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**Expert group meeting**
**Gender, science and technology**

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# Gender, Science and Technology

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## CONTENTS

## A. INTRODUCTION

Science and technology (S&T)[2] has long been recognized as a driving force for economic development and for improving the well-being of individuals and their communities. In this context, it is important to look at the various linkages pertaining to gender, science and technology. A well-known issue is the persistent underrepresenta

## B. ACADEMIC AND PO

- Examines intersections of gender, race, and ethnicity.
- Seeks methods of sex and gender analysis relevant for both Western-style and local knowledges.

**Problems:**

- Methods of sex and gender analysis are only now being codified.
- Scientists, engineers, and policy makers are unfamiliar with methods of sex and gender analysis.
- Methods of sex and gender analysis are not yet mainstreamed into S&T curricula.

***2. Past commitments and recommendations***

Governments have met at international conferences and made commitments to increase women's and girls' access to and participation in S&T. These include:

- **Beijing Platform for Action (1995)**

  The Beijing Platform for Action, adopted at the Fourth World Conference on Women (1995), calls on Governments and all stakeholders to increase girls' and women's access to and retention in science and technology, including by adapting curricula, and teaching materials (paras. 83 (g) and 83 (f)). Importantly for this expert group meeting (EGM) considerations, the Platform also urges stakeholders to promote gender-sensitive and women-centred health research, treatment, and technology, and to integrate traditional and indigenous knowledge with Western medicine (para.109 (b)), as well as to create training, research, and resource centers that disseminate environmentally sound technologies to women (para. 258 (b)(v)).[7]
- **Budapest Science Agenda and Framework for Action (1999)**

  The Budapest Agenda for Action, adopted at the World Conference on Science (1999), calls on government agencies, international organizations, and research institutions to ensure the full participation of women in the planning, orientation, execution, and assessment of research activities. The Agenda further calls for women to become active participants in shaping the future direction of scientific research (3.3(1)).[8]

  The Budapest Agenda also calls on governmental and non-governmental organizations (NGOs) to sustain traditional knowledge systems through active support of the keepers and developers of this knowledge. The Agenda notes that such support requires protection of native languages, ecological conservation, and recognition of women's traditional knowledges (3.4(4)).

  Finally, the Agenda urges that national education systems develop new curricula, teaching methodologies, and resources that take gender and cultural diversity into account (2.4(3)).

In addition to the commitments made by Governments, recommendations have been developed in other forums. The Gender Advisory Board of the United Nations Commission on Science and Technology for Development, for example, developed the following 'Transformative Actions':

[7] United Nations, Division for the Advancement of Women. (2010). Aide-Memoire for Expert Group Meeting on Women's and Girl's Access to and Participation in Science and Technology, 18 June.

[8] UNESCO World Conference on Science. (1999). Science Agenda—Framework for Action, Budapest, Hungary, 16 June – 1 July.

These three policy approaches are interrelated. Increasing girls' and women's participation in science and engineering will not be successful until institutions are restructured and gender analysis is mainstreamed into knowledge production.

implemented its Women in S&T-Friendly Institutional Transformation project, modeled on the NSF ADVANCE programme, in 2004. The goal of this programme is to promote women by developing family-friendly work environments.[18]

In India, where in 2000 women constituted only 7 per cent of total faculty across India's top four science and engineering academic institutions, a new report from the Academy of Science, Bangalore, has set out 13 policy recommendations to reform institutions and prevent the loss of trained scientific 'womanpower'. These include mandating at least 33 per cent women on all decision-making committees and implementing programmes to accommodate spouses working in the same field of study.[19]

This second policy approach focuses on restructuring institutions while assuming that what goes on inside institutions—research and knowledge production—is gender neutral. Restructuring institutions is important, but must be supplemented by efforts to eliminate gender bias from research and design.

***c. Knowledge. Enhancing excellence by mainstreaming gender analysis into S&T research***

The European Union's DG Research is the global policy leader in mainstreaming gender analysis into research. In the 6th Framework Programme for Research and Technological Development (FP6, 2002-2006), DG Research required that all S&T grantees include a 'gender dimension' in their research. As stated in the c.26amn in theirw -2 supplem organizations that requires grantees to address gender analysis in grant applications for all fields, although several European countries also include this as part of their national science policies.

Policies requiring researchers to integrate gender analysis into research are more common in health research organizations. The leader in this area is Canada. In 2009, Canada passed the Health Portfolio Sex and Gender-Based Analysis Policy (SGBA) to "develop, implement, and evaluate the Health Portfolio's research, programmes, and policies to address the different needs of men and women, boys and girls." In the same year, the Canadian Institutes of Health Research issued a guide for researchers and reviewers, *Gender and sex-based analysis in health research*.[23] The World Health Organization (WHO) also mainstreams gender analysis into all "research, policies, programmes, projects, and initiatives".[24] In Europe, Sweden's Karolinska Institute and Germany's Charité Universitätsmedizin have both created centres for gender medicine that promote sex and gender analysis in basic and clinical health research.[25]

Further research is needed to compare and contrast international, national, and institutional policies on mainstreaming gender analysis into S&T research.

## C. S&T EDUCATION AND EMPLOYMENT

Acquiring science and technology skills can open up a broad range of employment opportunities for women, both as highly-skilled professionals and as technicians. Girls and women, however, remain underrepresented both in the fields of study that lead to such jobs, and in S&T employment.

### *1. The current situation*

#### *a. Primary and secondary education*

Published in 2007, UNESCO's *Science, technology and gender: an international report* provides one of the most comprehensive reviews of gender issues in science, technology, math, and engineering education. This report highlights that:

- Girls do not pursue science and technical studies at the same rate as boys, though there is variation by subject area and by country. In both developed and developing countries, parents' attitudes toward boys' and girls' abilities may be an important factor in helping to explain girls' lower rates of science and technology participation.
- There are few differences between girls and boys on standardized measures of math and science achievement. International tests show some variation by country, grade level, subject area, and specific skill, but, overall, long-assumed gaps in math ability favouring

boys are narrow, if not negligible. Regional studies, moreover, show that math scores favour girls in some countries.[26]

- Science pedagogy and curricula may help to explain ongoing gender disparities in S&T interest and self-concept. Teaching strategies and materials

Some of the highest-volume S&E degree-producing countries are absent from the S&E data reported by UNESCO, including China (see textbox) and India.[31] However, recent data collection initiatives in India suggest that trends are similar. Between 2000 and 2010, women earned 34 per cent of all Ph.D. degrees awarded in India, but only 29 per cent of degrees in technical fields (defined as the natural sciences, agriculture, medicine, and engineering).[32] As in many countries, attrition was notable throughout the academic and professional pipeline. In 2010, for example, Indian women earned 32 per cent of all first-level degrees and 20 per cent of all third-level degrees in physics, but were only 11 per cent of professionally-employed physicists.[33]

**China: Drop in physics majors**

During much of the 1970s, women constituted over a third of tertiary first-degree level physics students at two of China's top universities—Beijing (42 per cent) and Nanjing (37 per cent). By 1999, women physics majors at these universities stood at only 9 per cent.

Why? The reasons are not well known. Some suggest that, in the earlier years, the government assigned women with high university entrance exams to physics in efforts to assert their equality in China's new society. Others note that the drop in numbers coincided with the opening up of China's economy to the West and a new emphasis on women's role in the family. More research is needed to understand and reverse this trend.*

*Yang J. (2002). China Debates Big Drop in Women Physics Majors. *Science* 295/5553, 263.

It is important to note that within S&T, certain fields of study attract women more than others. In the countries for which data are available, women's participation is high overall in biology, oceanography, earth, and agricultural sciences, and in environmental and biomedical engineering. For example, in the United States of America , women received 36 per cent of environmental engineering doctorates in 2008 – less than parity, but closer than in any other engineering field.[34] Fewer women are found in the physical sciences or in mechanical and electrical engineering. In Europe, for example, women make up 56 per cent of Ph.D.s in the life sciences but only 18 per cent in computer science, and in Japan women's numbers are high in agricultural science but low in physics and chemistry. In the Republic of Korea, women's participation is high in medicine and other life sciences but low in the physical sciences and math. Sex-disaggregated data of this sort are however rare, and should be collected more broadly and consistently.

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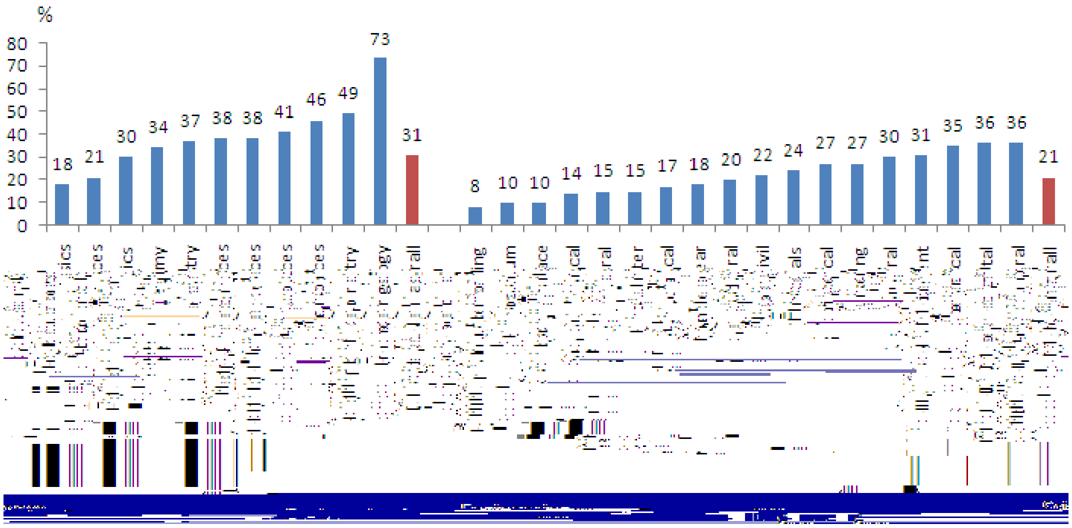
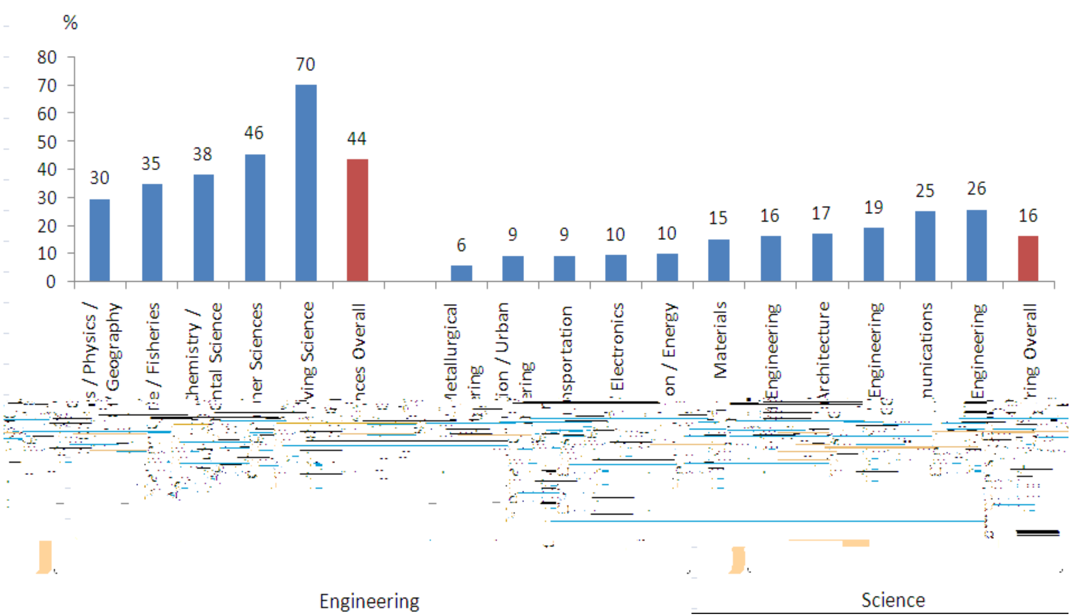
[31] Gereffi, G., Wadhwa, V., Rissing, B., & Ong, R. (2008

**Women's share of doctoral degrees in science (2007)[35] and engineering (2008)[36], United States of America :**




**Women's share of bachelor's, master's, and doctoral degrees combined among permanent employees in R&D (2007)[37], Republic of Korea:**

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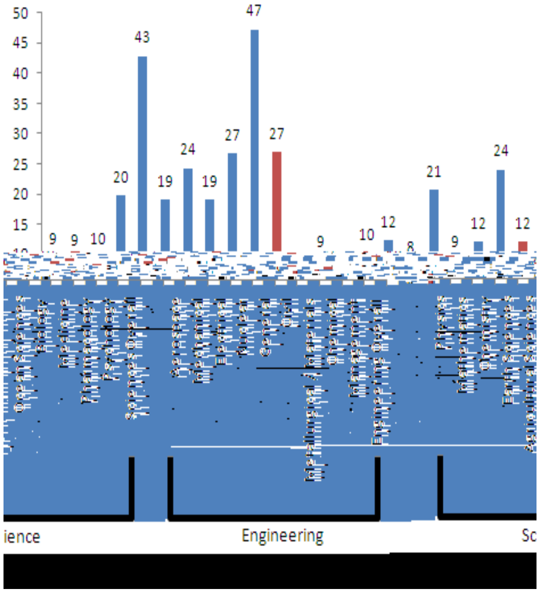
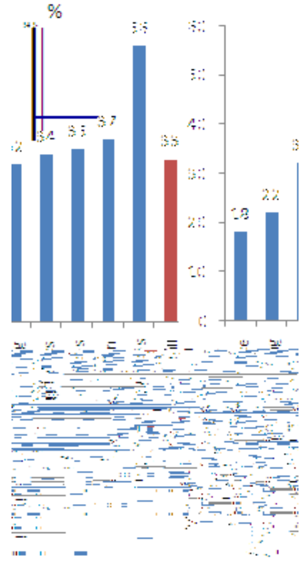
[35] NSF. (2007). *Science and Engineering Doctoral Degrees Awarded to Women, by Field: 1998–2007.* http://www.nsf.gov/statistics/wmpd/pdf/tabf-2.pdf

[36] American Society of Engineering Education. (2008). *Engineering by the Numbers.* http://www.asee.org/publications/profiles/upload/2008ProfileEng.pdf

[37] In the Republic of Korea, 'living sciences' refers to family and consumer sciences, and should not be mistaken for life sciences. Lee, K. (2010). Women in Science, Engineering, and Technology (SET) in Korea: Improving Retention and Building Capacity. *International Journal of Gender, Science, and Technology, 2 (2)*, 235-248; Korean National Institute for Supporting Women in Sc

**Women's share of science and engineering degrees by broad field (2006)[117], European Union:**



whole, suggesting that Kerala’s percentage of female researchers is likely higher than the research is conducted).[51] The percentage of women in grade A positions varies by field, with engineering and technology at the lowest (7 per cent in the EU-27, as compared with 13 per cent in the natural sciences, and 17 per cent in the medical sciences overall). The low representation of women in engineering and technology grade A positions is particularly evident in Denmark,

**Per cent women as researchers, authors of peer-reviewed publications, and authors of patents (2005)**[58]

Various programmes have been established to encourage women entrepreneurs. One successful Swedish initiative provided mentoring and legal advice to public healthcare workers, many of whom were female. The project produced several commercially-successful products, such as undergarments to improve the mobility of patients using catheters.[59] Another initiative seeks to highlight the achievements of women inventors and entrepreneurs in efforts to draw more women into the field. In 2009, the World Intellectual Property Organization (WIPO) recognized women entrepreneurs from fifteen different countries.[60] Other initiatives seek to increase the availability of venture capital to qualified women.[61]

### *2. Explanatory factors: Gender disparities in education and employment*

Why are there so few women in science and engineering? Many of the reasons for women's underrepresention are similar for S&T education and employment. These are addressed below.

#### *a. Stereotypes and cultural environments*

In many countries, engineering and the physical sciences – as communities of practice – continue to be seen, and experienced, as 'masculine'.[62] These gender stereotypes are sometimes

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[58] Naldi, F., Luzi, D., Valente, A., & Parenti, I. (2005). Scientific and Technological Performance by Gender. In Moed, H., Glänzel, W., & Schmoch, U. (Eds.), *Handbook of Quantitative Science and Technology Research* (pp. 299-314). Netherlands: Springer.

[59] Nählinder, J. (2010). Where are All the Female Innovators? Nurses as Innovators in a Public Sector Innovation Project. *Journal of Technology Management and Innovation, 5 (1),* 13-29.

[60]

unconscious, and may prevail even in people who support gender equality in science and technology. Such stereotypes may affect girls' and women's performance, self-assessment, and interest in science and engineering.

likely to approve an application with a male name than an otherwise-identical application with a female name.[72]

- A study of postdoctoral fellowship applications showed that female applicants were judged less scientifically competent than male applicants who had comparable bodies of published work. [73]

Evaluation practices may also be biased. At corporate research and development laboratories, measures of performance and perceptions of competence are often unconsciously modeled on masculine qualities of leadership, leaving female scientists at a disadvantage.[74] In a

Not only does evidence suggest cognitive bias against mothers in the hiring process (data are not specific to S&T fields)[81], but gender roles and their associated obligations, commitments, and expectations impede women's participation and advancement in scientific careers. As UNESCO states, "many women are forced to give up work or change to a part-time job (and there are few of those within S&T) unless a way can be found to combine their caring responsibilities with their current job".[82] Implicit in this statement is the reality that many male partners contribute less than an equal share to domestic life, leaving women with disproportionately large burdens.

Namrata Gupta and Arun Sharma describe how Indian women scientists grapple with the 'dual burden' of career and home. Despite this, married women usually have an advantage over single women in the S&T workplace, since single Indian women face significant social and professional barriers to collaborating with male colleagues.[83] By contrast, single and childless women scientists in the United States of America and Germany tend to have advantages in terms of career advancement.[84]

### *3. Solutions: Increasing girls' and women's participation in education and employment*

#### *a. Making S&T education female friendly*

There are several approaches to overcome gender disparities in S&T education. The first seeks to make traditionally male environments more female friendly. Recent innovations in S&T education benefit not only girls but also improve the quality of education in general.[85] These include:

- Emphasizing how S&T can effect positive social change related to health, environment, and safety.[86] For example, an introductory chemistry course might highlight the synthesis of steroids, which make birth control pills possible—a matter of special concern to women.[87]
- Implementing hands-on coursework. Prevailing gender roles mean that many male students arrive at school with practical S&T experience, such as repairing cars, using chemistry sets, etc.[88] Hands-on coursework has been shown to bolster skills and

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[81] Correll, S., Benard, S., & Paik, I. (2007). Getting a Job: Is there a Motherhood Penalty? *American Journal of Sociology, 112 (5)*, 1297-1338.

[82] UNESCO. (2007). *Science, Technology and Gender: An International Report*. Paris: UNESCO, 110.

[83] Gupta, N., & Sharma, A. (2002). Women Academic Scientists in India. *Social Studies of Science, 32,* 901-915.

[84] Ginther, D., & Kahn, S. (2009). Does Science Promote Women? Evidence from Academia, 1973—2001. In Freeman, R., & Goroff, D. (Eds.) *Science and Engineering Careers in the United States: An Analysis of Markets and Employment* (Chapter 5). Chicago: University of Chicago Press; Mason, M., Goulden, M., & Wolfinger, N. (2008). Babies Matter: Pushing the Gender Equity Revolution Forward. In Bracken, S., Allen, J., & Dean, D. (Eds.), *The Balancing Act: Gendered Perspectives in Faculty Roles and Work Lives* (Section I). Sterling, Virginia: Stylus Publishing.

[85] Margolis, J., & Fisher, A. (2002). *Unlocking the Clubhouse: Women in Computing.* Cambridge, Mass.: MIT

confidence in both male and female students without such experience, and to close achievement gaps between young men and women.[89]

- Creating collaborative learning environments. Such environments have been shown to be more attractive to women than highly-regimented classrooms.[90]
- Creating an inviting classroom. The physical layout of a classroom can be used to create a more inclusive environment—from the choice of posters displayed on the walls to seating arrangements.[91]
- Creating grading policies that provide students with insight into their standings relative to other class members. Female students tend to underestimate their class standings relative to male students— that is, a male student with a given grade will typically perceive himself to be higher in class standing than a female student with an identical grade.[92] Transparent grading can bolster female students' confidence.

One example is that of the Government of the United Republic of Tanzania, which addressed its gender gap in science and mathematics through two five-year initiatives: the Primary Education Development Program (PEDP) and Secondary Education Development Program (SEDP).[93] These programmes have implemented strategies such as annual science camps for girls and female-friendly science and mathematics course materials.[94] Concrete results have been produced: in secondary education, women's pass rates on standardized tests increased substantially between 1996 and 2000 – 38 per cent in mathematics, 17 per cent in physics, and 15 per cent in chemistry. Much remains to be done, however, especially at the tertiary level where women comprise only 3 per cent of students earning S&T degrees.[95]

***b. Changing research priorities, goals, and outcomes to increase women's participation***

Another approach to overcoming gender disparities in S&T education is to analyze what attracts women to particular fields. Educational and career choices are shaped by a range of factors, including students' performance, enjoyment, and interest in given subject matters. Fields such as the life sciences, for instance biology or environmental science, should be studied to

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[89] Burkam, D., Lee, V., & Smerdon, B. (1997). Gender and Science Learning in Early High School: Subject Matter and Laboratory Experiences. *American Educational Research Journal, 34 (2),* 297-331; Roberts, E., Kassianidou, M., & Irani, L. (2002). Encouraging Women in Computer Science. *Inroads,* June, 1-5.

[90] Faulkner, W. (2007). 'Nuts and Bolts and People': Gender-Troubled Engineering Identities. *Social Studies of Science, 37 (3),* 331-356.

[91] Cheryan, S., Plaut, V., Davies, P., & Steele, C. (2009). Ambient Belonging: How Stereotypical Cues Impact Gender Participation in Computer Science. *Journal of Personality and Social Psychology, 97 (6),* 1045-60.

[92] Barker, L., & Cohoon, J. (2009). Key Practices for Retaining Undergraduates in Computing. National Center for Women and Information Technology. http://www.ncwit.org/pdf/KeyPracticesRetainingUndergraduatesComputing_FINAL.pdf; Henwood, F. (2000). From The Women Question in Technology to the Technology Question in Feminism: Rethinking Gender Equality in IT Education. *European Journal of Women's Studies, 7,* 209-277.

[93] Machimu, G., & Minde, J. (2010). Rural Girls' Educational Challenges in Tanzania: A Case Study of Matrilineal Society. *The Social Sciences, 5 (1),* 10-15.

[94] Mungai, J. (2004). Secondary Education Development Plan (SEDP). United Republic of Tanzania Ministry of Education and Culture Education Sector Development Programme. http://planipolis.iiep.unesco.org/upload/Tanzania%20UR/Tanzania%20UR%20Secondary%20Education%20Development%20Plan.pdf

[95] Masanja, V. (2007). Gender Disparity in Science and Mathematics Education. Mathematics Department University of Dar Es Salaam, Tanzania. http://www.hbcse.tifr.res.in/episteme/episteme-1/themes/vedianamasanja%20modified.pdf

determine what about them attracts women. Current studies suggest that women are attracted to research that directly serves human needs.[96]

An example of this is found at the University of California, Berkeley, where Professor Andrew Szeri changed the demographics of his lab in mechanical engineering, a traditionally male dominated field, from a majority male to a majority female. How did he do it? "The mathematical methods upon which I rely heavily have not changed much at all," he wrote. "It is, rather, the goals of the projects which have".[97] Women joined Szeri's lab when interdisciplinary research addressed compelling social goals. Szeri's new research aims at particular socially-relevant outcomes, such as developing female-controlled HIV protection. One of the stated goals of Szeri's research is to assist women in cultures where they may have less power to say 'no' to sex or cannot rely on their partners to use condoms.

Women's preference for socially engaged research is shown also at the Technical University in Berlin, Germany, where one math course is offered through two different master's level engineering programmes. When this math course is offered in the programme for 'Engineering Science,' the students are predominately men. When this very same math course is offered in the programme for 'Global Engineering for Solar Technology,' many more women participate. The course is the same; the purpose of the programmes differs.[98]

Women's participation in research often depends upon its having clear social goals. Analyzing research priorities and social outcomes should be an integral part of basic research design—and not an 'ethical' component considered separately (see methods of sex and gender analysis #2). Researchers should examine research priorities: How are priorities set regarding what is to be known (and not known) in the context of limited resources?[99] Further, researchers should consider who will benefit in terms of wealth and well-being, and who will not, from a particular research project.

***c. Understanding women's preferences: Interdisciplinary research***

Another trend of note is that women tend to hold interdisciplinary appointments. A study at the University of California, Berkeley, in the United States of America, for example, found that 26 per cent women vs. 15 per cent men hold inter-departmental appointments. Bioengineering, one of the new interdisciplinary departments at Berkeley, has 50 per cent women on faculty.[100] A study of universities in the United Kingdom showed that women researchers engaged in interdisciplinary project more often than men across all fields (humanities, social science, and natural science).[101] This suggests that research institutions may undergo structural change as women gain equality. Established disciplines—and the prestige hierarchy among them—may change as newcomers are accommodated.

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[96] Rosser, S. (2000). *Women, Science and Society: The Crucial Union.* New York: Teachers College Press, chap. 2; Hill, C., Corbett, C., & St. Rose, A. (2010). *Why So Few? Women in Science, Technology, Engineering, and Mathematics.* Washington, D.C.: American Association of University Women Press, 23.

[97] Szeri, A. (2009). Email communication with Schiebinger, L. September 4th.

[98] Schraudner, M. (2010). Personal communication, results of study conducted at Technical University, Berlin, Germany.

[99] Harding, S. (1991). *Whose Science? Whose Knowledge.* Ithaca: Cornell University Press.

[100] National Academies. (2006). *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering*. Washington, D.C.: National Academics Press. See also Rhoten, D., & Pfirman, S. (2007). Women in Interdisciplinary Science: Exploring Preferences and Consequences. *Research Policy*, *36*, 56–75.

[101] Higher Education Funding Council of England (HEFCE). (1999). *Interdisciplinary Research and the Research Assessment Exercise*. London: Evaluation Associates Ltd.

***d. Sensitizing researchers to gender issues***

Strategies to overcome barriers to women's careers differ across nations and institutions, and are specific to local contexts. Initiatives range from benefits to support daycare and housework, flextime with regard to tenure systems or working hours, and couple hiring in addition to reevaluating how interdisciplinary research teams function, how hiring priorities are determined, how searches for qualified personnel are conducted, and the like.[102] S&T personnel need to become familiar with gender scholarship on institutional transformation. There is an urgent need to convey the findings from this body of literature to the current generation of researchers.

The question is how to train S&T researchers, both men and women. One successful North American programme, the University of Michigan's Strategies and Tactics for Recruiting to Improve Diversity and Excellence (STRIDE), took on the issue of training researchers how to avoid subtle gender bias in S&T hiring. Michigan increased its hires of women in the natural sciences and engineering from 14 per cent pre-STRIDE to 35 per cent post-STRIDE. In this programme, distinguished senior science and engineering faculty (five men and four women) were paid a stipend to learn the scholarly literature on gender bias in hiring practices. These S&T faculty then prepared a handbook that they used to teach their colleagues on hiring committees about evaluation bias and other barriers women face in academia.

The brilliance of the STRIDE programme is that these senior faculty are all regular members of departments. Because these newly trained gender experts are permanent and respected members of science and engineering faculties, knowledge concerning subtle gender bias cascades through the institution. The academic climate of opinion changes gradually as these faculty go about their day-to-day work.[103] This programme and others like it convey the many findings from gender research to S&T researchers and engage them as active participants in institutional reform.

GenSET, a project funded by European Commission (2009-2012), is another initiative that seeks to convey findings from gender scholarship to S&T researchers.[104] Through a series of workshops, this project brings together scientists, administrators, and gender experts from across Europe to produce practical guidelines to help European science institutions increase women's participation. The recommendations from GenSET workshops focus on four areas: science

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[102] See Kurup, A., Maithreyi, R., Kantharaju, B., & Godbole, R. (prepublication). *Trained Scientific Women Power:*

knowledge making, human capital, institutional practices and processes, and institutional accountability.

## D. MAINSTREAMING SEX AND GENDER ANALYSIS INTO S&T RESEARCH AND DEVELOPMENT

### 1. Developing methods of gender analysis

Western science—its methods, techniques, and epistemologies—is commonly celebrated for producing objective and universal knowledge, transcending cultural restraints. With respect to gender, ethnicity, and much else, however, science is not value-neutral. Research has documented how gender inequalities, built into society and research institutions, have influenced S&T.[105] Gender bias in research limits S&T's objectivity, development, and potential benefit to society.

**Points to consider**:

- Gender mainstreaming needs to be extended to S&T research.
- Gender experts, scientists, and engineers need to work together to develop internationally agreed upon methods of sex and gender analysis that can serve as a baseline for understanding how gender functions in research.
- S&T researchers need to be trained in methods of sex and gender analysis.
- Researchers need to consider all gender methods and think creatively about how these methods can enhance their research.

It is important to note that the terms 'sex' and 'gender' apply to both men and women. Methods of sex and gender analysis look at both biological sex and gender as a social construct as they relate to science, technology, and innovation.

Methods of sex and gender analysis for S&T are only now being developed.[107] Gender theory has had enormous impact in the humanities and social sciences over the past thirty years and is increasingly being integrated into medicine and the life sciences.[108] What is needed now is to distill and translate these often complex insights into methods readily useful to scientists and engineers. Although projects to develop such methods are currently underway in the United States of America and Europe, there is a need to develop internationally agreed upon methods of sex and gender analysis as recommended in the 2010 GenSET *Consensus Report*.[109] Internationally standardized methods must work across local knowledge systems as well as Western-style sciences and institutions. Emerging methods of sex and gender analysis are shown in the textbox below.

[107] World Health Organization. (2002). *Gender Analysis in Health: A Review of Selected Tools*. Geneva: WHO; Regitz-Zagrosek, V. (2006). Therapeutic Implications of the Gender-Specific Aspects of Cardiovascular Disease. *Nature Reviews Drug Discovery*, *5*, 1-14; Canadian Institute of Health Research (CHIR). (2010). Gender and Sex-Based Analysis in Health Research: A Guide for CIHR Researchers and Reviewers. http://www.cihr-r03(erae-9 Tw ,Bc((6t7e/3Tm9.htm)116(iEMC /P <MCID 18 0DC -0.015 Tc 0.0005179 T*0.3 Tdd(h)-4;; ) Kl; )i m)9ge,ReviI. &Wi m

**Methods of sex and gender analysis***
serve to enhance S&T policy and research. The methods listed here represent a *minimum* set of issues that policy analysts and S&T researchers should consider. As with any set of methods, researchers will fine tune methods to their specific enquiry. The value of these methods depends, as with any endeavor, on the talent and creativity of the research team.

1. **Formulating research questions/Envisioning design**
2. **Analyzing research priorities and social outcomes**
3. **Analyzing sex**
4. **Analyzing gender**
5. **Analyzing covariates (race, ethnicity, age, socioeconomic class, region, etc.)**
6. **Sampling**
7. **Analyzing reference models**
8. **Analyzing knowledge created through social divisions of labour (physical and cognitive)**
9. **Participatory research**
10. **Rethinking language and visual representation**
11. **Rethinking stereotypes**
12. **Analyzing academic disciplines**
13. **Redefining key concepts**
14. **Rethinking theory**

*See appendix

## 2. Benefits of methods of sex and gender analysis

This section provides several concrete examples of how sex and gender analysis has stimulated the creation of gender-sensitive science and technology. Each example

***b. Methods of analysis:*** It is important to critically question assumptions when ‘envisioning design’ (method #1). In much engineering design, men are taken as the norm; women are analyzed as an afterthought and often studied from the perspective of how they deviate from the norm. This means that women may be left out of the ‘discovery’ phase—as a result, many devices are adapted to women retrospectively, if at all. In this case, the three-point seatbelt was designed with no attention to pregnancy. Many caciscn-3( w)8s are -0.0fetus. Aut8s arobilees are 0.1434 Tw -21.525788.15 4

“Linda" by Volvo, the world’s first virtual pregnant crash-test dummy.

dizziness. Because women's symptoms do not match the 'accepted' (male) symptoms, women are often misdiagnosed and improperly treated.[115]

***c. Gendered innovations:*** Including women as research subjects (analyzing sex method #3) has lead to the discovery of important sex differences in MI symptoms, diagnostic testing, and preventative therapies. Further, analyzing covariates (method # 5) has led to the discovery that risk differs significantly by ethnicity and socioeconomic class. In the United States of America , African American women have 28 per cent higher CVD mortality compared to the overall female population.[116]

***d. Further comments:*** Analyzing *gender* (method #4) can also enhance women's health care. In the United States of America , women are 52 per cent more likely than men to experience delays in hospital transport after calling for emergency medical assistance.[117] The reasons are not fully understood, but a 2009 review suggests that delays result from emergency teams considering women's 'modesty' when placing chest leads during on-site EKGs or from patient choice in hospital destination.[118] Understanding this phenomenon can help medical teams overcome it.

***Example 3. Osteoporosis: Sex and gender analysis also benefits men***

***a. The problem*** It is important to understand that 'gender' relates to men as well as women. Osteoporosis is a disease traditionally seen as affecting post-menopausal women, and men have historically been excluded from osteoporosis research in much the same way as women have been excluded from CVD research. Current diagnostic criteria for osteoporosis are based on the relationship between bone mineral density (BMD) and fracture risk in postmenopausal white women, resulting in underdiagnosis of osteoporosis in men.[119] Yet men suffer from a third of all osteoporotic-hip fractures, and have higher average mortality than women with similar injuries.[120]

***b. Methods of analysis:*** Examining sex in diagnostic reference models (method #7) in osteoporosis research has broken the gender paradigm and turned attention to understanding the disease in men.

***c. Gendered innovations:*** As a result, diagnostic criteria are beginning to include men.[121]

***d. Further comments:*** Gender experts generally have not studied how science and technology fail men. Baby strollers and shopping carts are two artefacts that have been designed for women rather than men. In these cases, gender relations (the fact that women tend to care for young children and do household shopping in developed countries) have been designed into everyday

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[115] Mosca, L., Manson, J., Sutherland, S., Langer, R., Manolio, T., & Barrett-Connor, E. (1997). Cardiovascular Disease in Women: A Statement for Healthcare Professionals from the American Heart Association. *Circulation, 96,* 2468-482.

[116] American Heart Association. (2009). Women and Cardiovascular Disease Fact Sheet.

[117] Concannon, T., Griffith, J., Kent, D., Normand, S., Newhouse, J., Atkins, J., Beshansky, J., & Selker, H. (2009). Elapsed Time in Emergency Medical Services for Patients With Cardiac Complaints: Are Some Patients at Greater Risk for Delay? *Circulation, 2 (1),* 9-15.

[118] Ornato, J. (2009). Gender Delay in Emergency Medical Services: Does it Really Exist? *Circulation, 2 (1),* 4-5.

[119]

objects. These objects tend to reinforce inequalities in gender relations in that men, attempting to push a baby carriage, may experience discomfort or injury.

***Example 4. Conservation of biodiversity among the Subanen in the Philippines***

***a. The problem:*** The Subanen peoples living in the Philippines are, like many marginalized rural groups, afflicted by material poverty and often depend on natural resources for foods and medicines. However, deforestation and climate change are threatening plant biodiversity, and increased migration of young people to cities is undermining ethnobotanical knowledge.[122]

***b. Methods of analysis:*** Local knowledges play an important role in discussions of gender and S&T. Local knowledges develop over generations and are passed down, often orally, from generation to generation—often from woman to girl. Analyzing knowledge created through social divisions of labour (method #8) helps researchers understand that women may be the keepers of specific knowledges. Women are 60-90 per cent of agricultural workers in the developing world, and they are also often the first providers of family health care. As such, they have developed unique ethnobotanical knowledge about medicinal uses and processing of plants.[123] If local women are not part of the STI development process, knowledge and skills crucial to the success of a particular project may be overlooked or even destroyed.

STI policies often see women, especially women in developing countries, as 'receivers' of knowledge and technologies. Participatory research (method #9) recognizes women and men as holders of local knowledges and makes them active participants in solving local problems. Participants with local knowledges are viewed as innovators with intellectual resources to contribute to finding solutions.

***c. Gendered innovations:*** Between 2003 and 2004, the International Research Centre for Agroforestry (IRCA) worked with the Subanen community in the Philippines to help them document their ethnobotanical knowledge, much of which is held by women. The participatory research team engaged interdisciplinary experts—8 men and 5 women—from both the IRCA and the Subanen community. The project allowed the community to secure food supplies and medicines for local households in several ways. First, local women identified and documented the hundred-plus cultivars of rice they manage in order to preserve threatened strains. Second, the project recorded 200 wild forest plant species (used for sustenance when crops fail) in efforts to better preserve them. Third, the project documented medicinal plants traditionally collected in the forest so that local women can cultivate them in backyard or communal gardens.

***d. Further comments:*** Securing intellectual property rights to local knowledge—including women's knowledge—is important. A memorandum of understanding based on specific requests and stipulations of the communities was signed by all project partners.

***Example 5. Civil engineering to secure water supplies***

***a. The problem:*** Millions of people worldwide lack reliable, efficient access to water.

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[122] Suminguit, V. (2005). Indigenous Knowledge Systems and Intellectual Property Rights; An Enabling Tool for Development with Identity. Paper prepared for the Workshop on Traditional Knowledge, the United Nations and Indigenous Peoples, Panama City.

[123] Huyer, S. (2004). Gender and Science and Technology from an International Perspective. Position paper prepared for the Gender Advisory Board - United Nations Commission on Science and Technology for Development.

on women's health as a separate subject and leave it to the educator to mainstream relevant information into the basic medical curriculum.

The Gendered Innovations Project at Stanford University recently collected information about basic science and engineering courses that mainstream sex and gender.[128] Such courses are rare. More common are specialized courses on sex or gender, some of which directly relate to S&T. These courses, however, tend to be given in humanities or social science departments and not as part of basic S&T education. There is a need to collect model courses that integrate sex and gender methods into basic science education. Where these do not exist, there is a need to support interdisciplinary teams to create such courses.

In addition, there are several practical ways to encourage researchers to develop expertise in sex and gender analysis:

a. Granting agencies can require that all applicants include gender methodology in research design. The European Union has such policies (see above pp. 8-9).
b. Hiring and promotion committees can evaluate researchers and educators on their success in implementing gender analysis. Knowledge and use of methods of sex and gender analysis can be one factor taken into consideration by institutions in hiring and promotion decisions.
c. Editors of peer-reviewed journals can require sophisticated use of sex and gender methodology when selecting papers for publication. A number of journals do this: the *Journal of the American College of Cardiology*, and *Circulation*, the American Heart Association journals. *Nature* is considering adopting this policy.[129]

## E. CONCLUSION

Governments, the private sector and other stakeholders recognize that support for S&T is an essential investment for economic development. Innovations—new sciences and technologies, and their applications—can create economic returns as well as improve the well-being of citizens in terms of employment opportunities and standards of living. However, national science, technology, and innovation (STI) policies too rarely adequately address the full range of gender issues that are connected with S&T. While STI policies tend to support women's participation in S&T, they rarely consider the need for institutional transformation or the gender dimensions of research and development.

This shortcoming is also apparent at the international level. For example, the United Nations Millennium Project's Science, Technology, and Innovation Taskforce[130] stated that "women are central to economic and social development," and recognized that "reducing gender inequality is essential for reducing hunger, containing HIV/AIDS, promoting environmental

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[128] Stanford Gendered Innovations in Science, Medicine, and Engineering Project, 2009-13. Draft of the project can be viewed at: http://genderedinnovations.stanford.edu/ User id: gender; password: analysis. See 'Educators'.

[129] JACC Instructions for authors: http://content.onlinejacc.org/misc/ifora.dtl; *Circulation:* Instructions to Authors state: "Please provide sex-specific and/or racial/ethnic-specific data, when appropriate, in describing outcomes of epidemiologic analyses or clinical trials; or specifically state that no sex-based or racial/ethnic-based differences were present". http://circ.ahajournals.org/misc/ifora.shtml; *Nature* http://www.nature.com/nature/journal/v465/n7299/full/465665a.html

[130] The United Nations Millennium Project is an independent advisory body commissioned by the UN Secretary-General to propose the best strategies for meeting the Millennium Development Goals (MDGs).

sustainability" and achieving development goals generally.[131] This taskforce, however, did little to analyze how women and gender issues figure in the three platform technologies – information and communication technology, biotechnology, and nanotechnology – identified as critical for developing countries in the next decade. Several suggestions were made concerning how these technologies might be used by women, but the basic technology platforms are being developed without attention to gender.

STI plays an important role in development that will only increase in the coming years. It is crucial that gender analysis be mainstreamed into all aspects of this work, including policies, programmes, and funding arrangements. It is also important that women's organizations routinely address science and technology in their work.[132] For both STI policy makers and women's organizations, the issue may be one of lack of awareness and of training, as relatively few of them have expertise in both S&T and gender issues.

## APPENDIX: METHODS OF SEX AND GENDER ANALYSIS (short descriptions only)

**1. Formulating research questions/Envisioning design:**

Researchers should critically analyze the assumptions about sex and gender that shape their research. What does the research community assume—what are the shared preconceptions and practices? What are the researcher's own assumptions about sex and gender? Uncovering these 'blind-spots', or unexamined assumptions, may open new areas of research and ensure that research benefits both men and women.

**2. Analyzing research priorities and social outcomes:**

Researchers should consider how research priorities are set and examine social outcomes. Ethics should be part of the basic research design and not applied separately or after the fact. Key questions include: who benefits, and who does not, from a particular research project?

**3. Analyzing sex:**

Researchers should include both male and female subjects in studies, and disaggregate data by sex—whether test subjects are humans, animals, single cells, or biological products of such. Results should report: sex differences found or null finding. Research should also examine gender and other confounders (ethnicity, socioeconomic class, age, geographic region, etc.) before attributing differences between males and females to biological sex.

**4. Analyzing gender:**

Gender refers to the social attributes and opportunities associated with being male and female. These attributes, opportunities and relationships are socially constructed and are learned through socialization processes. They are context/time-specific and changeable. Any observed sex differences may in fact be caused by gendered variables, such as social divisions of labour or life styles. Researchers should analyze cultural factors related to gender when sex differences are observed.

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[131] Millennium Project. (2005). *Investing in Development: A Practical Plan to Achieve the Millennium Development Goals*. London: Earthscan Publishing; Organization for Economic Cooperation and Development (OECD). (2008). *.705 0 Td(yle4 T Td(Go)e4 s r20)iologicaOTc 0 opportu*

**5. Analyzing covariates:**

Men as well as women differ by factors such as race and ethnicity, age, socioeconomic status, geographical location, type of employment, educational background, sexual orientation, religion, and other significant aspects. Without covariate analysis, it is difficult to assign differences between groups to sex, gender, or any other specific causal factor. Understanding how these factors interact many also help to explain the effects of sex and gender.

**6. Sampling:**

Populations studied must be representative with respect to sex, gender, race, ethnicity, age, socioeconomic class, genotype, or other relevant characteristics.

**7. Analyzing reference models:**

Reference models are created as heuristic devices used to better understand physical and cultural phenomena. These models can bias research in specific ways. In much medical research, for example, males have been taken as the standard model; females are studied as deviations from that model. Reference models should be analyzed for how inclusion and exclusion bias results.

**8. Analyzing knowledge created through social divisions of labour:**

Social divisions of labour can create unique knowledges. Researchers need to recognize that men and women often have different social, cultural, physical, and cognitive experiences related to sexual divisions of labour. These experiences stem from sex differences (for example, females become pregnant and males do not) as well as gender differences (for example, men and women often have different roles in the workforce).

**9. Participatory research:**

STI policies often see women, especially women in developing countries, as ‘receivers’ of knowledge and technologies. Participatory research recognizes holders of local knowledges as active participants in solving local and global problems.

**10. Rethinking language and visual representation:**

In addition to mathematics, language is a prime glue of scientific culture, and much gender analysis has focused on the rhetoric of scientific texts and images. Analogies and metaphors construct as well as describe—they have both a hypothesis-creating and proof-making function in science. Language and images should be analyzed for unintended gendered messages.

**11. Rethinking stereotypes:**

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Like language, key concepts can both describe and construct phenomena. Researchers should scrutinize assumptions related to sex and gender in their key concepts. ‘Out-of-position’ drivers (p. 3 above) is an example of a key concept that normalizes people excluded from the standard design by conceptualizing them as ‘out-of-position’. This suggests that something is wrong with the drivers who do not ‘fit’ the design rather than something wrong with the design itself.

**14. Rethinking theory:**

Theory, in a particular field, determines what constitutes significant research, what needs explanation, and what counts as evidence. Considering gender issues may require reformulating basic theories that govern research. In evolutionary theory, for example, designating only certain stone objects, such as arrowheads and hand axes, as ‘tools’ has led theorists to see early human society as dominated by men. Shifting definitions of tools to include artefacts used for nutting,