INTERDISCIPLINARY SCIENCE REVIEWS, Vol. 36 No. 2, June, 2011, 154–67

Interdisciplinary Approaches to Achieving Gendered Innovations in Science, Medicine, and Engineering[1]

Londa Schiebinger
University of Stanford, USA

Martina Schraudner
Technical University Berlin and Fraunhofer Gesellschaft, Germany

'Gendered Innovations' is defined as the process that integrates sex and gender analysis into all phases of basic and applied research to assure excellence and quality in outcomes. Gendered Innovations enhance excellence in science, medicine, and engineering both in terms of knowledge and personnel; they lead to gender-responsible science and technology, and seek to enhance the lives of women and men globally. This paper presents three approaches to gender equality taken by policy makers, institutional administrators, and scientists and engineers over the past three decades. These approaches include: 1) fixing the numbers of women in science, medicine, and engineering; 2) fixing research institutions by removing barriers and transforming structures; 3) fixing knowledge by incorporating gender analysis into basic and applied research. This paper treats each of these approaches but focuses on the third approach — 'Gendered Innovations' — by presenting concrete examples of how gender analysis has enhanced scientific knowledge and technology design. Realizing the full potential of gendered innovations in the next decade will require deep interdisciplinary collaborations between gender experts, natural scientists, and engineers. Realizing the full potential of gendered innovations will also require international coordination, as recommended in the 2010 European Commission genSET Consensus Report and the 2011 United Nations resolutions on Gender, Science and Technology.

KEYWORDS Gendered innovation, Women in science, Gender in science, Sex differences, Gender differences, Gender dimension

Gendered innovation uses gender as a dimension of quality in research process and in the transfer of ideas to markets. It introduces new analytical

DOI 10.1179/030801811X13013181961518
Published by Maney on behalf of the Institute

perspectives for considering the role of gender/sex similarities/differences as determinants of outcomes. To better understand gendered innovations, we distinguish three approaches taken by policy makers, institutional administrators, and scientists and engineers over the past three decades (Schiebinger 1999; 2008). The first focuses on programmes designed to increase women's participation. The second approach seeks to increase women's participation by transforming research institutions. The third focuses on overcoming gender bias in science and technology by designing gender analysis into all phases of basic and applied research — from setting priorities, to funding decisions, to establishing project objectives and methodologies, to data gathering, to evaluating results, and transferring ideas to markets. All three approaches are necessary for gendered innovations: it is important to point out, however, that increasing women's participation in science and engineering will not be successful without restructuring institutions and incorporating gender analysis into research.

The ultimate goal of gendered innovations is to enhance scientific and technological excellence. Research must 'control' for sex and gender. Sex and gender analysis act as yet further controls — one set among many standard methodologies — that serve to provide critical rigour in science. Gendered innovations also seek to create gender excellence; that is to say, to build inclusive scientific communities where men and women share equally at all levels in decision making, policy, and defining and carrying out research. Gendered innovations seek: 1) to create gender equality; 2) to enhance creativity; 3) to stimulate economic and technological development (or business innovation); 4) to make research more responsive to society. Innovation is what makes the world tick. Including gender analysis in science, medicine, and engineering can spark creativity by offering new perspectives, posing new questions, and opening new areas to research.

Fixing the numbers of women in science, medicine, and engineering

The first and most straightforward approach to gendered innovations focuses on programmes to increase the participation of women in science, medicine, and engineering. The rationale is that the dearth of women scientists and engineers is a 'pipeline' problem and that more women need to be trained in technical fields.

Efforts in this area began in the 1980s as national governments and international agencies began collecting sex-disaggregated data to monitor women's participation. In 1982, the US National Science Foundation (NSF) published the first congressionally mandated report, *Women and Minorities in Science and Engineering* (NSF 1982). In 2003, the European Commission's Directorate-General (DG) for Research & Innovation published its first *She Figures,* reporting trends in women's participation across EU member states (European Commission 2003a).

In 1989, the US NSF established a Task Force on Programs for Women which sought to support women's careers in science and engineering by increasing women's research funding, teaching women negotiation skills, and setting up mentoring networks — or, more generally, making women more competitive in the scientific workplace (Rosser 2008). The European

Commission recommended similar measures in its 2000 European Technology Assessment Network (ETAN) report, issued by the Helsinki group (ETAN 2000).

This first approach seeks to increase women's participation by supporting women's education and careers. While critically important, this approach has also been criticized for 'fixing the women'. The implicit assumption is that science, medicine, and technology institutions and research are gender neutral. Consequently, this approach fails to look beyond women's careers to the need to reform scientific institutions and research methods. Achieving gender equality requires examining gendered divisions of labour in society at large and in science in particular, as well as considering how research is conceptualized and carried out.

Fixing the institutions: transforming structures and removing barriers

Despite claims to objectivity and value-neutrality, academic institutions have identifiable cultures that have developed over time — and, historically, in the absence of women (Hopkins 2006, 16; Margolis and Fisher 2002; Rosser 1994; Schiebinger 1989). To the extent that Western-style science has been replicated around the world, institutional structures, cultural stereotypes, and divisions of labour disadvantage women's participation. The second general approach taken by government policy makers and academic administrators seeks to increase gender equality by transforming research institutions. Beginning in 1993, the US NSF implemented programmes designed to create 'positive and permanent changes in academic, social, and scientific climates: in classrooms, laboratories, departments, institutions and organisations' (Rosser 2008).

The NSF's robust ADVANCE programme, launched in 2001, has made the US a global leader in institutional transformation. This model programme assists institutions (not individuals) in implementing structural changes to improve women and underrepresented minorities' success in science and engineering. Institutional reform ranges from counteracting subtle gender and ethnic bias in hiring and promotion practices to restructuring work/life balance by offering parental leave, supporting dual careers as well as child- and elder-care, and allowing for career breaks (NSFa; NSFb; Lavaque-Manty and Stewart 2008, 165–81; Schiebinger *et al*. 2008).

In 2010, the European Commission also moved to the institutional level, funding projects that encourage research organizations and universities to implement multi-year action plans to address institutional barriers, such as recruitment, promotion, retention policies and practices, management and research assessment standards, and policies for dual-career couples and career breaks (European Commission 2010b). In Germany, universities have agreed to increase substantially the number of women leaders in decision-making positions by the year 2013 (Deutsche Forschungsgemeinschaft).

Much remains to be done to restructure research and educational institutions to achieve gender equality. The goals here is to create conditions that allow both men and women's careers to flourish — conditions that allow all faculty members to achieve at the highest level.

This second policy approach focuses on institutional reform while often assuming that what goes on inside institutions — basic and applied research — is gender neutral. Restructuring institutions is important, but must be supplemented by efforts to eliminate gender bias from research and design. Change needs to come also at a third level: gendered innovations in scientific knowledge and technology design.

Fixing the knowledge: enhancing excellence by mainstreaming gender analysis into basic and applied research

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 science, medicine, and technology (Institute of Medicine 2010; Klinge 2010; Wajcman 2007; Bührer and Schraudner 2006; Faulkner 2006; Schiebinger 1993; Harding 1991). Gender bias in research limits scientific creativity, excellence, and benefits to society. Gender bias in research can also be expensive: Between 1997 and 2000, 10 drugs were withdrawn from the United States market because of life-threatening health effects — four of these were more dangerous to women. Part of the problem is that preclinical research uses primarily male animals (Beery and Zucker 2011; Wald and Wu 2010; Zucker and Beery 2010; US GAO 2001).

The global leader in terms of this policy approach is the European Commission's DG Research & Innovation. In the 6th EU Framework Programme (FP6, 2002–2006), the DG Research & Innovation implemented its cutting-edge policy requiring that grantees applying for the largest grants (the Integrated Projects and Networks of Excellence grants) include a 'gender dimension' in research. As stated in the call for proposals, research design must specify 'whether, and in what sense, sex and gender are relevant in the objectives and the methodology of the project' (European Commission 2003b). The EU, however, scaled back its innovative research requirement in the FP7 (2007–2013) because few researchers understood how to addressing gender in research (CSES 2009).

Where do other granting agencies stand on this issue? The DG Research & Innovation is one of the few research organizations that requires grantees to address gender analysis in applications for all fields, although several European countries also include this as part of their national science policies — see, for example, Norway (Research Council of Norway)[2] and Spain (Sanchez de Madariaga 2011). The US NSF currently has no programmes that address these issues. Most recently, the Bill and Melinda Gates Foundation has committed to including gender analysis in their agricultural grants (Gates Foundation).

Policies requiring researchers to integrate gender analysis into research are more common in health research organizations. Since 1993, the US National Institutes of Health has required researchers to reconceptualize medical research to include women and minorities in federally-funded research, though this has not been rigorously enforced (NIH 1993). The World Health Organisation mainstreams gender analysis into all 'research, policies, programmes, projects, and initiatives' (WHO 2002). The Canadian Institutes of Health Research has committed to 'Integrating Sex and Gender into Health Research' (CIHR 2003). 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 (Haafkens and Klinge 2007).

Gender mainstreaming, adopted by the United Nations Fourth World Conference on Women in Beijing (1995), entails the systematic integration of gender equality into all systems and structures, policies, programmes, processes and projects, into ways of seeing and doing (Rees 2002). Gender mainstreaming now needs to be expanded to include gender analysis in basic and applied research. Mainstreaming gender analysis into research creates 'Gendered Innovations'.

Creating new knowledge and design

Gendered innovations use gender as a resource to create new knowledge. It is crucially important to identify gender bias and understand how it operates in science, medicine, and engineering. But analysis cannot stop there: focusing on bias is not a productive strategy. Gender experts are now shifting emphasis away from critique towards a positive research programme that employs gender analysis as a *resource* to achieve excellence in science, medicine, and engineering (Klinge 2008; Schiebinger 2008; Wajcman 2007; Schraudner and Lukoschat 2006; Faulkner 2001).

There is an urgent need for gender experts, natural scientists, and engineers to work together to develop internationally agreed upon methods of sex and gender analysis that can serve as a basis for understanding how gender functions in research. Gender analysis must become an integral part of identifying priorities and designing research. As the World Health Organisation states, 'It is not enough simply to 'add in' a gender component late in a given project's development. Research must consider gender from the beginning' (WHO). Sex and gender analysis act as yet further controls — one set among many — providing critical rigour in science, medicine, and engineering research, policy, and practice.

The European Commission DG Research & Innovation currently seeks to train researchers in how to integrate sex and gender analysis into research (Yellow Window 2009). In 2006, Fraunhofer Gesellschaft, the German industrial applied research engine, was funded by the German Ministry for Education and Research to prepare a checklist to help technology designers and engineers identify key gender components of their projects (Schraudner 2010; Bührer and Schraudner 2006; Schraudner and Lukoschat 2006). The Austrian 'FEMtech' and Danish 'Female Interaction' projects, funded by national governments, also operationalize sex and gender analysis for designers (FEMtech; Schröder 2010).

These projects demonstrate that more systematic approaches are required. In 2009, the Clayman Institute for Gender Research at Stanford University initiated the Gendered Innovations in Science, Medicine, and Engineering Project (Gendered Innovations). This project has been expanded internationally through a collaboration with the European Commission in 2011 entitled Innovation through Gender. Systematic methods of sex and gender analysis are being produced in a series of expert meetings in 2011 and 2012. These meetings bring together gender experts, basic scientists, engineers, public health and medical experts, policy makers, and technology designers.
The purpose is to develop practical methods of sex and gender analysis for researchers. Emerging methods of sex and gender analysis are listed in Figure 1.

Methods of Sex and Gender Analysis
serve to enhance scientific and technological excellence. The methods listed here represent a *minimum* set of issues that 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 intellectual endeavour, on the talent and creativity of the research team.

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

FIGURE 1 Emerging Methods of Sex and Gender Analysis

The Gendered Innovation project demonstrates methods through case studies. Each section below presents a case study highlighting a problem, a method of sex or gender analysis important to overcoming the problem, and a solution, or gendered innovation.

Example 1. Technology design: pregnant crash test dummies

a. The problem: Conventional seatbelts do not fit pregnant women properly, and in the US, 82% of foetal deaths with known causes result from motor vehicle collisions (Weiss *et al.* 2001, 1863). Because millions of pregnant women drive every year, the use of seatbelts in pregnancy is a major safety concern (Ventura *et al*. 2001, 1). When a lap belt is placed over (rather than under) the pregnant belly, force transmitted through the uterus increases three- to fourfold (Pearlman and Viano 1996, 977). Seatbelts were first installed in automobiles in the 1950s, and commonly used since the late 1980s. However, it was not until 1996 that researchers invented pregnant crash test dummies to test crash safety in foetuses. Even today, governments for the most part do not mandate pregnant crash test dummies in automobile safety testing.

b. Methods of analysis — # 7 Reference models (Figure 1): In much engineering design, men are taken as the norm; women are analysed 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 years later, a supplementary strap was developed (to hold conventional lap belts in place) in efforts to fix the original design. A better solution might be a completely new basic design, a four-point seatbelt, perhaps, that works without a lap belt (Duma *et al.* 2006, 1). From the start, devices should be designed for a broad population to enhance safety and ensure a broad user base.

c. Gendered innovation: Solutions to safety testing are emerging from Sweden. Volvo's 'Linda', designed in 2002 by mechanical engineer Laura Thackray, is the world's first computer simulated pregnant crash-test dummy (Figure 2). 'Linda' generates data modelling the effects of high-speed impact on a woman and foetus. Automobile manufacturers, however, have yet to implement an alternative to the three-point seat belt.

d. Further comments: Using methods of sex and gender analysis from the beginning would have helped engineers avoid leaving out pregnant women. Sampling (method #6, Figure 1) encourages designers to study user populations and to include both men and women in design development. These men and women should represent people from different regions, social classes, ages, reproductive status, etc. Analysing sex (method #3, Figure 1) encourages designers to look at sex-specific characteristics of men and women. Pregnancy should not be overlooked.

Example 2. Civil engineering to secure water supplies

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

b. Methods of analysis: Analysing social divisions of labour (method #8, Figure 1) helps researchers understand who in a community holds the knowledge required for a particular project. Women, as traditional water fetchers, often have specialized knowledge concerning water sources. Participatory research (method #9, Figure 1) calls for women with specialized knowledge to be engaged in development projects from the start. Increased diversity in research teams helps to enhance results.

c. Gendered innovation: Social divisions of labour in much of Africa make water procurement women's work. Consequently, women have detailed

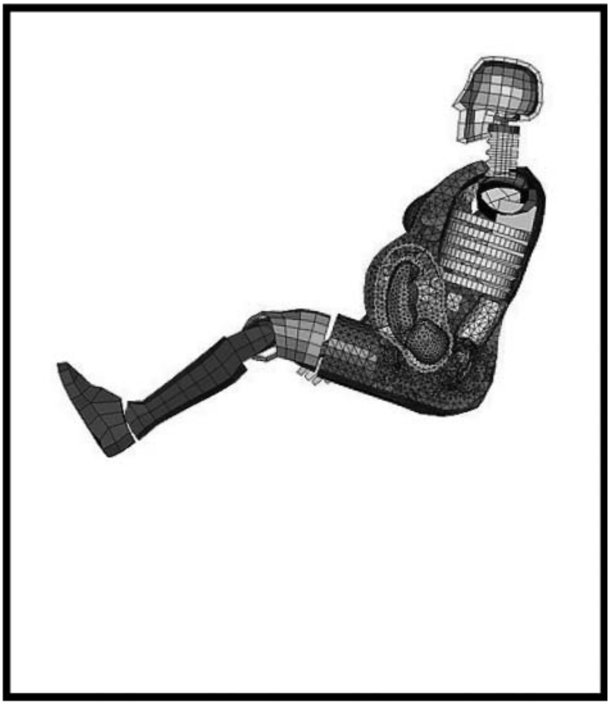

FIGURE 2 'Linda' by Volvo, the world's first virtual pregnant crash-test dummy.

FIGURE 3 Woman in the Volta region of Southeast Ghana mapping well sites. *Image courtesy of Afram Plains Development Organisation (APDO), and water.org*

knowledge of soils and their water yield. A study of water projects in 13 nations revealed that 'equal representation and participation by women contributes to the success of community-managed water services' (Postma *et al*. 2003, 13). Women's participation correlates strongly with project sustainability as well (Gross *et al*. 2001).

Example 3. Medical research: cardiovascular disease

a. The problem: Cardiovascular disease is the leading cause of death for women in the United States, Europe, and in many developed countries (American Heart Association 2011). Despite this, cardiovascular disease has long been defined as a male disease, and clinical standards and treatments have been developed for men.

b. Methods of analysis: Researchers must analyse disease reference models (method #7, Figure 1). In the case of cardiovascular disease, myocardial infarction or 'heart attack' symptoms were modelled in men and the results generalized to the entire population. Symptoms, however, can differ between men and women. Men typically experience pain in the chest and left arm. Women often experience chest pain along with a series of less recognized symptoms, such as nausea and vomiting, pain in the right arm and back, fatigue, cold sweat, and dizziness. Because women's symptoms do not match 'standard' (male) symptoms of myocardial infarction, women are often misdiagnosed and improperly treated (Mosca *et al.* 1997, 2468).

c. Gendered innovation: Including women as research subjects (analysing sex, method #3, Figure 1) has led to the discovery of important sex differences in myocardial infarction symptoms, diagnostic testing, and preventative therapies. Further, analysing covariates (method #5, Figure 1) has led to the discovery that risk differs significantly by ethnicity and socioeconomic class. In the United States, African-American women have 28% higher cardiovascular disease mortality compared to the overall female population (American Heart Association 2011).

Example 4. Osteoporosis: sex and gender analysis also benefits men

a. The problem: It is important to understand that gender analysis relates to men as well as women. Osteoporosis is a disease traditionally seen as affecting postmenopausal women, and men have historically been excluded from osteoporosis research in much the same way as women have been excluded from cardiovascular disease 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 under-diagnosis of osteoporosis in men (Faulkner and Orwoll 2002, 87). Yet men suffer from a third of all osteoporotic-hip fractures, and have higher average mortality than women with similar injuries (Sweet *et al.* 2009, 193).

b. Methods of analysis: Examining sex in diagnostic reference models (method #7, Figure 1) in osteoporosis research has broken the gender paradigm and turned attention to understanding the disease in men.

c. Gendered innovation: Diagnostic criteria are beginning to include men (Cummings *et al*. 2006, 1550).

Example 5. Stem cells: analysing sex

a. The problem: Stem cell research has failed to evaluate differences between XX and XY stem cells (Wizemann *et al*. 2001). By failing to consider sex, researchers may be overlooking important aspects of how XX and XY cells work differently in human bodies.

b. Method of analysis: Analysing sex (method #3, Figure 1) — both reporting sex and designing research to analyse data by sex — can lead to important breakthroughs. Researchers need to: 1) identify the sex of cell lines; 2) prospectively design experiments for meaningful analysis of sex differences of results (not all sex differences will be significant); 3) record and format data in ways that allow for systematic review or meta-analysis.

c. Gendered innovation: Sex analysis is beginning to reveal that the sex of stem cells matters: clinical outcomes of stem cell transplantation can differ depending on the sex of donor cells used, the sex of the host, the type of stem cells transplanted, and the disease being treated (Csete 2008, 232).

Conclusion and recommendations

Employing gender analysis to stimulate innovation in science, medicine, and engineering involves interdisciplinary coordination throughout the research process — from making policy about what fields of research to fund, to refining methods of sex and gender analysis in basic and applied research, to the process of hiring and promoting faculty, to the reviewing of manuscripts for publication. Realizing the full potential of gendered innovations in the next decade will also require international cooperation to match the global reach of science and technology, as recognized in the European Commission's genSET *Consensus Report* and the United Nations resolutions on Gender, Science and Technology (genSET 2010, 6; UN Women 2011).

Once methods of sex and gender analysis are in place, there are a few further steps. These involve both researchers and research institutions:

1. **Train current researchers** and evaluators in gender methodology. The genSET project offers a good model for how to engage researchers as active participants in gendered innovations (genSET 2010).
2. **Hold senior management accountable** for developing evaluation standards that take into account proper implementation of sex and gender analysis in research. There are several practical ways to encourage researchers to develop proficiency in sex and gender analysis:
   a. **Granting agencies** can require that all applicants specify whether, and in what sense, sex and gender are relevant in the objectives and the methodology of their project. Research projects that fulfil this criterion might achieve a higher score for funding. Researchers might also achieve this score by demonstrating that sex or gender is not relevant to a particular project. It is important, however, that the issue be addressed.
   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 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*, the *Canadian Medical Association Journal*, and *Circulation*[3], the American Heart Association journal. *Nature* is considering adopting this policy (Nature Editorial 2010, 665). Journals should also enforce consistent use of key words such as 'sex' and 'gender' to facilitate meta-analysis.

3. **Train the next generation** in methods of sex and gender analysis. Sex and gender analysis should be taught throughout the curriculum, including basic science, medicine, and engineering courses. It is important that research institutions support programmes in gender research where experts develop new knowledge concerning gender, science, medicine, and technology. Yet at the same time, gender analysis must also be taught to future scientists and engineers. In this way, students in technical fields learn methods of sex and gender analysis continuously throughout their studies. Textbooks should be revised to integrate sex and gender results and methods.

Innovation has been placed at the heart of the Europe 2020 strategy (European Commission 2010a). Innovation is seen as a way to address major social problems as well as stimulate economic development. Gendered innovations in science, medicine, and engineering employ sex and gender analysis as a resource to stimulate creativity, and by doing so enhance the lives of both men and women. As this paper suggests, gender analysis sparks creativity by offering new perspectives, posing new questions, and opening new areas to research. Can we afford to ignore such opportunities?

Notes

1 Parts of this paper were included in a keynote address for the Oesterreichische Forschungsgemeinschaft by Londa Schiebinger and have been published in their proceedings: *Wissenschaft und Gender*, ed. Gottfried Magerl, Reinhard Neck, and Christiane Spiel. Vienna: Boehlau, 2011.

2 'The Research Council views it as essential that gender perspectives are given adequate consideration in research projects where this is relevant. Good research must take into account biological and social differences between women and men, and the gender dimension should be one of the main pillars of the development of new knowledge. In research projects this dimension may be manifested through the research questions addressed, the theoretical approaches chosen, the methodology applied, and in the efforts to assess whether the research results will have different implications for women and men'.

3 *Circulation* (Journal of the American Heart Association) Instructions for 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://content.onlinejacc.org/misc/ifora.dtl. (10/2/11)

Bibliography

American Heart Association (AHA). 2011. *Women, heart disease and stroke.* Dallas, TX: American Heart Association.

Beery, Annaliese K. and Irving Zucker. 2011. Sex Bias in Neuroscience and Biomedical Research. *Neuroscience and Biobehavioral Reviews*, 35(3): 565–572.

Bührer, Susanne, and Martina Schraudner, eds. 2006. *Wie können Gender-Aspekte in Forschungsvorhaben erkannt und bewertet werden?* Karlsruhe: Fraunhofer Verlag.

Canadian Institutes of Health Research (CIHR), Institute of Gender and Health. 2003. *What's sex and gender got to do with it? Integrating sex and gender into health research.* Ottawa: CIHR Publishing Office.

Centre for Strategies and Evaluation Services (CSES). 2009. *Monitoring progress towards gender equality in the Sixth Framework Programme. Synthesis report.* Luxembourg: Publications Office of the European Commission.

Csete, Marie. 2008. Gender issues in transplantation. *Anesthesia and analgesia* 107: 232–8.

Cummings, Steven R., Peggy M. Cawthon, Kristine E. Ensrud, Jane A. Cauley, Howard A. Fink, and Eric S. Orwoll. 2006. Bone Mineral Density (BMD) and risk of hip and nonvertebral fractures in older men: A prospective study and comparison with older women. *Journal of Bone and Mineral Research* 21: 1550–56.

Deutsche Forschungsgemeinschaft. *The DFG's research-oriented standards on gender equality*. German Research Foundation. http://www.dfg.de/download/pdf/foerderung/grundlagen_dfg_foerderung/chancengleichheit/forschungsorientierte_gleichstellungsstandards_en.pdf. (9/2/11)

Duma, Stefan M., David M. Moorcroft, Hampton C. Gabler, Sarah M. Manoogian, Joel D. Stitzel, and Greg G. Duma. 2006. Analysis of pregnant occupant crash exposure and the potential effectiveness of four-point seatbelts in far side crashes. *Virginia Tech — Wake Forest Center for Injury Biomechanics Accident Reconstruction Newsletter,* March 7.

European Commission. 2003a. *She figures*. Luxembourg: Office for Official Publications of the European Communities.

European Commission. 2003b. *Vademecum: Gender mainstreaming in the Sixth Framework Programme — Reference guide for scientific officers and project officers.* Brussels: Directorate-General for Research.

European Commission. 2010a. *Europe 2020 Flagship Initiative. Innovation Union. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions*. http://ec.europa.eu/research/innovation-union/pdf/innovation-union-communication_en.pdf. (10/2/11)

European Commission. 2010b. Work Programme, Science in Society, Implementing Structural Change in Research Organisations/Universities.

European Technology Assessment Network (ETAN) Expert Working Group. 2000. *Science policies in the European Union.* Brussels: European Commission.

Faulkner, Ken, and Eric Orwoll. 2002. Implications in the use of T-scores for the diagnosis of osteoporosis in men. *Journal of Clinical Densitometry* 5: 87–93.

Faulkner, Wendy. 2001. The technology question in feminism: A view from feminist technology studies. *Women's Studies International Forum* 24: 79–95.

Faulkner, Wendy. 2006. Genders in/of engineering. *University of Edinburgh Economic and Social Research Council*, March 1.

FEMtech. Femtech FTI Projekte. *Eine Initiative des Bundesministeriums für Verkehr, Innovation und Technologie*. http://www.femtech.at/index.php?id=44. (10/2/22)

Gates Foundation. *Gender checklist. Knowledge networking for rural development in the Asia-Pacific region* (ENRAP). http://www.enrap.org/events/ifad-events/Checklist%20Gender%20Gates%20Foundation%20April%2008.pdf/at_download/file. (9/2/11)

Gendered Innovations in Science, Medicine, and Engineering. http://www.stanford.edu/group/gender/GenderedInnovations/index.html. (9/2/11)

genSET. 2010. *Recommendations for action on the gender dimension in science.* London: Portia. http://www.genderinscience.org/resources.html. (21/3/2011)

Gross, Bruce, Christine van Wijk, and Nilanjana Mukherjee. 2001. *Linking sustainability with demand, gender, and poverty: A study in community-managed water supply projects in fifteen countries.* Delft, Netherlands: IRC International Water and Sanitation Centre.

Haafkens, Joke, and Ineke Klinge. 2007. *Promoting attention to the gender dimension in health research: Experiences from three centres of excellence in the European Union.* Maastricht: Universiteit Maastricht Centre for Gender and Diversity and Care and Public Health Research Institute.

Harding, Sandra. 1991. *Whose science? Whose knowledge? Thinking from women's lives.* Ithaca: Cornell University Press.

Hopkins, Nancy. 2006. Diversification of a university faculty: Observations on hiring women faculty in the schools of science and engineering at MIT. *Massachusetts Institute of Technology (MIT) faculty newsletter* XVII: 1–22.

Institute of Medicine (IOM). 2010. *Women's health research: Progress, pitfalls, and promise*. Washington, DC: National Academies Press.

Klinge, Ineke. 2008. *GenderBasic: Promoting integration of the gender dimension in biomedical and health-related research*. Maastricht: Centre for Gender and Diversity, School for Public Health and Primary Care.

Klinge, Ineke. 2010. How incorporation of sex and gender in research will lead to better healthcare. In *Sex and gender in biomedicine: Theories, methodologies, results*, ed. Klinge, Ineke and Claudia Wisemann, 15–33. Göttingen: Universitätsverlag Göttingen.

Lavaque-Manty, Danielle, and Abigail Stewart. 2008. A very scholarly intervention: Recruiting women faculty in science and engineering. In *Gendered innovations in science and engineering*, ed. Londa Schiebinger, 165–81. Stanford: Stanford University Press.

Margolis, Jane, and Allan Fisher. 2002. *Unlocking the clubhouse: Women in computing.* Cambridge: Massachusetts Institute of Technology (MIT) Press.

Mosca, Lori, JoAnn E. Manson, Susan E. Sutherland, Robert D. Langer, Teri Manolio, and Elizabeth Barrett-Connor. 1997. Cardiovascular disease in women: A statement for healthcare professionals from the American Heart Association. *Circulation* 96: 2468–82.

National Institutes of Health (NIH). 1993. Public Law 103–43, Subtitle B, Clinical Research Equity Regarding Women and Minorities.

National Science Foundation (NSFa). *ADVANCE — Increasing the participation and advancement of women in academic science and engineering careers*. http://www.nsf.gov/pubs/2009/nsf0941/nsf0941.pdf. (9/2/11)

National Science Foundation (NSFb). ADVANCE — Institutional Transformation Awardee Websites. NSF. http://www.nsf.gov/crssprgm/advance/itwebsites.jsp. (9/2/11)

National Science Foundation (NSF). 1982. *Women and minorities in science and engineering.* Washington, DC: National Academies Press.

Nature Editorial. 2010. Putting gender on the agenda. *Nature* 465: 665.

Pearlman, Jerome, and David Viano. 1996. Automobile crash simulation with the first pregnant crash test dummy. *American Journal of Obstetrics & Gynecology* 175: 977–81.

Postma, Leoine, Christine van Wijk, and Corine Otte. 2003. Participatory quantification in the water and sanitation sector. *Participatory Learning and Action (PLA) Notes* 47: 13–18.

Rees, Teresa. 2002. *National policies on women and science in Europe: A report about women and science in thirty countries.* Luxembourg: Office for Official Publications of European Communities.

Research Council of Norway. Researcher Project. Research Council Application Information. http://www.forskningsradet.no/en/Researcher_project/1195592882768. (9/2/11)

Rosser, Sue. 1994. *Women's health — missing from US medicine.* Bloomington: Indiana University Press.

Rosser, Sue V. 2008. Building two-way streets to implement policies that work for gender in science. In *Gendered innovations in science and engineering*, ed. Londa Schiebinger, 182–97. Stanford: Stanford University Press.

Sanchez de Madariaga, Inés. 2011. Director, Women and Science Unit, Ministry of Research, Spain. Personal communication: Spain's Law of Science, Technology and Innovation, passed March 2011, promotes gender as a 'category of analysis, so that its relevance is considered in all aspects of the process: definition of priorities of scientific and technological research; of research problems; in theoretical and explanatory frameworks, methods, collection and interpretation of data, and findings'. According to the law, 'gender shall also be considered in applications and technological developments, and in proposals for future studies'.

Schiebinger, Londa. 1989. *The mind has no sex? Women in the origins of modern science.* Cambridge: Harvard University Press.

Schiebinger, Londa. 1993. *Nature's body: Gender in the making of modern science.* Boston: Beacon Press.

Schiebinger, Londa. 1999. *Has feminism changed science?* Cambridge: Harvard University Press.

Schiebinger, Londa, ed. 2008. *Gendered innovations in science and engineering.* Stanford: Stanford University Press.

Schiebinger, Londa, Andrea D. Henderson, and Shannon K. Gilmartin. 2008. *Dual-career academic couples: What universities need to know*. Stanford: Stanford University Press.

Schraudner, Martina. 2010. Gender and innovation: Fraunhofer's 'discover gender' research findings. In *The innovation potential of diversity — practical examples for the innovation management*, ed. Anne Spitzley, Peter Ohlhausen, and Dieter Spath, 169–82. Karlsruhe: Fraunhofer Verlag.

Schraudner, Martina, and Helga Lukoschat, eds. 2006. *Gender als Innovationspotenzial in Forschung und Entwicklung*. Karlsruhe: Fraunhofer Verlag.

Schröder, Klaus. 2010. Gender dimensions of product design. Paper presented at the Gender, Science, and Technology Expert Group meeting of the United Nations Division for the Advancement of Women (UN-DAW), 28 September–1 October, Paris, France.

Sweet, Mary G., Jon M. Sweet, Michael P. Jeremiah, and Sim S. Galazaka. 2009. Diagnosis and treatment of osteoporosis. *American Family Physician* 3: 193–200.

UN Women. 2011. Gender, Science and Technology, Agreed Conclusions. http://www.un.org/womenwatch/daw/csw/55sess.htm#agreed. (26/3/11)

United States General Accounting Office (US GAO). 2001. *Drug safety: Most drugs withdrawn in recent years had greater health risks for women.* Washington, DC: Government Publishing Office.

Ventura, Stephanie J., William D. Mosher, Sally C. Curtin, and Joyce C. Abma. 2001. Trends in pregnancy rates for the United States, 1976–97: An update. *National Vital Statistics Report* 49: 1–9.

Wajcman, Judy. 2007. From women and technology to gendered technoscience. *Information, Communication, and Society* 10: 287–98.

Wald, Chelsea, and Corinna Wu. 2010. Of mice and women: The bias in animal models. *Science* 327: 1571–2.

Weiss, Harold B., Thomas J. Songer, and Anthony Fabio. 2001. Fetal deaths related to maternal injury. *Journal of the American Medical Association* 286: 1863–8.

Wizemann, Theresa, and Mary-Lou Pardue, eds. 2001. *Exploring the biological contributions to human health: Does sex matter?* Institute of Medicine. Washington, DC: National Academy Press.

World Health Organisation (WHO). What is Gender Mainstreaming? Gender, Women, and Health. http://www.who.int/gender/mainstreaming/en/index.html. (9/2/11)

World Health Organisation (WHO). 2002. *Integrating gender perspectives in the work of WHO*. Geneva: WHO Publishing.

Yellow Window Management Consultants. 2009. *Toolkit: Gender in EU-funded research*. Brussels: Directorate-General for Research.

Zucker, Irving, and Annaliese K. Beery. 2010. Males still dominate animal studies. *Nature* 465: 690.

Notes on contributors

Londa Schiebinger is the John L. Hinds Professor of History of Science in the History Department at Stanford University, and Director of the EU/US Gendered Innovations in Science, Medicine, and Engineering Project. From 2004–2010, Schiebinger served as the Director of Stanford's Clayman Institute for Gender Research. Her current work explores Gendered Innovations in Science, Medicine, and Engineering. Londa Schiebinger presented the keynote address and wrote the background paper for the United Nations' Expert Group Meeting on Gender, Science, and Technology in Paris, September 2010.

Correspondence to: schieb@stanford.edu

Martina Schraudner is Professor of Gender and Diversity in Organisations at the Institute for Machine Tools and Factory Management at the Technical University of Berlin and develops new strategic tools in research planning for Fraunhofer. She has undertaken first steps in establishing gender mainstreaming strategies for research institutions in Germany especially by integrating gender aspects in different research themes.

Martina Schraudner has served in several innovation committees of the German government and the European Commission.

Correspondence to: martina.schraudner@zv.fraunhofer.de