUNCH

Day 1. 10 March, 1998

PANEL 2: DATA SOURCES - INSTRUMENTS IN USE

In this session, speakers from two APEC economies will provide an overview of various practices with respect to the collection and use of gender disaggregated science and technology statistics within APEC. Two speakers from international organizations will provide particular insights on the issue of the comparability of data.

14:00 Introductory Remarks: Co-Chairs

14:05 Virginia MIRALAO (Philippines)
Statistical agency of an economy

14:30 Nancy GHALAM (Canada)
Statistical agency of an economy

14:55 Mary GOLLADAY (United States)
Statistical agency of an economy

15:20 Gunnar WESTHOLM (Consultant; formerly OECD)
International Agency

15:45 BREAK

16:00 Tony MARJORAM (UNESCO - Paris)
International Agency

16:25 Discussant: Mariko KAMIJO (Japan)
Comparability of data - challenges and solutions

16:35 Question Period

17:25 Concluding Remarks: Co-Chairs

..17:30 End of Day 1

Agenda

Day 2: 11 March, 1998

PANEL 3: STATISTICS WITH A PURPOSE: POLICY-MAKING WITHIN APEC ECONOMIES

Speakers at this session will present case studies where policy actions are instrumental in facilitating access to S&T for women, and will examine the type of gender disaggregated data that is needed to support and monitor policies.

8:30 Introductory Remarks: Co-Chairs

8:35 Fanny CHEUNG (Hong Kong, China)
The need for objective and subjective indicators in gender statistics

9:00 Ellen FORCH (New Zealand)
Women in the reformed New Zealand environment

9:25 Malee Suwana ADTH (Thailand)
Case study from APEC economy

9:50 Break

10:05 Monique FRIZE (Canada)
Increasing the participation of women in science and engineering research

10:30 Discussant: Romulo VIROLA (Philippines)

10:40 Question Period

11:20 Concluding Remarks: Co-Chairs
Instructions for the workshops

Day 2: March 11, 1998

WORKSHOPS:

11:30 Workshops *(6 concurrent workshops)*

Each group should make specific recommendations for policy-makers.
Participants will break out into 6 groups according to the following themes:

1. *Kindergarten to grade 12*
2. *Recruitment and retention in science and technology fields in universities*
3. *Research*
4. *Gender, and science and technology: issues in the work place*
5. *Gender, and science and technology: issues in associations*
6. *APEC coordination mechanisms to enhance comparability of data collected in APEC economies.*

12:30 LUNCH

14:00 Workshops Resume

15:30 BREAK

15:45 Plenary: Reports from the Workshops

16:15 Question Period

17:00 Summary of Recommendations: Co-Chairs

17:30 End of Meeting

PARTICIPANTS'

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ASIA-PACIFIC ECONOMIC COOPERATION
INDUSTRIAL SCIENCE & TECHNOLOGY WORKING GROUP
EXPERTS' MEETING ON
GENDER AND SCIENCE & TECHNOLOGY
Century Park Hotel, Manila, Philippines, 10-11 March 1998

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