Gendered innovations

Mainstreaming sex and gender analysis into basic and applied research

Meta-analysis of gender and science research – Topic report

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This is one of the thematic reports of the study *Meta-analysis of gender and science research*, a project of the 7th RTD Framework Programme of the European Union (RTD-PP-L4-2007-1), commissioned by DG Research to the consortium led by CIREM (Spain) and made up of Université Libre de Bruxelles (Belgium), Inova Consultancy Ltd. (United Kingdom), Fondazione Giacomo Brodolini (Italy), Bergische Universität Wuppertal (Germany) and Politikatörténeti Intézet KHT (Hungary). The study was carried out between 2008 and 2010.

The purpose of the study was to collect and analyse research on horizontal and vertical gender segregation in research careers, as well as the underlying causes and effects of these two processes.

The objectives of the study were to:

- Provide an exhaustive overview and analysis of research on gender and science carried out at the European, national, and regional levels.
- Make the study results accessible to researchers and policy-makers via an informed bibliography (online database) and a set of reports.
- Steer policy-making on gender and science and define future research priorities within the Framework Programme, in particular through good practice examples and gap analysis in the various research topics.

For the purposes of the study, 'science' was understood in its broadest meaning, including social sciences and humanities as well as research and technological development.

The study covered the research on gender and science produced between 1980 and 2008, in all European languages, in 33 countries: the 27 EU Member States as well as 6 Associated Countries to the Seventh Framework Programme for Research and Technological Development (FP7) (Croatia, Iceland, Israel, Norway, Switzerland, and Turkey).

The study produced five country-group reports, seven topic reports and the final synthesis report:

Country-group reports	**Authors**
Continental countries	Hafsatou Diallo, Danièle Meulders, Síle O'Dorchai & Robert Plasman
Eastern countries	Mária Palasik, Nikolina Sretenova, Robert Takács & Núria Vallès
Nordic countries	Seppo Roivas
Southern countries	Elisabetta Addis & Costanza Pagnini
United Kingdom and Ireland	Cinnamon Bennett, Marina Larios, Louise Norman & Emma Parry
Topic reports	**Authors**
Horizontal and vertical segregation	Danièle Meulders, Robert Plasman, Audrey Rigo & Síle O'Dorchai
Gender wage gap and funding	Danièle Meulders, Síle O'Dorchai, Robert Plasman & Audrey Rigo
Stereotypes and identity	Felizitas Sagebiel & Susana Vázquez-Cupeiro
Science as a labour activity	Maria Caprile & Núria Vallès
Scientific excellence	Elisabetta Addis with the assistance of Costanza Pagnini
Gendered innovations	Londa Schiebinger, Ineke Klinge, Addison Arlow & Sarah Newman
Policies towards gender equity in science and research	Cecilia Castaño, Jörg Müller, Ana Gonzalez & Rachel Palmen
Synthesis report - Authors	
Maria Caprile (coord.), Elisabetta Addis, Cecilia Castaño, Ineke Klinge, Marina Larios, Danièle Meulders, Jörg Müller, Síle O'Dorchai, Mária Palasik, Robert Plasman, Seppo Roivas, Felizitas Sagebiel, Londa Schiebinger, Núria Vallès, Susana Vázquez-Cupeiro	

All the reports and the online database (Gender and Science Database, GSD) are available at the website of the study: **www.genderandscience.org**

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I. INTRODUCTION

Londa Schiebinger, Ineke Klinge, Addison Arlow and Sarah Newman

This series of three articles reviews gendered innovations in knowledge production over the past three decades with a focus on current approaches. The introduction lays out important analytical issues. The article by Ineke Klinge and Sarah Newman reviews and analyzes gendered innovations in biomedical and health research. The article by Londa Schiebinger and Addison Arlow reviews and analyzes gendered innovations in engineering and technology.

Three Policy Approaches

To better understand the complex processes involved in increasing women and minorities' participation in science, medicine, and engineering, we distinguish three policy approaches to gender equality in these areas.[1] The first of these approaches focuses on programs targeting women themselves in efforts to increase their participation in science and technology (S&T). The second approach seeks to increase women's participation by reforming research institutions. The third focuses on overcoming gender bias by mainstreaming gender analysis into basic and applied research. These three policy approaches are interrelated: increasing women's participation in science and engineering will not be successful without restructuring institutions and mainstreaming gender analysis into knowledge production. This cluster of articles focuses on the third approach—gendered innovations in knowledge production.

1. Fixing the Numbers of Women in Science, Medicine, and Engineering

The first and most straightforward policy approach focuses on research support to increase the participation of women in S&T. The rationale is that the dearth of women scientists and engineers is a "pipeline" problem and that more girls and young women needed to be trained in technical fields.

In the 1980s, national governments and international agencies began collecting sex-disaggregated data to monitor women's participation in science and engineering. In 1982, the United States National Science Foundation (NSF) published the first congressionally mandated report, *Women and Minorities in Science and Engineering*, to which persons with disabilities were added in 1984.[2] In 2003, the European Union (EU)'s Directorate-General for Research (DG Research) published its first *She Figures,* reporting trends in women's participation across its member states.[3]

There is still work to be done in data collection. For example, data showing sex ratios in science and engineering subfields reveal men's and women's research preferences. Certain S&T subfields attract women more than others. In the countries for which data are available, women's participation is high

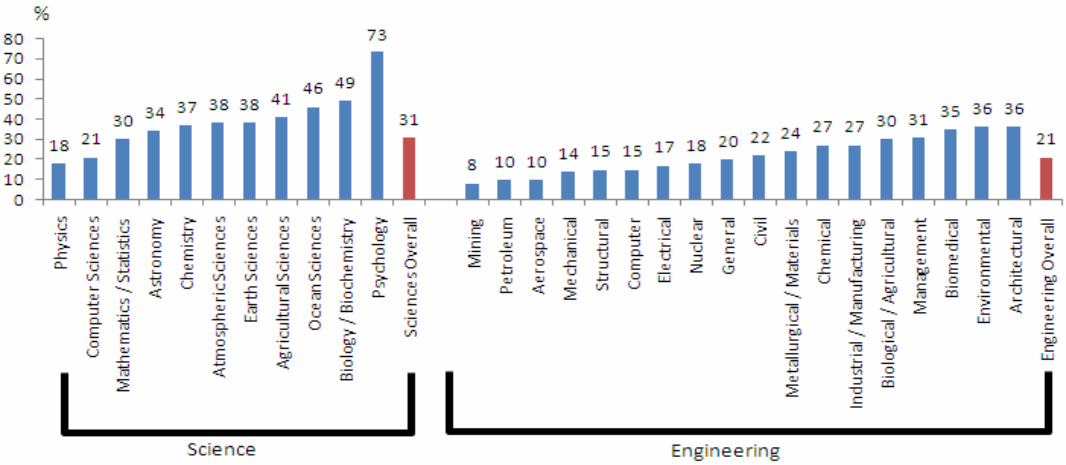
[1] Schiebinger, L. (2008). Getting More Women into Science and Engineering—Knowledge Issues. In Schiebinger, L. (Ed.) *Gendered Innovations in Science and Engineering*, pp. 1-21. Stanford: Stanford University Press; Schiebinger, L. (1999). *Has Feminism Changed Science?* Cambridge: Harvard University Press.

[2] National Research Council. (2009). *Gender Differences at Critical Transitions in the Careers of Science, Engineering, and Mathematics Faculty.* Washington, D.C.: National Academies Press; National Science Foundation (NSF). (1982). *Women and Minorities in Science and Engineering.* Washington, D.C.: National Academies Press.

[3] European Commission. (2003). *She Figures*. Luxembourg: Office for Official Publications of the European Communities.

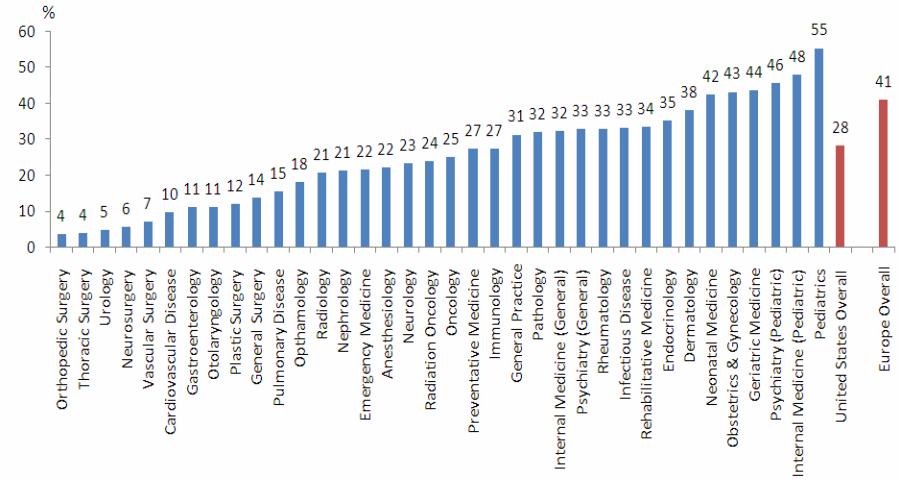
overall in biology, oceanography, earth, and agricultural sciences, and in environmental and biomedical engineering. For example, in the United States, women received 36 per cent of environmental engineering doctorates in 2008 – less than parity, but closer than in any other engineering field.[4] Fewer 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. Data from the European Union are not as detailed as that from the United States and does not allow for as fine comparisons. An examination of women's research preferences suggests that research institutions may undergo structural change in terms of preferred research areas as women gain equality.

Women's share of doctoral degrees in science (2007)[5] and engineering (2008)[6], United States:

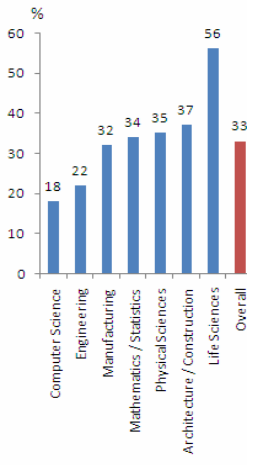


[4] Gibbons, M. (2009). Engineering by the Numbers. In American Society for Engineering Education (ASEE) (Ed.), *Profiles of Engineering and Engineering Technology Colleges, 2008*. Washington, D.C.: ASEE.
[5] NSF. (2007). Science and Engineering Doctoral Degrees Awarded to Women, by Field: 1998–2007. In United States Department of Education (Ed.), *Integrated Postsecondary Education Data System Completion Survey*. Washington, D.C.: Government Publishing Office.
[6] Gibbons, M. (2009). Engineering by the Numbers. In American Society for Engineering Education (ASEE) (Ed.), *Profiles of Engineering and Engineering Technology Colleges, 2008*. Washington, D.C.: ASEE.

Percent female physicians by specialty in the United States (2007)[7] and overall in Europe (2007)[8]:



Women's share of science and engineering degrees by broad field (2006)[9], European Union:



[7]American Association of Medical Colleges (AAMC). (2008). Physician Specialty Data. *AAMC Center for Workforce Studies Publications*, November.
[8]Eurostat. (2009). Proportion of Female Physicians, Tertiary Level Academic Staff, and Managers Increasing. *Eurostat News Release*, March 6.
[9] European Commission. (2003). *She Figures*. Luxembourg: Office for Official Publications of the European Communities.

Governments and international agencies combine data collection with programs aimed at bringing more women into the S&T pipeline. In 1989, the United States National Science Foundation (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.[10] The European Union recommended similar measures in its 2000 European Technology Assessment Network (ETAN) report, issued by the Helsinki group.[11]

These three policy approaches are interrelated. Increasing women's participation in science and engineering will not be successful without restructuring institutions and mainstreaming gender analysis into knowledge production.

This first policy approach seeks to increase women's participation in S&T by supporting women's educational opportunities and careers. While critically important, this approach has also been criticized for 'fixing the women'—attempting to give women more education, more research money, and more training to better assimilate them to traditionally male domains. The implicit assumption is that S&T institutions and research are gender neutral. Consequently, this approach fails to look beyond women's careers to reform S&T institutions and research methods. Achieving equality requires examining gendered divisions of labor in society at large and in science specifically, as well as considering how research is conceptualized and carried out.

2. 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.[12] To the extent that Western-style science has been replicated around the world, institutional structures, cultural stereotypes, and social divisions of labor disadvantage women's participation. The second general policy approach seeks to increase women's participation by reforming research institutions. Beginning in 1993, the NSF implemented programs designed to create "positive and permanent changes in academic, social, and scientific climates: in class rooms, laboratories, departments, institutions and organizations."[13]

The NSF's robust ADVANCE program, launched in 2001, has made the United States a global leader in institutional transformation. This model program assists institutions (not individuals) in implementing structural changes to improve women and minorities' success in science and engineering. These efforts reform institutions that historically developed around the needs of male professionals with stay-at-home wives. Institutional reform ranges from counteracting subtle gender and ethnic biases in hiring and promotion practices to restructuring work/life balance by offering parental leave, supporting child- and

[10] Organization for Economic Cooperation and Development (OECD). (2006). *Women in Scientific Careers*. Paris: OECD Publishing.
[11] ETAN Expert Working Group. (2000). *Science Policies in the European Union.* Brussels: European Commission.
[12] Schiebinger, L. (1989). *The Mind Has No Sex? Women in the Origins of Modern Science*. Cambridge, Mass.: Harvard University Press. Diversification of a University Faculty: Observations on Hiring Women Faculty in the Schools of Science and Engineering at MIT. *MIT Faculty Newsletter, 18 (4),* 1, 16-23; Margolis, J., & Fisher, A. (2002). *Unlocking the Clubhouse: Women in Computing*. Cambridge: MIT Press; Haraway, D. (1989). *Primate Visions: Gender, Race and Nature in the World of Modern Science*. New York: Routledge; Harding, S. (1986). *The Science Question in Feminism*. Ithaca: Cornell University Press; Keller, E. (1985). *Reflections on Gender and Science*. New Haven: Yale University Press.
[13] NSF. (2009). Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers. http://www.nsf.gov/pubs/2009/nsf0941/nsf0941.pdf

elder-care, and allowing for career breaks.[14] In 2010, the European Commission also moved to the institutional level funding projects whereby

research organizations and universities are encouraged to implement multi-year action plans to address institutional barriers, such as recruitment, promotion, retention policies, management and research assessment standards, policies for dual-career couples and career breaks.[15]

Much remains to be done to restructure research and educational institutions to remove barriers that limit women's full participation in academic life. The goals here is to create conditions in which both men and women's careers can flourish—conditions in which all faculty can achieve at the highest level.

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. Change needs to come at a third level: gendered innovations in knowledge production.

3. 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, race, 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.[16] Gender biases in research limit scientific creativity, excellence, and benefit to society.

The global leader in terms of this policy approach is the European Union's DG Research. As Klinge details in her article in this series, in 1999 the European Commission adopted an action plan to promote research *by, for,* and *about* women.[17] This approach focused research on women as a group rather than on gender and did not take into account sex and gender issues in research.[18] In the 6th EU Framework Programme (FP6, 2002-2006), the DG Research 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." The EU's 2003 *Vademecum: Gender Mainstreaming in the 6th Framework Programme* offers

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[14] Schiebinger, L. (2008). Getting More Women into Science and Engineering—Knowledge Issues. In Schiebinger, L. (Ed.) *Gendered Innovations in Science and Engineering*, pp. 1-21. Stanford: Stanford University Press; Schiebinger, L. (1999). *Has Feminism Changed Science?* Cambridge: Harvard University Press.

[15] European Commission, Work Programme, Science in Society, 2010-2.1.1-1 Implementing Structural Change in Research Organisations/Universities, 16-17. See also Marina Cacace, PRAGES *Guidelines for Gender Equality Programmes in Science*. Rome: ADSO, 2009.

[16] Wajcman, J. (2007). From Women and Technology to Gendered Technoscience. *Information, Communication & Society, 10 (3),* 287-298; Wyer, M. (Ed.) (2001). *Women, Science, and Technology: A Feminist Reader*. New York: Routledge; Spanier, B. (1995). *Im/partial Science: Gender Ideology in Molecular Biology*. Bloomington: Indiana University Press; Schiebinger, L. (1993). *Nature's Body: Gender in the Making of Modern Science*. Boston: Beacon Press; Harding, S. (1991). *Whose Science? Whose Knowledge.* Ithaca: Cornell University Press; Biology and Gender Study Group. (1989). The Importance of Feminist Critique for Contemporary Cell Biology. In Tuana, N. (Ed.), *Feminism and Science*, pp. 172-187. Bloomington: Indiana University Press.

[17] Commission of the European Communities (COM). (1999). *Women and Science: Mobilizing Women to Enrich European Research*. Luxembourg: Office for Official Publications of the European Communities.

[18] Klinge, I., & Bosch, M. (2001) Gender Impact Assessment of the Specific Programmes of the Fifth Framework Programme: Quality of Life and Management of Living Resources. *Publications of the European Commission for Community Research*, July.

guidance to program officers on how to structure the competitive grant process to ensure that the gender dimension is included in basic research.[19]

The EU scaled back its innovative research requirement in the FP7 (2007-2013). The gender monitoring studies identified two obstacles to addressing gender in research content: 1) the FP6 did not explicitly outline all actors' roles and responsibilities related to integrating gender analysis into basic and applied research; 2) researchers themselves lacked an understanding of what addressing gender in the research content meant.[20] The European Union DG Research currently seeks to train researchers in how to integrate gender analysis into research.[21] This is the problem these three papers seek to address.

Where do other granting agencies stand on this issue? The DG Research is one of the few S&T research 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. The United States NSF currently has no programs that address whether or to what extent sex and gender analysis should be used in basic or applied research. Policies requiring researchers to integrate gender analysis into research are more common in health research organizations. Since 1990, the United States National Institutes of Health has required researchers to reconceptualize medical research to include women and minorities in federally-funded research, but this has not been enforced.[13] The World Health Organization mainstreams gender analysis into all "research, policies, programmes, projects, and initiatives."[22] The Canadian Institutes of Health has committed to "Integrating Sex and Gender into Health Research."[23] In Europe, Sweden's Karolinska Institute and Germany's Charité Universitätsmedizin have both created centers for gender medicine that promote sex and gender analysis in basic and clinical health research.[24]

It is important to recognize that these three levels of analysis are interrelated. Efforts to increase women' participation will not succeed without mainstreaming the methods of sex and gender analysis into knowledge production. Further research is needed to compare and contrast international, national, and institutional policies on mainstreaming gender analysis into S&T research.

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[19] European Commission. (2003). *Vademecum: Gender Mainstreaming in the 6th Framework Programme–Reference Guide for Scientific Officers/Project Officers.* Brussels: Directorate-General for Research.

[20] Centre for Strategies and Evaluation Services (CSES). (2009). *Monitoring Progress Towards Gender Equality in the 6th Framework Programme.* Luxembourg: Publications Office of the European Union; DunnGalvin, A., Hourihane, J., Frewer, L., Knibb, R., Elberink, J., & Klinge, I. (2006). Incorporating a Gender Dimension in Food Allergy Research: A Review. *European Journal of Allergy and Clinical Immunology*, *61 (11)*, 1336-1343.

[21] Yellow Window Management Consultants. (2009). *Toolkit: Gender in EU-Funded Research*. Brussels: Directorate-General for Research; genSET (2010). *Recommendations for Action on the Gender Dimension in Science.* London: Portia; Stanford Gendered Innovations in Science, Medicine, and Engineering Project, 2009-13, http://genderedinnovations.stanford.edu/

[22] World Health Organization (WHO). (2002). *Integrating Gender Perspectives in the Work of WHO*. Geneva: WHO Publishing.

[23] 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.

[24] Haafkens, J., & Klinge, I. (2007). *Promoting Attention to the Gender Dimension in Health Research: Experiences from Three Centers of Excellence in the EU.* Universiteit Maastricht: Centre for Gender and Diversity & Care and Public Health Research Institute.

Four Scholarly Approaches to Mainstreaming Gender Issues into Knowledge Production

Before turning to Gendered Innovations in Biomedical and Health Research, and Engineering and Technology, it is important to sketch four theoretical approaches that underlie much work in the area of women and gender in science, medicine, and technology. These approaches parallel to a certain extent science policy approaches, yet they are distinct theoretical approaches underlying scholarly literature that addresses gender in research. Sue Rosser (2005) has distinguished at least ten different feminist approaches to science and technology.[25] Here I want to emphasize only four theoretical approaches: gender-neutral, difference, co-constructionism, and gender analysis.[26]

Sex refers to biological characteristics that define females and males. ***Gender*** refers to the rules, traditions, and social relationships in cultures that together define and sanction feminine and masculine behavior. Gender relations also determine how resources are allocated between, and used by, women and men.

1. Gender-Neutral Approach (1970s-present)

This approach, which might also be called liberal feminism, was dominant in the 1970s, when women first gained access to graduate education in large numbers and had the potential to become professors in science, medicine, and engineering. Since Mary Wollstonecraft's vigorous call for equality in her 1792 *Vindication of the Rights of Woman*, liberal feminism has informed major legislation guaranteeing women rights, equal education, pay, and opportunity (the 1997 Treaty of Amsterdam, for example). Liberal feminists generally see women as the in-principle equals of men—everything else being equivalent—and therefore strive to provide women the skills and opportunities to make it in a man's world.[27] Feminism at this level has made such inroads in Europe and North America that most people no longer even think of these issues as "feminist," but as "just" or simply "true."

Basic tenets:

- Supports equal access for women and girls to education and employment.
- Considers science and technology unbiased.

Problems:

- Considers science and technology sex- and gender-neutral.
- Tends to ignore sex and gender differences.
- Locates problems in women (their education, socialization, aspirations, and values). To achieve success, women or girls are often required to assume male values, behaviors, and life rhythms.
- Tends to transfer Western-style science models to developing countries.

[25] Rosser, S. V. 2005. "Through the Lenses of Feminist Theory: Focus on Women and Information Technology." *Frontiers: A Journal of Women Studies, 26*, 1-23.
[26] For details, see Feminist Epistemology and Philosophy of Science, *Stanford Encyclopedia of Philosophy*, http://plato.stanford.edu/entries/feminism-epistemology/#standpoint
[27] Schiebinger, L. (2001). *Has Feminism Changed Science?* Cambridge: Harvard University Press; Harding, S. (1986). *The Science Question in Feminism*. Ithaca: Cornell University Press.

Policy implications still valid:

- Supports equal access for women to education and employment.

2. Difference Approach (late 1980s-1990s)

This approach bears resemblance to stand-point theory that seeks to represent the world from particular socially situated perspectives that lay a claim to epistemic privilege or authority—in this case from women's perspectives. This approach gave rise to much discussion about "women's ways of knowing."[28] Carol Gilligan famously claimed that women speak "in a different voice" when making moral judgments and that they value context and community over abstract principles.[29]

Basic tenets:

- Emphasizes sex and gender differences between men and women.
- Uses traditional feminine values to reform science and technology. Importantly, this approach identifies bias in science and technology by seeing what is left out from the feminine side of life.
- Opens definitions of science to include non-Western science and local knowledges (also referred to as indigenous or traditional knowledges).

Problems:

- Tends to romanticize traditional masculinity and femininity, and play into conventional stereotypes of men and women.[30]
- Fails to take into account that men and women across classes and cultures hold many different perspectives and values.[31]
- Tends to essentialize gender characteristics and impute positive traits, such as nurturing, to women. By conceptualizing women as the key agents of change, this approach can exclude men.

Policy implications still valid:

- Understanding gender bias in science and technology.

3. Co-Constructionism (1990s-present)

This approach sees science, technology, and gender as constructed through social processes rather than as natural or given *a priori*. Social constructionism provides rich analyses of how ideas, objects, and identities emerge from cultural contexts and has been particularly strong in technology studies. Co-constructionism goes one step further to look specifically at how science/technology and gender influence and mold each other. Co-constructionism seeks to avoid both technological determinism (seeing

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[28] Goldberger, N., Tarule, J., Clinchy, B., & Belenky, M. (Eds.) (1996). *Knowledge, Difference, and Power: Essays Inspired by Women's Ways of Knowing.* New York: Basic Books; Ruddick, S. (1989). *Maternal Thinking: Towards a Politics of Peace.* Boston: Beacon Press; Belenky, M., Clinchy, B., Goldberger, N., & Tarule, J. (1986). *Women's Ways of Knowing: The Development of Self, Voice, and Mind*. New York: Basic Books; Noddings, N. (1984). *Caring, A Feminine Approach to Ethics and Moral Education*. Berkeley: California University Press; Rose, H. (1983). Hand, Brain, and Heart: A Feminist Epistemology for the Natural Sciences. *Signs: Journal of Women in Culture and Society*, *9 (1)*, 73-90.

[29] Gilligan, C. (1982). *In a Different Voice: Psychological Theory and Women's Development*. Cambridge: Harvard University Press.

[30] For critique, see Schiebinger, L. (2001). *Has Feminism Changed Science?* Cambridge: Harvard University Press.

[31] Haraway, D. (1991). *Simians, Cyborg, and Women: The Reinvention of Nature*. New York: Routledge; Butler, J. (1990). *Gender Trouble: Feminism and the Subversion of Identity*. New York: Routledge.

technology as the prime driver of modernity) and gender essentialism (seeing gender characteristics as innate and unchangeable).[32]

Basic Tenets:

- Gender and science/technology are co-constructed.
- Gender identities and discourses are produced simultaneously with science and technologies. Neither pre-exists the other. Gender is material, discursive, and social; it permeates artifacts, culture, and social identities.
- Technologies play an important role in constructing the identities of users and vice versa.[33]

Problems:

- Does not offer scientists and engineers clear methods.

Policy implications still valid:

- Understanding that gender and science/technology are deeply interrelated.

4. Gendered Innovations: Enhancing Excellence through Gender Analysis (2000-present)

Gendered innovations develops methods of sex and gender analysis for basic and applied research. Gendered innovations in science, medicine, and engineering employs gender analysis as a *resource* to stimulate creativity in science and technology, and by doing so to enhance the lives of both men and women.

Basic tenets:

- Employs gender analysis as a resource to enhance scientific excellence.
- Mainstreams methods of sex and gender analysis into basic and applied research.
- Refutes the notion that increasing women's participation will automatically lead to gender-sensitive science and technology. Everyone—men and women—can and must be trained in sophisticated methods of sex and gender analysis.
- Examines intersections of gender, race, nationality, and ethnicity.
- Seeks methods of sex and gender analysis relevant for both Western-style and local knowledges.

Gender mainstreaming entails the systematic integration of gender equality into all systems and structures, policies, programs, processes and projects, into ways of seeing and doing.[34] Gender mainstreaming now needs to be expanded to include gender analysis in basic and applied research in science, medicine, engineering and technology. Mainstreaming gender analysis into research creates "Gendered Innovations."

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[32] Wajcman, J. (2007). From Women and Technology to Gendered Technoscience. *Information, Communication & Society, 10 (3)*, 287-298; Zorn, I., Maass, S., Rommes, E., Schirmer, C., & Schelhowe, H. (Eds.) (2007). *Gender Designs IT: Construction and Deconstruction of Information Society Technology.* Wiesbaden: VS Verlag für Sozialwissenschaften; Faulkner, W. (2006). Genders in/of Engineering: A Research Report. *Economic & Social Research Council,* March; Faulkner, W. (2001). The Technology Question in Feminism: A View from Feminist Technology Studies. *Women's Studies International Forum*, *24 (1)*, 79-95; Wajcman, J. (2000). Reflections on Gender and Technology Studies: in What State is the Art? *Social Studies of Science, 30 (3)*, 447-464.

[33] Oudshoorn, N., Rommes, E., & Stienstra, M. (2004). Configuring the User as Everybody: Gender and Design Cultures in Information and Communication Technologies. *Science, Technology & Human Values, 29* (*1*), 30-63.

[34] Rees, T. (2002) National Policies on Women and Science in Europe. Directorate General for Research, Women and Science, Luxembourg: office for official Publications of European Communities.

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 and technology. But analysis cannot stop there: focusing on bias is not a productive strategy. Gender experts in science and technology are now shifting emphasis away from critique and toward a positive research program that employs gender analysis as a *resource* to stimulate gender-responsible science, medicine, and technology.[35]

In order to mainstream gender analysis into basic and applied research, there is a need for gender experts, working with scientists and engineers, to develop internationally agreed upon methods of sex and gender analysis that can serve as a baseline for understanding how gender functions in research. 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.[36] Designing sex and gender analysis into basic and applied research requires that researchers are trained in specific methods, so that they can address gender issues where appropriate.

Methods of sex and gender analysis*
serve to enhance science 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 endeavor, on the talent and creativity of the research team.

1. **Analyzing gender**
2. **Analyzing sex**
3. **Analyzing covariate (race, ethnicity, age, socioeconomic class, region, etc.)**
4. **Formulating research questions/Envisioning design**
5. **Analyzing research priorities and potential outcomes**
6. **Redefining key concepts**
7. **Sampling**
8. **Analyzing standards and reference models**
9. **Analyzing language and visual representation**
10. **Rethinking theory**
11. **Analyzing academic disciplines**
12. **Analyzing knowledge created through gendered divisions of labor**

*See appendix

[35] Klinge, I. (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; Schiebinger, L. (Ed.) (2008). *Gendered Innovations in Science and Engineering*. Stanford: Stanford University Press; Wajcman, J. (2007). From Women and Technology to Gendered Technoscience. *Information, Communication & Society, 10 (3)*, 287-298; Faulkner, W. (2001). The Technology Question in Feminism: A View from Feminist Technology Studies. *Women's Studies International Forum*, *24 (1)*, 79-95;.
[36] WHO. (2010). What is Gender Mainstreaming? http://www.who.int/gender/mainstreaming/en/index.html

Gender theory has had an enormous impact in the humanities and social sciences over the past thirty years and is increasingly being integrated into medicine and the life sciences.[37] To develop methods of sex and gender analysis, gendered innovations draws from the best gender theorists of the past thirty years. To name a few, Peggy McIntosh presented an early (1983) model of progress in science from a "womanless science" to a stage that advocated adding women to "science as usual" to a stage that looked at things from the "female point of view."[38] Hilary Rose urged scientists to engage in equal measure "hand, brain, and heart."[39] Science theorists Donna Haraway and Sandra Harding called for adding a greater understanding of social context to scientific research (Haraway's "situated knowledge" and Harding's "strong objectivity").[40] Philosopher Helen Longino explicated how "background cultural and social assumptions" shape science.[41] Technology theorists Judy Wajcman and Nelly Oudshoorn demonstrate how gender relations "materialize" in various technologies; that is to say, how gender identities and technologies are "co-produced," or mutually shape one another.[42]

What is needed now is to develop methods of sex and gender analysis readily useful to scientists and engineers.[43] This should be an international effort, as recommended in the 2010 genSET *Consensus Report* and the 2010 United Nations Expert Group Meeting on Gender, Science and Technology.[44] In 2009, the Clayman Institute for Gender Research at Stanford University initiated the Gendered Innovations in Science, Medicine, and Engineering Project to develop methods of sex and gender analysis for basic and applied research. This project expanded through a collaboration with the European Union's Unit for Scientific

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[37] Klinge, I. & Wiesemann, C. (Eds.) (2010). *Sex and Gender in Biomedicine: Theories, Methodologies, Results*. Göttingen: Universitätsverlag; Harding, S. (2008). *Sciences from Below: Feminisms, Postcolonialities, and Modernities.* Durham: Duke University Press; Wajcman, J. (2007). From Women and Technology to Gendered Technoscience. *Information, Communication & Society, 10 (3)*, 287-298; Regitz-Zagrosek, V. (2006). Therapeutic Implications of the Gender-specific Aspects of Cardiovascular Disease. *Nature Reviews Drug Discovery, 5*, 1-14; Schraudner, M., & Lukoschat, H. (Eds.) (2006). *Gender als Innovationspotenzial in Forschung and Entwicklung*. Karlsruhe: Fraunhofer Institut; Oudshoorn, N., Rommes, E., & Stienstra, M. (2004). Configuring the User as Everybody: Gender and Design Cultures in Information and Communication Technologies*. Science, Technology & Human Values, 29 (1),* 30-63; Wajcman, J. (2000). Reflections on Gender and Technology Studies. *Social Studies of Science, 30 (3),* 447-464; Harding, S. (1998). *Is Science Multi-Cultural? Postcolonialism, Feminism, and Epistemologies*. Bloomington: Indiana University Press; Haraway, D. (1991). *Simians, Cyborgs, and Women: The Reinvention of Nature*. New York: Routledge; Longino, H. (1990). *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry*. Princeton: Princeton University Press; Haraway, D. (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspectives. *Feminist Studies, 14,* 575–599.

[38] McIntosh, P. (1983). "Interactive Phases of Curricular Re-Vision: A Feminist Perspective," Working Paper, no. 124, Wellesley College, Center for Research on Women.

[39] Rose, H. (1994). *Love, Power, and Knowledge: Towards a Feminist Transformation of the Sciences*. Bloomington: Indiana University Press.

[40] Haraway, D. (1991). *Simians, Cyborg, and Women: The Reinvention of Nature*. New York: Routledge; Harding, S. (1991). *Whose Science? Whose Knowledge?* New York: Cornell University Press; Harding, S. (1998). *Is Science Multi-Cultural? Postcolonialism, Feminism, and Epistemologies*. Bloomington: Indiana University Press; Harding, S. (2008). *Sciences from Below: Feminisms, Postcolonialities, and Modernities* Durham: Duke University Press.

[41] Longino, H. (1990). *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry*. Princeton: Princeton University Press.

[42] Faulkner, W. (2001). The Technology Question in Feminism: A View from Feminist Technology Studies. *Women's Studies International Forum*, *24 (1)*, 79-95; Faulkner, W. (2006). Genders in/of Engineering: A Research Report. *Economic & Social Research Council,* March.

[43] See also Schiebinger, L. & Schraudner, M. (2011). Interdisciplinary Approaches to Achieving Gendered Innovations in Science, Medicine, and Engineering, *Interdisciplinary Science Reviews*, special issue on *Gender in Science*, ed. Elizabeth Pollitzer, *36*, 154-167.

[44] genSET (2010). *Recommendations for Action on the Gender Dimension in Science.* London: Portia. United Nations Expert Group Meeting on Gender, Science and Technology, Paris, 28 September to 1 October 1020 at http://www.un.org/womenwatch/daw/egm/gst_2010/index.html.

Culture and Gender Issues in 2011.[45] Similar efforts are also underway in Canada.[46] Internationally standardized methods of sex and gender analysis 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.

Problems:

- Scientists, engineers, and policy makers are not yet trained in methods of sex and gender analysis.
- Methods of sex and gender analysis are not yet mainstreamed into curricula from primary through tertiary science and technology education.

Policy Recommendations: Where does the European Union Stand?

The EU's DG Research has already established the framework for including gender analysis in basic and applied research (see discussion above). Future actions:

1. Develop internationally agreed upon methods of sex and gender analysis (as discussed above). This is underway.

2. Train current researchers and evaluators in gender methodology. Although used for other purposes (i.e, to train faculty about subtle gender bias and other institutional issues), the University of Michigan's Strategies and Tactics for Recruiting to Improve Diversity and Excellence (STRIDE) programme and the genSET project offer good models for how to engage science and technology researchers as active participants in gender reform.[47]

3. Hold senior management accountable for developing evaluation standards that promote proper implementation of 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 include gender methodology in research design. Research projects that fulfill 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*, and *Circulation*, the American Heart Association

[45] The Stanford/EU collaboration is facilitated through the FP7 Work Programme 2011, Science in Society (SiS.2011.2.1.1-3), Expert group on Innovation through Gender.

[46] 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.

[47] Stewart, A., LaVaque-Manty, D., & Malley, J. (2004). Recruiting Female Faculty Members in Science and Engineering: Preliminary Evaluation of One Intervention Model. *Journal of Women and Minorities in Science and Engineering, 10*, 361-375; genSET (2010). *Recommendations for Action on the Gender Dimension in Science.* London: Portia.

journals. *Nature* is considering adopting this policy.[48] Journals should also enforce consistent use of key words such as "sex" or "gender to facilitate meta-analysis.

4. 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, at the primary, secondary, and tertiary levels. It is important that research institutions support programs specializing in gender studies where experts develop new knowledge on gender, science, and technology. 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 methods.

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The two papers that follow provide concrete examples of how sex and gender analysis can enhance excellence in science and engineering. Ineke Klinge and Sarah Newman write on gendered innovations in biomedical and health research, and Londa Schiebinger and Addison Arlow discuss gendered innovations in engineering and technology. These papers review the literature in their respective areas from 1980-2010 and focus on how mainstreaming sex and gender analysis into research enhances scientific creativity and promotes positive social outcomes.

[48] *Circulation* (*Journal of the American College of Cardiology)* 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; Nature Editorial. (2010). Putting Gender on the Agenda. *Nature, 465 (7299)*, 665.

APPENDIX: METHODS OF SEX AND GENDER ANALYSIS (short descriptions only. Full methods are found on the Gendered Innovations in Science, Medicine, and Engineering website: http://genderedinnovations.stanford.edu)

1. 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 labor or life styles. Researchers should analyze cultural factors related to gender when sex differences are observed.

2. 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.

3. 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.

4. 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? Examining these assumptions may open new areas of research and ensure that research benefits both men and women.

5. Analyzing research priorities and potential 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?

6. Redefining key concepts:

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 (short women and also men), for example, is a key concept that normalizes people excluded from the standard automobile 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.

7. Sampling:

A study will only be valid for a given population if the individuals sampled are representative of that population, according to characteristics such as sex, race, ethnicity, age, socioeconomic class, genotype, biomarkers, etc. Further, if the study's findings will be applied to a certain

subpopulation, then researchers must sample enough individuals in that subpopulation to test for specific effects. If an insufficient number of women are enrolled in a study, researchers may be unable to detect or rule out sex differences with statistical certainty, even if sex is correctly reported.

8. Analyzing standards and 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.

9. Analyzing 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.

10. 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 artifacts used for nutting, leatherworking, and grain harvesting has allowed theorists to better understand women's role in early human societies.

11. Analyze academic disciplines:

Academic fields of study, or disciplines, are the basic units organizing universities and research institutions. Disciplines produce their own economies of value, mediate employment in S&T, regulate funding from universities and governments, and confer and guard prestige. The current movement towards interdisciplinarity indicates that traditional disciplines may not divide knowledge in the most productive way for global S&T. Researchers should analyze how disciplinary boundaries may limit the types of questions they examine.

12. Analyzing knowledge created through gendered divisions of labor:

Social divisions of labor 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 labor. 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).

II. BIOMEDICAL AND HEALTH RESEARCH

Ineke Klinge and Sarah Newman

INTRODUCTION: The Value of a Gender Framework in Biomedical and Health Research

This paper seeks to outline the status of gender and sex in biomedical and health research, using relevant and selected examples. Over the last three decades feminists scholars have demonstrated how a failure to pay attention to gender and sex in biomedical research has led to bad science, namely flawed research designs, inadequate measures, inappropriate tests, and inaccurate interpretation of results, and has allowed culturally based conceptions of gender norms to limit research advancements. Recently, feminist scholars have created innovative methodologies to help scientists incorporate gender and sex into biomedical and health research. Europe along with Canada and the United States has already begun requiring the use of sex and gender in publicly funded biomedical and health research with the goal of incorporating the results into healthcare systems. Several reviews have been done documenting the progress made the U.S[1], however, no such review has been done on the field in Europe. This paper begins to fill this gap in the literature by analyzing the status of sex and gender in biomedical research in Europe from an international perspective. This is not an exhaustive review of developments in mainstreaming gender and sex in biomedical and health research, but should provide European policy-makers, researchers, non-government organizations and medical and healthcare practitioners with a summary of significant developments and direction for future policy proposals.

Early feminist contributions to the field of biomedicine and health research came in the form of critiques and through the construction of critical theoretical frameworks. Often the emergence of these critiques and feminist frameworks overlapped, converged and transformed each other and so they should not be understood as developing in a linear fashion. Each framework will be described below and the most influential and path breaking research will be used as illustrative examples.

A. Gaps in Biomedical Research on Women's Health

The first framework, which can be referred to as the *Strong Objectivity* Framework*,* developed out of the second wave feminist movement, which sought to make the female experience a relevant topic of scientific research and investigation. U.S. Feminist Philosopher Sandra Harding coined the term *Strong Objectivity*. She argues that by starting thought from women's lives increases objectivity of the results by bringing scientific observation and the need for explanation to bear on assumptions and practices that would otherwise appear natural or unremarkable from the perspective of male scientists.[2] Scholars that can be categorized under the *Strong Objectivity* Framework apply Harding's notion of *Strong Objectivity* to their own scientific fields and are interested in investigating what science has to say about women. [3] In

[1] Institute Of Medicine. (2010) *Women's Health Research: Progress Pitfall and Promise*. Washington: National Academies Press; Regina M. Vidaver et al. (2004) 'Women Subjects in NIH-Funded Clinical Research Literature: Lack of Progress in Both Representation and Analysis by Sex', *Journal of Women's Health and Gender Based Medicine*. Vol. 9 Issue. 5; Steven Epstein. (2007) *Inclusion: The Politics of Difference in Medical Research*. Chicago: The University of Chicago Press; Olena Hankivsky. (2006) 'Beijing and Beyond: Women's Health and Gender-Based Analysis in Canada', *International Journal of Health Services.* Vol. 36. No. 2.

[2] Sandra Harding. (1991) *Whose Science, Whose Knowledge: Thinking from Women's Lives.* New York: Cornell University Press. Pg.150.

[3] Anne Fausto-Sterling. (1985) *Myths of Gender: Biological Theories About Women and Men.* New York: BasicBooks; Ruth Hubbard. (1990) *The Politics of Women's Biology*. New Jersey: Rutgers University Press; Ruth Bleier. (1988). *Science and Gender: A Critique of Biology and Its Theories of Women*. United Kingdom: Pergamon Press; Evelyn Fox Keller. (1985) *Reflections on Gender and Science*. London: Yale University Press.

doing so, they reveal how normative notions of gender have distorted scientific research priorities, designs, and interpretations.

Ruth Bleier, U.S. Feminist Neuroscientist, explains that much of the research on sex differences in the neurosciences has "looked for the biological bases for differences in prenatal hormonal effects on the developing brain and differences in brain hemispheric lateralization."[4] The purpose of this research has been to explain presumed sex differences in cognitive ability. The predominant theory argues that women tend to use both the right and left hemispheres to process visual-spatial information, while men rely almost exclusively on the right hemisphere. As Bleier explains, the fundamental gender assumption built into the design of the studies is that since women's brains are less lateralized (read specialized) than men's brains, they are not as good at processing visual spatial information. This assumption, however, has no independent evidence to support it. Rather it is based on culturally constructed gender norms that assume men are better visual-spatial thinkers and relies on circular reasoning to connect brain lateralization to different thinking abilities between men and women.

In her analysis of the research, Bleier found misleading interpretations of the results and an overemphasis of differences in male and female cognitive abilities. For instance, "when the sex differences are found, they often have very weak if any statistical significance, and the statistical differences that exist are between the *mean* scores of the two groups tested, whose scores mainly overlap."[5] In other words, the majority of studies found greater variability in cognitive sex differences within each sex than between them; however, researchers direct attention to the weak findings that corresponded with established beliefs about male and female cognitive abilities. In addition, Bleier also found problems in the design of many of the studies, which could have enhanced, negated or reversed the so-called sex differences in brain lateralization processing. These design flaws included "uncontrolled or uncontrollable factors such as age, test procedures, task difficulty, information-processing strategies by the subject, practicing doing the task, attention, motivation, memory duration, and general aptitude."[6] These studies neglect to account for the interaction between brain development and the, often highly gendered, external environment. By using a feminist analysis Bleier is able to critically re-analyze the research and see things that others have missed, mainly "a combination of valid and irrelevant findings, flimsy evidence and unsupported conjectures."[7]

Similarly, U.S. Feminist Biologist Anne Fausto-Sterling explains that by 1985 we had "amassed an encyclopedia worth of information about female biology—existence of hormones, the function of menstruation, the regulation of ovulation, and physiology of menopause"—yet there was no reliable medical research into the pervasive female condition of Premenstrual Syndrome (PMS) to make a true diagnosis or develop a rational treatment.[8] Several scientists hypothesized about the biological causes of PMS, such as "end-of-the cycle deficiency in the hormone progesterone", "deficiencies in vitamin B-6, fluid retention, and low blood sugar", but none of these possible causes were supported by scientific data.[9] Fausto-Sterling not only takes issue with these biological causes from a feminist perspective. She points out that none of these biological causes account for the lived experiences of women. Fausto-Sterling explains that as most women know, "overexcitement, exhaustion, travel, illness, and stress can alter the timing of one's period, change the number and intensity of premenstrual signals, and influence the presence of absence of the menstrual flow and its degree of discomfort."[10] In other words, a narrow focus on biological variables ignores the impact of social-cognitive variables on women's experiences of PMS and the regular rhythmic variation in symptoms that women regularly experience with their monthly cycles.

In addition, Fausto-Sterling identifies significant flaws in PMS research design and methodology. The majority of PMS research produced skewed results because of narrow definitions of the female menstrual cycle that bases studies on an "ideal, regular, twenty-eight-day menstrual cycle", although many women

[4] Ruth Bleier. (1988). Ibid. Pg. 147.
[5] Ibid.
[6] Ibid.
[7] Ibid. Pg. 159.
[8] Anne Fausto-Sterling. (1985) Pg. 95.
[9] Ibid Pg. 96.
[10] Ibid Pg. 105.

experience infrequent, shorter, or longer cycles.[11] Researchers are also inconsistent in how they define the period of time women experience PMS as "some studies look only at the day or two preceding the menstrual flow, [while] others look at the week preceding", making it impossible to compare studies and produce useful insights.[12] In research on treatment for PMS, Fausto-Sterling found few studies that test treatments with "commonly accepted standard of a large-scale, double blind study that includes placebo" and in the few scientifically reliable studies "women under treatment for PMS respond just as well to sugar pills as to medication containing hormones and other drugs."[13] Fausto-Sterling demonstrates that researchers have been unsuccessful at defining what constitutes the healthy female reproductive cycle and so it has been impossible to produce an effective treatment without any scientifically comparable or valid research.[14]

B. Construction of Gender and Sex in Biomedicine and Health Research

The second framework, which can be referred to as the *Partial Perspective Framework,* is influenced by postmodern theory and its textual critiques, specifically how language used by biomedical and health researchers, to access and observe the world, is embedded with cultural assumptions and normative ideas about gender and sex. The term the *Partial Perspective* refers to U.S. Feminist Biologist Donna Haraway's work, which encourages feminist scientists to go beyond exposing bias and bad science to examine the partial perspective of the researcher and struggles over how to *see* such things as human biology, physiology, development etc. Haraway suggests that feminist researchers need to direct their attention to metaphors used by scientific researchers, as "metaphor invites us to investigate the varied apparatuses of visual production."[15] In using metaphors, biomedical researchers draw on established cultural beliefs and read into biological processes normative ideas about gender and sex. By critically analyzing these metaphors, feminist scientists make visible the socially constructed nature of these ideas and demonstrate that "the world neither speaks itself nor disappears in favour of a master decoder."[16] Therefore, feminists scholars categorized under the *Partial Perspective* framework critically (re)examine biological knowledge claims that conceptually construct sexed and gendered bodies. By doing so, these feminist scholars identify the material consequences of these frameworks and help to create conceptual space to re-theorize and re-visualize gendered and sexed bodies.

Dutch Feminist Biologist Nelly Oudshoorn demonstrates how cultural assumptions about sexual duality influenced developments in early biomedical research on hormones and constrained biomedical research possibilities. Oudshoorn explains that that until the eighteenth century the biomedical sciences "were not very interested in differences between the sexes" because it was assumed that the only differences in male and females bodies were in their anatomy and genitalia. By the twentieth century "new ways of studying sex differences were introduced through the emergence of new fields of science, including the important field of endocrinology."[17] Endocrinologists read established cultural notions of sexual duality into the biological process of the gonad glands secreting chemical substances, and thus coining the term 'sex hormones'. In doing so, they constructed a new model that conceived of sex hormones as chemical

[11] Ibid Pg. 98.
[12] Ibid.
[13] Ibid. Pg. 100.
[14] Feminist scientists continue to use this framework to reveal serious methodological flaws in biomedical and health research. For contemporary research in the field of neuroscience refer to Cordelia Fine (2010) *Delusions of Gender: the real science behind sex differences*. London: Icon Books and in the field of PMS research refer to Paula Nicolson, (1995) 'The menstrual cycle, science and femininity: Assumptions underlying menstrual cycle research', *Social Science and Medicine*. Vol. 41. No. 6. and Diana Taylor (2006) 'From "*It's All in Your Head*" to "*Taking Back the Month*": Premenstrual Syndrome (PMS) Research and the Contributions of the Society for Menstrual Cycle Research', *Sex Roles.* Vol 54. No. 5-6.
[15] Donna Haraway (1988) 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective', *Feminist Studies*, Vol. 14, No. 3. Pg. 589.
[16] Ibid. Pg. 593.
[17] Nelly Oudshoorn. (1990) 'Endocrinologists and the Conceptualization of Sex, 1920-1940', *Journal of the History of Biology*. Vol. 23, No. 2. Pg. 164.

agents of masculinity and femininity, in which "female sex hormones could be found only in the female organism and male hormones were believed to be present only in males."[18]

Oudshoorn demonstrates that the now established dualistic conception of sex hormones was a "biological translation" of the social values of the time, namely "the Victorian Doctrine of the Two Sexes, which held that women's activities were in most respects opposite to those of men." [19] This conception was eventually empirically challenged by biochemists observations of female sex hormones in male urine.[20] These findings challenged the established notion that female sex hormones were sex specific, however, normative beliefs in separate and distinct sexes continued to color scientific interpretations of the findings.[21] Scientists proposed hypotheses using the same sex hormones terminology, suggesting that female hormones had a functionless presence of in males or had a disease causing functions in males—specifically focusing on the development of homosexuality.[22] The distinct sex specific character of hormones was further solidified with the introduction of the terms estrogen and testosterone to represent the assumed sexed nature of each hormone.[23] Subsequently, chemical processes of human biology themselves have been branded with cultural ideas about gender, limiting how scientist and those outside the field understand and conceptualize the function of the manifold activity of each hormonal substance.

Similarly, U.S. Feminist Anthropologist Emily Martin, by critically analyzing metaphors used in biological textbooks, demonstrates how culturally constructed gender stereotypes have been read into scientific accounts of the reproductive process. Martin finds that descriptions of the male and female reproductive processes are interpreted through culturally established ideas that women are unproductive and wasteful and men are productive. For instance, Martin illustrates that the female menstrual cycle is described using words such as "debris", "dying", "losing", "expelling", while male reproductive physiology is described with great enthusiasm as "*producing* hundreds of millions of sperm each day."[24] Even the female ovulation process is not productive but rather "textbook descriptions stress that all of the ovarian follicles containing ova are already present at birth. Far from being produced, as sperm are, they merely sit on the shelf, slowly degenerating and aging like overstocked inventory."[25] Martin demonstrates that scientists' descriptions do not simply describe the reproductive physiology of male and females but also read onto male and female reproductive physiology established cultural beliefs about women and men, with females consistently conceptualized as valueless and unproductive.

Martin explains that stereotypical notions of gender have been particularly pervasive in descriptions of the egg and the sperm. The egg is described as being "large and passive" and fragile and "does not move or journey, but passively is transported, is swept, or even drifts."[26] While the sperm is described as being active as they "deliver their genes to the egg" and "their tails are strong and efficiently powered" so "that with a whiplash like motion and strong lurches they can burrow through the egg coat and penetrate it."[27] Martin explains that the description invokes the old fairytale romances based on stereotypical gender roles and the "egg as damsel in distress, shielded only by her sacred garments; sperm as heroic warrior to the rescue."[28] Even when new scientific discoveries found the sperm to be weak and the egg to have an adhesive quality, stereotypical assumptions about gender continued to limit interpretations of these findings. For instance, scientific descriptions that gave the egg a more active role in the process continued to draw on gender stereotypes of the "women as a dangerous and aggressive threat" and "the egg ends up as the female aggressor who captures and tethers the sperm with her sticky zona, rather like a spider

[18] Ibid. Pg. 164.
[19] Ibid. Pg. 169.
[20] Ibid. Pg. 170.
[21] Ibid. Pg. 174.
[22] Ibid. Pg. 177.
[23] Ibid. Pg. 183.
[24] Emily Martin. (1991) 'The Egg and the Sperm: How Science Has Constructed a Romance Based on Stereotypical Male- Female Roles'*, Signs*. Vol. 16, No. 3. Pg. 486.
[25] Ibid. Pg. 487.
[26] Ibid. Pg 487.
[27] Ibid. Pg 489.
[28] Ibid. Pg 491.

lying in wait in her web."[29] Martin's analysis demonstrates how gender roles have been written into cellular constitution of females and males, and therefore, further naturalizing these roles for biomedical researchers and those outside the field. Naturalizing these gender stereotypes limits research on reproductive issues and closes possibilities for changing hierarchical gendered social relations outside the field of biomedicine.[30]

C. Incorporating Gendered and Sexed Bodies into Biomedical and Health Research

The final framework, which can be referred to as the *Gendered Innovations* framework*,* demonstrates how mainstreaming a gender and sex analysis into biomedical research allows researchers to produce more accurate, reliable and innovative research. U.S. Feminist Historian Londa Schiebinger coined the term *Gendered Innovations*. Schiebinger defines gendered innovations as "transformations in the personnel, cultures, and content of science and engineering brought about by efforts to remove gender bias from these fields."[31] Gendered innovations come from applying a gender and sex analysis, which has the "potential to enhance human knowledge and technical systems by opening them to new perspectives, new questions, and new missions."[32] And so, the feminist scholars categorized under this framework have sought to promote new innovations in biomedical research, health policy and practice by constructing methodological tools for sex and gender analysis.[33] The focus is primarily on the concepts of sex and gender and translating the theoretical developments in the social sciences to biomedical research practices.

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[29] Ibid. Pg 498.

[30] Feminist scientists continue to employ this framework to illustrate conceptual assumptions about gender limit research design and interpretation of results. For contemporary research on hormones refer to Celia Roberts (2007) *Messengers of Sex: Hormones, Biomedicine and Feminism*. New York: Cambridge University Press, and research on biological aspects on the body refer to Bonnie Spanier (1995) *Impartial Science: Gender Ideology and Molecular Biology*. Bloomington: Indiana University Press.

[31]Londa Schiebinger. (2008) *Gendered Innovations in Science and Engineering*. California: Standford University Press. Pg. 4.

[32] Ibid.

[33] E. Annandale,. and Eliane Riska. (2009) 'New Connections: Towards a Gender-Inclusive Approach to Women's and Men's Health', *Current Sociology*. Vol. 57. No. 2.; M.H.J Bekker,., (2003) 'Investigating gender within health research is more than sex disaggregation of data: A Multi-Facet Gender and Health Model', *Psychology, Health and Medicine.* Vol. 8.no. 2; Chloe E. Bird, and Patricia P. Rieker. (2008) *Gender and Health: The effects of constrained choices and social policies*. New York: Cambridge University Press; Clow, Barbara et al. (2009) *Rising to the Challenge: Sex- and gender-based analysis for health planning, policy and research in Canada*. Halifax: Atlantic Centre of Excellence for Women's Health; R. Correa-de-Araujo, (2006). 'Serious gaps: How the lack of sex/gender-based research impairs health', *Journal of Women's Health* 15(10); Courtenay, W.H., & Keeling, R.P. (2000). 'Men, gender and health: Toward an interdisciplinary approach', *Journal of American College Health.* 48(6). Doyal, L. (2003). 'Biological sex and social gender: Challenges for preventive and social medicine', *Sozial- und Praventivmedizin.* 48(4); J.Johnson et al. (2009), 'Better science with sex and gender: Facilitating the use of a sex and gender-based analysis in health research', *International Journal for Equity in Health*. Vol. 8 no. 1; A Kazanjian, & O, Hankivsky,. (2008) 'Reflections on the Future of Women's Health Research in a Comparative Context: Why More Than Sex and Gender Matters', *Women's Health Issues.* Sep/Oct; 18(5); Ineke Klinge, (2010) 'Innovative changes in biomedicine: integration of sex and gender aspects in research and clinical practice', *Gender Change in Academia*. 10; Ellen Kuhlmann, and Ellen Annandale (eds.) (2010) *The Palgrave Handbook of Gender and Healthcare*. New York: Palgrave Macmillan; Toine, Lagro-Janssen, (2007) 'Sex, Gender and Health Developments in Research', *European Journal of Women's Studies*. Vol. 14. No. 1; Linda Nieuwenhoven, and Ineke Klinge, (2010) 'Scientific Excellence in Applying Sex- and Gender-Sensitive Methods in Biomedical and Health Research', *Journal of Women's Health*. 19(2). Susan Philips. (2005) 'Defining and measuring gender: A social determinant of health whose time has come', *International Journal for Equity in Health*. 4:11;

Vivian W Pinn. (2003) 'Sex and Gender Factors in Medical Studies: Implications for Health and Clinical Practice', *JAMA.* Vol. 289;M.T, Ruiz-Cantero et al. (2007).'A Framework to Analyse Gender Bias in Epidemiological Research', *Journal of Epidemioogy and Community Health*. *61*

Londa Schiebinger. (2008) *Gendered Innovations in Science and Engineering*. California: Standford University Press; T. Schofield, R. Connell et al. (2000) 'Understanding men's health and illness: a gender –relations approach to policy, research, and practice', *Journal of American College of Health*. 48. 6.; Lisa K. Whittle, and Marcia C. Inhorn. (2001) 'Rethinking Difference: A Feminist Reframing of Gender/Race/Class for the Improvement of Women's Health Research', *International Journal of Health Services*. Vol 31. No. 1

Acknowledging that many biomedical researchers "cannot easily find ways and methods to incorporate sex and gender issues into their research", Dutch Feminist Public Health Scientist Linda Nieuwenhoven and Dutch Feminist Biologist Ineke Klinge draw on the work of German Feminist Social Scientist Margrit Eichler[34] to help them do so. Eichler's work has been highly influential and has contributed to gender and sex policies in Health Canada[35] and has also been important for the development of gender sensitive analysis in Germany[36]. Nieuwenhoven and Klinge (2010) use Eichler's work to identify three pitfalls that should be considered by biomedical researchers when mainstreaming sex and gender into biomedical and health research projects.[37] The first pitfall Nieuwenhoven and Klinge (2010) identify is 'overgeneralization' and it "takes place when only one sex is studied but the data are presented as if they were of general (rather than sex specific) applicability."[38] An example of overgeneralization in biomedicine is when "the American Heart Association recommended aspirin therapy to high-risk adults to reduce the incidence of coronary heart disease" although the medical studies used to support the recommendation did not use an adequate number of female subjects.[39] The second pitfall is 'sex and gender insensitivity' and "occurs when sex and gender are not addressed in the research, although they are related to the research content."[40] Nieuwenhoven and Klinge (2010) identify several cases where there is no mention of sex in multiple articles in respected biomedical journals, including studies that collect data from both sexes, but do not analyze sex differences in the results. Nieuwenhoven and Klinge (2010) also stress that sex and gender sensitivity should be taken into account when choosing an investigator, as the "way female and male researchers sound, smell and handle animals" could impact the results of the study. Researchers also need to remain sex and gender sensitive when creating tests and protocols for a study, as specific tests might be less accurate or appropriate for the weight, size, body composition, and cell metabolism for male or female subjects.[41] Finally, the last pitfall is the 'double standard' and is the result of "same or identical situations, traits, or behaviours are treated or evaluated differently on the basis of a person's sex."[42] In biomedical research this is evident in medical literature that "often speaks of atypical symptoms when discussing women's symptoms" and by implication situates male symptoms as the norm.[43] By identifying major pitfalls, Nieuwenhoven and Klinge (2010) provide biomedical researchers with some research practices to consider that could lead to the development of more effective treatments and prevention practices and encourage new and innovative lines of research.[44]

[34] Margrit Eichler (1988). *Nonsexist research methods: A practical guide*, New York: Routledge.
[35] Margrit Eichler (2000c) 'Moving Toward Equality: Improving the Health of All People: Recognizing and Eliminating Gender Bias in Health', *Health Canada (draft*), Women's Health Bureau.
[36] Margrit Eichler, M., J. Fuchs, et al. (2000). 'Richtlinien zur Vermeidung von Gender Bias in der Gesundheitsforschung', *Journal of Public Health* **8**(4).
[37] Linda Nieuwenhoven and Ineke Klinge (2010) op.cit. Pg.314
[38] Ibid. Pg. 316
[39] Ibid.
[40] Ibid.
[41] Ibid. Pg. 316
[42] Ibid. Pg. 317
[43] Ibid. Pg. 318
[44] Recently, an editorial by Michael Gochfeld (2010) 'Sex-Gender Research Sensitivity and Healthcare Disparities'in the *Journal of Women's Health* Vol. 19 No. 2 commended Nieuwenhoven and Klinge for drawing attention to the critical gender gaps in biomedical research and how these gaps in research impact "causation, diagnosis, risk factors, prevention and treatment". Gochfeld (2010) supported their conclusions with additional examples of persistent gender and sex insensitivity in biomedical research, treatment interventions, pharmacology, drug trials and epidemiology.

SECTION I: Europe's Commitment to Mainstreaming Sex and Gender in Biomedical Research

The first time Europe honored its gender-mainstreaming[45] commitments, set out in the Platform for Action of the 1995 Fourth World Conference on Women in Beijing[46] and reflected and strengthened by the terms of the 1997 Treaty of Amsterdam[47], by mainstreaming gender into European science research policy was between 1998-2001 with the Fifth Framework Programme (FP5). The FP5 is part of a multi-annual Framework Programme strategy that the European Union initiated in the 1980s to integrate European Union (EU) activities in the field of scientific research and development, and encourage collaborative research and technological development across a range of sectors in Europe.[48] Prior to the FP5 the EU adopted "a consistent and deliberate policy of gender blindness"[49] and initiatives to incorporate gender and sex in scientific research, and implicitly biomedical research, in Europe were mostly restricted to sporadic and isolated positive measures at single universities and research institutes.[50] As U.S. Political Scientists Pollack and Hafner-Burton (2000) explain, in the early 1990s it didn't appear promising that gender would be mainstreamed into European Research and Development, as "the Directorate General (DG) for research had the smallest percentage of women among its senior or A-grade officials (7.6 per cent) of any of the Commission services, providing few élite allies for advocates of gender mainstreaming."[51] Nevertheless, with a strong internal advocate within the European Commission, "Edith Cresson, then the Commissioner in charge of Research and Development" and pressure on the European Parliament and the Council of Ministers from external advocates such as Women's International Studies Europe (WISE) and the European Women's Lobby, the European Commission (EC) on February 17, 1999 adopted a Communication entitled *Women and science: mobilising women to enrich European research* that committed the EU to gender mainstream the FP5. [52]

[45] Gender Mainstreaming as defined by the European Commission means "that in all phases of the political process – planning implementation, monitoring and evaluation – account is taken of the gender perspective. The goal is the promotion of gender equality between women and men. Under the Gender Mainstreaming concept, all policy measures must constantly be monitored for their effects on the life situation of women and men and, if necessary, revised. Only in this way can equality of the sexes become a reality in the lives of women and men. All people – within organisations and communities – must be given the opportunity to make their contribution to the development of a communal vision of sustained human development and to the realisation of this vision."

[46] In the Platform for Action, "governments, the international community and civil society, including non-governmental organizations and the private sector, are called upon to take strategic action in the following critical areas of concern" including Inequalities and inadequacies in and unequal access to health care and related services" and Inequality in economic structures and policies, in all forms of productive activities and in access to resources"
(see: http://www.un.org/womenwatch/daw/beijing/platform/plat1.htm)
In addition the European Commission published a Communication On February 21, 1996 that formally committed to Incorporating equal opportunities for women and men into all Community policies and activities."

[47] Amendment of Article 2
The list of tasks facing the Commission will include the promotion of equality between men and women.
Amendment of Article 3
"In all the other activities referred to in this Article, the Community shall aim to eliminate inequalities, and to promote equality, between men and women."
(see:http://europa.eu/legislation_summaries/institutional_affairs/treaties/amsterdam_treaty/index_en.htm)

[48] Thomas Roediger-Schluga and Michael J. Barber. (2006) 'The structure of R&D collaboration networks in the European Framework Programmes', Working Paper of United Nations University - Maastricht Economic and social Research and training centre on Innovation and Technology.

[49] Mark A. Pollack and Emilie Hafner-Burton. (2000) 'Mainstreaming gender in the European Union', *Journal of European Public Policy.* 7:3 Special Issue. Pg. 448.

[50] See National Initiatives included in the: Communication of the European Commission on "Women and Science-Mobilising Women to Enrich European Research" (COM (1999) 76), 1999

[51] Mark A. Pollack and Emilie Hafner-Burton. (2000). op.cit. Pg. 448

[52] Ibid.

The Fifth Framework Programme

The EC Communication "*Women and science: mobilising women to enrich European research*" sets out an action plan to "promote research *by, for*, and *about* women".[53] In FP5 much of the focus by policy-makers and advocates was on promoting research *by* women and the promotion of research *for* and *about* women was arguably framed through the same participation framework. For instance, the promotion of research *for* women refers to "vigilance when drawing up the work programmes and an in-depth analysis of how all the fields covered by research affect women." [54] In other words, promoting research *for* women meant investing in research that would benefit women as a group. The promotion of research *about* women contributes "to our knowledge of what it is to be a woman, and of gender and gender relationships and of the impact of these concepts on European society."[55]And so, promoting research *about* women focused primarily on increasing research on women and women's lives. The strategy of gender-mainstreaming the FP5 was focused primarily on increasing the number of women in scientific research, both as subjects and scientists. The EC created a GenderWatch System, which would assess how well gender was mainstreamed in the FP5 by "collecting and disseminating statistics, encouraging women's participation in evaluation panels and consultative assemblies, conducting Gender Impact Assessment Studies (GIA) of the research programmes, and providing a contact point within the Commission."[56] The GIA studies "carried out by seven groups of researchers, investigated the participation of women and analyzed whether the research themes, methods and issues prioritized affect women and men differently" and the results of the studies would be used to gender mainstream the design of the following Sixth Framework Programme.[57]

The GIA studies of the FP5 found that researchers were least successful at promoting research *for* and *about* women. Researchers failed to take account of sex and gender issues in the research content, namely considering biological and socio- cultural differences in the objectives, methodology and implementation of the research. Most of the research focused narrowly on technical aspects and if women were included in the research. Most of the time researchers failed to analyze social implications of the research in relation to gender dimensions, although in many cases "it appeared relevant for the research topic."[58] Moreover, "very few proposals focused on topics advancing women's needs and gender in general."[59] In general most research proposals in the FP5 took a very limited quantitative approach to gender, namely counting female participants, rather than qualitative attention to gender issues within the research.

Ineke Klinge and Mineke Bosch (2005) GIA study of the *Quality of Life and Management of Living Resources* Work Programme assessed the fields of life sciences and health research. The studies found that projects did not address sex or gender differences or other differentiated aspects of their subjects of study, such as age, ethnicity, sexual orientation etc. Moreover, the composition of the research population was often not argued for in project design, which led both to the under-representation of women and to

[53] Commission of the European Communities, "Women and Science" Mobilizing women to enrich European research, COM (1999) 76 final, Communication from the Commission, Luxembourg: Office for Official Publications of the European Communities European Commission. Pg. 10.
[54] Communication of the European Commission on "Women and Science-Mobilizing Women to Enrich European Research" (COM (1999) 76), 1999 Pg. 11
(see: http://ec.europa.eu/research/science-society/pdf/g_wo_co_en.pdf)
[55] Communication of the European Commission on "Women and Science-Mobilizing Women to Enrich European Research" (COM (1999) 76), 1999 Pg. 11
[56] Science policies in the European Union: Promoting excellence through mainstreaming gender equality. (2000) A Report from the ETAN Expert Working Group on Women and Science. Pg. 2
(see: http://ec.europa.eu/research/science-society/pdf/g_wo_etan_en_200101.pdf)
[57] Ineke Klinge and Mineke Bosch. (2005) 'Transforming Research Methodology in EU Life Sciences and Biomedicine: Gender Sensitive Ways of Doing Research', *European Journal of Women's Studies*. 12. pg. 381
[58] Gender Impact Assessment of the Specific Programmes of the Fifth Framework: An Overview. (2001) European Commission Community Research. Pg. 22
(see:http://www.bmwf.gv.at/fileadmin/user_upload/wissenschaft/frauen/women_gender_impact_fp5_en.pdf)
[59] Ibid.

taking males as a norm.[60] Similarly, data collection methods were not explicitly explained in terms of their suitability for both sexes.[61] Klinge and Bosch (2005) stressed in their assessment that these sex and gender omissions in the data and research designs would produce incomplete understandings of critical health issues in the EU.

Several critical and practical recommendations, specifically related to integrating gender and sex dimensions into the research content, came out of the GIA studies. The hope was that they would be used to gender mainstream the following Sixth Framework Programme:[62]

1. Funding should be made dependent on whether sex and gender aspects are adequately addressed in research proposals. Attention to gender should be a target in all Work Programmes and Work Programmes should include examples of important gender issues within each research theme.
2. Proposals should integrate the gender dimension in the research design of the project, such as population studies, data collection and analysis of methods used, and concepts applied, as well as in the expected socio-economic impact.
3. Evaluators should consider the extent to which gender is covered, regarding the participation of women, the scientific content and methodology.
4. Training to build the competence of evaluators, supplemented by the development of a manual on how to assess the gender dimension of proposals.

The Sixth Framework Programme

Following the results of the Gender Impact Assessment studies that were conducted in the FP5, the European Commission (EC) adopted a new top-down policy to guide gender mainstreaming activities in the projects of the FP6, which can be symbolically represented by the following formula:

GE = WP + GD

GE stands for 'Gender Equality' and distinguishes the two elements needed to achieve Research Excellence: Women's Participation and Gender Dimension of the research content. The GE policy represented a shift from the FP5 strategy, which focused primarily on women's participation. A focus on gender dimensions in the research content means that in research attention is paid to the role that gender *and* sex can play in the research content. The concept of gender refers to the social and cultural influences that lead to differences between women and men, while sex refers to the differences in biology.

In order to ensure the gender dimensions were adequately considered in all EU funded research content, attention to gender issues are mentioned in "the Guides for Proposers, in the Evaluation Criteria, in the Guidelines on Proposal Evaluation Procedures and in Model Contracts"[63] and it was mandatory for researchers applying for the largest grants (the Integrated Projects IP or Networks of Excellence NoE) to submit a Gender Action Plan (GAP) along with their proposals. The GAP created a regulatory requirement that obligated IP and NoE researchers to review gender aspects in their research field and explain how the project would address issues of gender. This requirement had the potential to ensure that gender and sex was effectively integrated into the research content of these projects.

[60] Ineke Klinge and Mineke Bosch (2001) Gender Impact Assessment of the Specific Programmes of the Fifth Framework Programme: Quality of Life and Management of Living Resources. European Commission Community Research. Pg. 12
(see: http://www.genderdiversiteit.nl/en/download/pdf/Gender%20in%20research.pdf)

[61] Ibid.

[62] Refer to: Gender Impact Assessment of the Specific Programmes of the Fifth Framework: An Overview. (2001) European Commission Community Research. Brusssels: EC.

[63] European Commission Vademecum. (2003) 'gender mainstreaming in the 6th Framework Programme- reference Guide for Scientific Officers/Project Officers. Unit C-5 Women and Science. Brussels; EC.
Pg. 4 (see ftp://ftp.cordis.europa.eu/pub/science-society/docs/gendervademecum.pdf)

Nevertheless, the gender monitoring studies of the FP6, which were similar to the GIA studies in FP5, found that "many studies failed to do so."[64] Most of the GAPs only "included planned actions related to increasing the participation of women", while how gender considerations contributed to overall scientific excellence was often neglected.[65] In general "projects rarely assigned budgets to the GAPs" and so the "monitoring of the implementation of GAPs was found to be weak."[66] Furthermore, "the GAPs were not scored during evaluation" and often evaluators did not provide comments relating to the GAPs.[67] In other words, the GAPs were treated as an afterthought by researchers and as an unnecessary administrative requirement that had no critical impact on the research design, implementation or outcomes and there was no evaluation structure in place to challenge this perception.

The lack of importance placed on the GAPs by researchers was partly connected to a lack of knowledge about gender dimensions in scientific research. The gender monitoring studies of FP6 found that the primary obstacle to addressing gender in research content was a "lack of understanding of what addressing gender in the research content meant" and a general assumption that "research topics were gender neutral and that there was no need for 'special treatment' of women."[68] For instance the gender analysis of the EuroPrevall study *The prevalence, cost and basis of food allergies across Europe* that fell under the *Food Quality and Safety* Work Programme found that "with few exceptions, work packages do not specify if and how a gender dimension is taken into account."[69] When researchers were asked to communicate how they integrated gender dimensions into their individual Work Packages, only 10 of 20 work package leaders responded. Of those that responded, it was found that "collecting sex disaggregated data was better understood and taken on board than taking account of possible gender effects" but often the sex-disaggregated data was not even analyzed.[70] In an effort to address the lack of knowledge among researchers about gender issues in scientific research, the European Commission created a guide[71] to assist Scientific Officers and Project Officers with gender mainstreaming their research projects, but researchers seemed unable and unwilling to take the initiative to consider the meaning of gender differences in their results or consider gender in their research design and data collection.

The gender monitoring studies suggested that the confusion and disinterest on behalf of researchers was also related to a lack of investment in systems to support the gender mainstreaming process in the FP6. As the authors of the EuroPrevall study explain, "the researchers are not solely responsible for not taking gender dimensions into account", but rather the FP6 did not explicitly outline the roles and responsibilities of integrating gender for the all the actors involved.[72] For instance, coordinators and contractors were required to complete interim and final reports, documenting progress made on implemented their GAPs, but there was no clear instructions provided on how to complete the forms and there were no formal sanctions if they were not completed.[73] Furthermore, inconsistent interpretations of how gender dimensions were to be integrated into research content, resulted in poor feedback from evaluators. For example, the study Nanotech, Aerospace, Transport, Energy, and Citizens and Governance in a knowledge-based society required a GAP in their proposal but did not include one and "passed the

[64] European Commission, (2009a) Monitoring Progress Towards Gender Equality in the Sixth Framework Programme: Synthesis Report. European Commission European Research Area. Brusssels: EC. Pg. 13.
(see: http://ec.europa.eu/research/science-society/document_library/pdf_06/gender-monitoring-studies-synthesis-report_en.pdf)
[65] Ibid. Pg. 22.
[66] Ibid.
[67] Ibid.
[68] European Commission, (2009a). op.cit. Pg. 14.
[69] Piek Knijff and Ineke Klinge. (2009) 'Final Report Gender Issues in EuroPrevall', *EuroPrevall*. Pg. 3.
[70] .Ibid. Pg. 4 and 6.
[71] See: European Commission Vademecum. (2003) 'Gender mainstreaming in the 6th Framework Programme-reference Guide for Scientific Officers/Project Officers. Unit C-5 Women and Science. (ftp://ftp.cordis.europa.eu/pub/science-society/docs/gendervademecum.pdf)
[72] Piek Knijff and Ineke Klinge. (2009) Pg. 6.
[73] European Commission, (2004) Project reporting in FP6: Guidance notes for Integrated Projects, Networks of Excellence, Specific Targeted Research or Innovation Projects, Coordination Actions, Specific Support Actions, Co-operative Research Projects and Collective Research Projects. Brusssels: EC.

evaluation stage."[74] The little guidance and sanctions given by evaluators reinforced the message to researchers that attention to gender was not integral to the design and content of their research projects.

All of the monitoring studies suggested that the "GAPs could have the potential to become a very effective tool if they were more rigorously evaluated and implemented—and made more user friendly to both project holders and evaluators."[75] Several practical recommendations were provided to facilitate this process:

1. The creation of comprehensive and practical guidelines outlining how gender dimensions should be integrated into each research area.
2. The involvement of gender experts in the drafting of the Work Programme so that this information is integrated throughout the Work Programme documentation
3. Ensuring that gender experts are available to provide direct support to facilitate the integration of gender dimensions into research content at a practical level.
4. Researchers also need to be provided with concrete examples and good practices of how attention to gender dimensions in research contribute to scientific excellence.
5. The roles and responsibilities for integrating gender into research content needs to be more clearly defined to all actors and so that gender commitments are implemented and monitored.

The Seventh Framework Programme

In the Seventh Framework Programme, rather than clarifying what integrating gender dimensions in research content looks like and giving stronger guidelines for the GAP, the EC effectively discarded the mandatory GAP for the FP7 Programme. In the FP7, the guidelines for the promotion of Gender Equality are non-binding and have become little more than a footnote. For instance, in the Negotiation Guidance Notes in the FP7 states "all projects are encouraged to have a balanced participation of women and men in their research activities and raise awareness on combating gender prejudice and stereotypes" [76] and that "the commission will inform the coordinator, during the grant negotiation, of the importance of having a good gender balance within the project. The commission will also inform the coordinator on whether it considers the GD of the research content an area that should be addressed within the project."[77] The non-binding nature of this statement makes considering gender an option for researchers rather than an integral aspect of the research content and design. Furthermore, how gender dimensions are integrated into the research proposal is left to the discretion of the coordinator and there is no regulatory mechanism to systematically evaluate, monitor or measure gender dimensions in the research content.

Nevertheless, EC did invest in the development of *Gender in Research Toolkit and Training* for the FP7. The toolkit explains, "that excellent research is gender-sensitive research and that investing in a gender sensitive approach to the research content makes for higher quality and validity."[78] The Toolkit provides researchers with a checklist to ensure that gender dimensions are integrated within their research projects. Training workshops are also provided for specific research fields to demonstrate to researchers how to use the Toolkit and assist them with integrating gender dimensions into their research. National Contact Points, FP7 project coordinators and participants are all encouraged to attend these workshops, but, again, these training workshops are at the discretion and willingness of the actors involved. The GAPs provided a mechanism to ensure that gender dimensions are systematically integrated into all publicly funded EU scientific research and so discarding the GAPs will most likely result in minimal attention to gender issues, as reflected on the scarce efforts to address gender in the previous two Framework Programmes.

[74] European Commission, (2009a) op.cit.Pg. 15
[75] Ibid. Pg. 23
[76] European Commission. (2009b) *Negotiation Guidance Notes.* FP7 Collaborative Projects, Networks of Excellence, Coordination and Support Actions, Research for the Benefit of Specific Groups (in particular SMEs). Brusssels: EC. (see: (see: ftp://ftp.cordis.europa.eu/pub/fp7/docs/negotiation_en.pdf)
[77] European Commission. (2009b) op. cit. Appendix 7.
[78] European Commission. (2009c). Toolkit Gender in the EU funded research (EUR 23857). Luxemburg: Office for official Publications of the European Communities. Section 1.6

Many advocates of gender mainstreaming in European scientific research argue that the EC should implement a golden rule: *gender issues should be regarded as relevant unless proven otherwise*. There is hope that it could be introduced in the FP8 with the announcement of funding for project in the *Science in Society* 2011 Work Programme that would set up an "expert group composed of gender experts in the various fields of science, technology, medicine and engineering to promote the integration of the gender dimension in European research, including EU financed research."[79] This is perhaps the first step in creating the support systems necessary for mainstreaming gender into EU financed scientific research.

SECTION II: Sex in Biomedical and Health Research

The widely read scientific journal *Nature* published an editorial in June 2010 stating "male research subjects continue to dominate biomedical studies" and subsequently "medicine as it is currently applied to women is less evidence-based than that being applied to men."[80] Survey studies of prominent biomedical journals found the pervasive publication of clinical studies that excluded women and failed to analyze sex differences between male and female subjects.[81] Similar findings were also found in animal studies. A survey of almost 2000 animal studies in 2009 found "a male bias in 8 out of 10 biological disciplines", which means that female animal models are not used in the development of treatments for numerous diseases.[82] Perhaps most concerning is that pregnant women continue to be completely excluded from clinical research studies on "drugs, vaccines, nutraceuticals, natural health products and medical devices because of the harm the intervention might do to the developing fetus."[83] Subsequently, there is little research on treatments that are safe for pregnant women and so "when a pregnant woman has a health condition that requires treatment, her physician often has insufficient information to make an evidence-based recommendation."[84] The authors concluded that it is imperative that sex bias in basic and clinical medicine end for the purposes of improving scientific excellence and human health.

Eliminating sex bias in basic and clinical research is particularly critical, as "sex plays a major role in the etiology, onset, complications and course of diseases."[85] Sex differences may serve as possible explanations for differences in risk factors, symptoms and disease course for a number of various diseases including: autoimmune diseases such as rheumatoid arthritis[86], lupus[87], and multiple sclerosis[88], in some psychological disorders, including major depressive disorders[89], schizophrenia[90], autism[91], eating

[79] European Commission. (2010) 'Work Programme 2011 Capacities Part 5, Science in Society'.
[80] Editorial. (2010) 'Putting gender on the agenda', *Nature*. Volume: 465. Pg. 665
[81] Regina M. Vidaver, Bonnie Lafleur, Cynthia Tong, Robynne Bradshaw, Sherry A. Marts. (2000) 'Bias in Clinical Intervention Research', Journal of Women's Health & Gender-Based Medicine. 9(5); Alison M. Kim, Candace M. Tingen & Teresa K. Woodruff. (2010) 'Sex bias in trials and treatment must end', *Nature*, 465; Wendy A. Rogers, Angela J. Ballantyne. (2008) 'Exclusion of Women From Clinical Research: Myth or Reality?', Mayo Clinic Proceedings. Vol. 83 no. 5.
[82] Irving Zucker and Annaliese K. Beery. (2010) 'Putting gender on the agenda', *Nature.* Volume: 465. Pg. 690.
[83] Francoise Baylis. (2010) 'Pregnant Women Deserve Better', *Nature.* Vol. 465. Pg. 689
[84] Ibid.
[85] Toine Lagro-Janssen. (2010) 'Sex, Gender and Health: Developments in Medical Research', in Ellen Kuhlmann, and Ellen Annandale (eds.) (2010) op.cit.Pg. 412.
[86] Ana Lleo, Pier Maria Battezzati, Carlo Selmi, M. Eric Gershwin and Mauro Podda (2010) 'Is autoimmunity a matter of sex?', *Autoimmunity Reviews,* Volume 7, Issue 8.
[87] L-J. Lu et al. (2010) 'Review: Male systemic lupus erythematosus: a review of sex disparities in this disease', *Lupus.* 19.
[88] Arnaud B. Nicot. (2009) 'Gender and sex hormones in multiple sclerosis pathology and therapy', *Front Biosci*. 14.
[89] Marco Piccinelli and Greg Wilkinson. (2000) 'Gender differences in depression', *The British Journal of Psychiatry*.177.
[90] Leung M.D., D. A. and Chue M. R. C. Psych., D. P. (2000), Sex differences in schizophrenia, a review of the literature. *Acta Psychiatrica Scandinavica,* 101.
[91] Sigan L. Hartley (2009) 'Sex Differences in Autism Spectrum Disorder: An Examination of Developmental Functioning, Autistic Symptoms, and Coexisting Behavior Problems in Toddlers', *Journal of Autism and Developmental Disorders.* Vol. 39 No. 12.

disorders[92] and attention deficit hyperactivity disorder[93]; chronic fatigue syndrome[94], asthma[95] and several types of cancer.[96] The most researched disease presenting sex differences is acute in cardio- vascular disease (CVD). Interest in sex differences in CVD has produced findings that illustrate the critical health consequences of failing to mainstream sex in biomedical research. Researchers have found that the "different symptoms that women present with in the early stages of coronary artery disease (CAD) such as unusual fatigue, abdominal discomfort and back, jaw or neck pain, have often been ignored because diagnostic standards were mainly established from research on men."[97] As a result, women suffering from CVD are often "subject to potentially life-threatening delays before crucial diagnostic tests are administered."[98] Furthermore, most of the therapies and diagnostic tests "are of little use to women because they are unable to detect CAD with the same sensitivity" in women as in men.[99]

To determine how physiological sex differences contribute to explaining different disease patterns and symptoms, biomedical and health-related researchers need to fully integrate the concept of *sex* into clinical human and animal research studies. The concept of *sex* refers to biological characteristics that distinguish male and females. In human beings, sex differences are thought to derive from basic chromosomal differences in which females have two X chromosomes and males have one X and one Y. From these basic genetic differences arise "variations in body size and shape, the proportion of fat to muscle, which hormones are circulating in the body or at what levels and different reproductive organs."[100]

However, feminist and queer scholarship, particularly on the topics of intersexuality, have challenged the belief that *sex* is comprised of only two categories [101], male and female, and demonstrate that "maleness and femaleness exist and are expressed along a continuum." [102] Variations in body hair and secondary sex characteristics are given as the most obvious examples, but variation from the sex binary has also been discovered at the cellular level (47, XXX females, XXY, XYY, XO, and XX males). In addition, many individuals with non-conforming sex chromosomes appear to be either typically male or female with respect to their external genitals, secondary sex characteristics, and overall appearance.[103] In deconstructing the concept of sex, feminist and queer scholars begin to investigate the material inside of once assumed binary sexed bodies and in doing so, provide a new theoretical framework for biological sciences and clinical practices. This conception of *sex* as biologically fluid prevents researchers from adopting the "add women and stir approach". Instead researchers must account and control for variations in once assumed sex characteristics, namely hormones and chromosomes, in the design of studies

92 William Rhys Jones and John F Morgan. (2010) 'Eating disorders in men: a review of the literature', Journal of public mental health. Vol. 9 no. 2.

93 Roberto B. Sassi. (2010) 'Attention-Deficit Hyperactivity Disorder and gender', *Archives of Women's Mental Health.* Vol. 13. No. 1.

94 Chin-Lin Tseng and Benjamin H. Natelson. (2004) 'Few Gender Differences Exist Between Women and Men with Chronic Fatigue Syndrome', *Journal of Clinical Psychology in Medical Settings.* Vol. 1. No. 1

95 Jennifer W. Mccallister and John G. Mastronarde. (2008)' Sex Differences in Asthma', *Journal of Asthma*. Vol. 45, No. 10.

96 S. F Shariat and J.P Sfakianos et al. (2010), The effect of age and gender on bladder cancer: a critical review of the literature. *BJU International*. Vol.105.

97 Alison M. Kim, Candace M. Tingen & Teresa K. Woodruff. (2010) 'Sex Bias in Trials and Treatment must End', *Nature.* 465. Pg 688.

98 Ibid.

99 Ibid.

100 Clow, Barbara, Ann Peterson, Margaret Haworth-Brockman, and Jennifer Bernier. (2009) 'Rising to the Challenge: Sex and gender-based analysis for health policy and research in Canada', *Atlantic Centre of Excellence for Women's Health*. Pg.10

101 Alice Domurat Dreger. (1998). 'Ambiguous Sex--- or Ambivalent Medicine? Ethical Issues in the Treatment of Intersexuality', *Hastings Center Report*. 28, 3; Molly J. Dingel and Joey Sprague. (2010) 'Research and reporting on the development of sex in fetuses: gendered from the start', *Public Understanding of Science*. 19; Juan Carlos Jorge. (2007) Statistical Management of Ambiguity: Bodies that defy the algorithm of sex classification. *International Journal of Critical Statistics*, Vol.1, No.1.

102 Clow, Barbara, Ann Peterson, Margaret Haworth-Brockman, and Jennifer Bernier. (2009). op.cit. Pg.10

103 Melanie Blackless, Anthony Charuvastra, Amanda Derryck, Anne Fausto-Sterling, Karl Lauzanne, Ellen Lee. (2000) 'How Sexually Dimorphic Are We? Review and Synthesis', *American Journal of Human Biology*. 12. Pg. 161 Pg 152.

investigating sex differences.

In an effort to advance the debate about how to use the concept of *sex* in basic scientific and clinical research, using this feminist/queer conceptualization of *sex,* and key consensus reports[104] on the subject, we will explore factors to consider when designing experimental studies that investigate the biological cause of sex differences when using human or animal subjects.

Research on Human Beings

Hormone cycles: Males and females experience fluctuating hormone concentrations and biological hormone rhythms need to be systematically accounted for by researchers when designing studies. Hormone concentrations cannot be assumed by simply studying gonadally intact female and males.

For women, hormone levels change at every stage of the menstrual cycle. It is often inadequate to classify women by stage of their menstrual cycle defined on basis of timing or indirect criteria such as changes in basal body temperature because there are large individual differences in hormone concentrations at each stage. For instance, "what constitutes a mid-luteal value in one woman may only be mid phase value in another."[105] Moreover, the timing of stages cannot be assumed because it is common for women to have regular cycles as short as 25 or as long as 35 days.[106] The only way for researchers to definitively determine different stages of the female cycle is "retrospectively based on the onset of the next menstrual period or by following changes in hormones over a number of menstrual cycles."[107]For men, the production of sex steroids changes seasonally and according to the time of day with the highest concentrations early in the morning and in the autumn.

Moreover, when referring to hormones used in a study, researchers need to be specific to ensure accuracy rather than rely on binary sex classification of hormones. For instance, "estrogen refers to any of a number of steroid hormones akin to estradiol. In fact, "estrogen" and "progestin" refer to *classes* of hormones, each specific hormone being "an estrogen" or "a progestin". The same goes for male hormones "androgens".

Age: The hormone concentrations of men and women also differ systematically over a lifetime as a result of puberty, adolescence, adulthood and aging and so the age and hormone concentrations of participants need to be recorded.

For females and males during puberty experience major hormonal changes, which make it difficult to control for hormone levels. Additionally, the hormone concentrations in men and women drop as they age. In men, "total testosterone concentrations in serum drop by approximately 35% and bioavailable testosterone by 50% between ages of 30 and 80."[108] Women experience menopause in which they cease menstruating and the "production of 17B-estradiol and estrone by the ovaries declines considerably."[109]

However, there is considerable variation in hormone levels across individuals, for instance there are some 80 year olds who have higher testosterone than some 35 year olds. Therefore, it is important to control for hormone concentrations and age and account for the fact that results cannot be generalized across all age groups.

Oral Contraceptive: Women using oral contraceptives must be studied separately because contraceptives, depending on the contraceptive formula, greatly alter the endocrine environment in females. However,

[104] Jill B. Becker et al. (2005) 'Strategies and Methods for Research on Sex Differences in Brain and Behaviour', *Endocrinology*. 146 (4); Joel D. Greenspan et al. (2007) 'Studying sex and gender differences in pain and analgesia: A Consensus Report', *Pain*. 132.;Anita Holdcroft. (2007) 'Integrating the Dimensions of Sex and Gender into Basic Life Science Research: Methodologic and Ethical Issues', *Gender Medicine*. Vol. 4. Supplement B. pg. S67.
[105] Jill B. Becker et al. (2005) op.cit. Pg. 1666.
[106] Ibid. (2005) Pg. 1663.
[107] Ibid. Pg. 1666.
[108] Jill B. Becker et al. (2005). op.cit. Pg. 1664
[109] Ibid. Pg.1663

women using oral contraceptives can be included in studies that compare them with females or males and match on specific criteria such as age, education, socioeconomic status, ethnicity to determine factors that contribute to variability between women and between women and men.[110]

Physiological Differences: Physiological sex differences that need to be considered in scientific and clinical research studies, particularly for those testing drugs, include higher percentage of body fat, higher cerebral blood flow, slower gastric emptying time, decreased gastric acid secretion, lower body weight, less blood volume, lower plasma and protein binding, lower heptatic biotransformation, and slower renal clearance.[111] These differences also vary considerably by age.

Pregnancy: During pregnancy women experience several physiological changes that could impact clinical studies, and could considerably impact outcomes on drug testing. These changes include and increase in total body water by up to eight liters, plasma concentrations vary dramatically, body fat increases by three to five kilograms, and maternal cardiac output increases by thirty to fifty percent.[112] Furthermore, these changes vary during the different stages of pregnancy and so it is necessary to document the exact stage of pregnancy.

Cellular Composition: Individuals with 47, XXX female, XXY, XYY, and XX (male) chromosomes can often appear typically male or female and so it cannot be assumed that all female subjects are XX and male subjects are XY. It is necessary to test and account for the genetic composition of all subjects.

Research on Animals

Hormone cycles: Animals have clearly defined reproductive cycles and so, just as with human subjects, it is critical to determine the phase of the animal cycle so that different times of the cycle can be compared. This requires "sampling vaginal cytology, [and] requires that females be handled and probed daily for at least two cycles."[113] Yet, this approach also presents problems that might impact the outcome of the study, namely due to the fact that male and female animals respond differently to acute stressors "it is not clear whether daily handling of males adequately control for this potential confound." Moreover, "repeated vaginal samples in rodents also may affect sensitivity to drugs."[114] Conversely, a "gonadectomy and hormone supplementation could be used to produce stability [with the cycle] artificially."[115] This approach also comes with its problems because the "effects of a hormone treatment can vary with the time after treatment, because steroid hormones can have both rapid effects as well as effects that are not seen for days or months."[116]

Physiology: Similar to human beings, "male rodents tend to be larger than females, a particular physical technique may not fit the anatomy of one or the other sex."[117] These physical sex differences not only relate to weight, but also translate into other physical differences in "fat, protein, and blood flow."[118] These differences have particular relevance to research on drug testing.

Environment: Other co-founding factors that could impact the variation in results between male and females include: "food, the presence of animals of the other sex, light, stress, discomfort, isolation, noise, temperature, the sex of the laboratory staff, odors."[119] It is necessary for researchers to disclose such factors so that results can be compared.

[110] Ibid. Pg. 1664
[111] Ibid.
[112] Ibid. Pg. 1665
[113] Joel D. Greenspan et al. (2007). op.cit. S28 Pg.36
[114] Ibid.
[115] Anita Holdcroft. (2007) op.cit.
[116] Jill B. Becker et al. (2005). op.cit. Pg. 1653
[117] Anita Holdcroft. (2007) op.cit. S67 Pg.65
[118] Ibid.
[119] Ibid.

Chromosome composition: Mouse models have been developed to test mice of the same gonadal sex (either males or females) that differ in sex chromosome complement (XX vs. XY). For example, it is now possible to compare differing responses of XX males and XY males and determine if Y chromosome genes, present only in the XY mice, or the X chromosome genes cause the difference. Although these new mouse models present the opportunity to discover previously unknown direct effects of specific X and Y chromosome genes, the "chromosome effect does not tell where the X or Y chromosome genes act to cause the sex difference."[120]

The feminist/queer conception of sex introduces some new critical factors to consider when designing research studies that examine sex differences, but the concept of *sex* cannot be used in isolation from the concept of *gender* because, as Feminist biologist Ruth Hubbard, explains,

> *Society defines the sex-appropriate behaviour to which each of us learns to conform, and our behaviour affects our bones, muscles, sense organs, nerves, brains, lungs, circulation, everything. In this way society constructs us as biologically, as well as socially gendered people. It does not give us a vagina or a penis, but it helps give us the muscles, gait, body language, and nervous response that we associate with people who are born with one or the other*.[121]

And so, the research exploring physiological differences in men and women provides only a partial direction for prevention because it is uncertain whether these differences are biologically determined or have been partially socially produced.

SECTION III: Untangling Gender From Sex in Biomedical and Health Research

Feminist health researchers have documented how the concepts of sex and gender are often used interchangeably and the meaning of gender is conflated with the meaning of sex in mainstream biomedical and health research.[122] Subsequently, the impacts of the gendered social environment are under researched and differences in health outcomes are assumed to derive from biological differences between men and women, foreclosing an analysis of the social causes of health differences.[123] Feminist health researchers have demonstrated that a sex analysis is insufficient for understanding differences in health and illness between men and women.[124] U.S. Feminist health researchers Patricia P. Rieker and Chloe E. Bird (2008)[125] explain the utility of the concept of gender for biomedical and health researchers.

> *Gender shapes men's and women's choices and expectations regarding social roles and role-related activities, which in turn affects their exposures to various risks (including stress, role overload, occupational health problems such as carpal tunnel syndrome and exposure to toxic chemicals) and their access to protective resources (including income, wealth, health and disability insurance and social support).*[126]

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[120] Anita Holdcroft. (2007) op. cit. S69 Pg.66

[121] Ruth Hubbard (1990) *The Politics of Women's Biology*. London: Rutgers University Press. Pg. 138.

[122] J. Johnson, and L. Greaves, et al. (2009) 'Better science with sex and gender: Facilitating the use of a sex and gender-based analysis in health research', *International Journal for Equity in Health*. Vol. 8 no. 1; N. Krieger, (1992) 'The Making of Health Data: paradigms, politics and policy', *Journal of Public Health Policy.* Vol. 13. No. 4.

[123] N. Krieger, and S. Gruskin. (2001) Frameworks Matter: ecosocial and health in human rights perspective on disparities in women's health- the case of tuberculosis', *Journal of the American Medical Women's Association.* 56. 4; P. Ostlin and G. Sen, et al. (2004) Paying Attention to Gender and Poverty in Health Research: content and process issues. *Bulletin of the World Health Organization*. 740-745; J. Lorber. (1993) 'Believing is Seeing: biology as ideology', *Gender and Society*. Vol. 7. No. 4. ;Toni Schofield (2008) 'Gender and Health Inequalities: What they are and what we can do about them?', *Australian Journal of Social Issues*. Vol. 43. No. 1.

[124] P. P. Rieker and C. E. Bird (2005) 'Rethinking gender differences in health: Why we need to integrate social and biological perspectives', *Journal of Gerontology- Series B- Psychological Sciences and Social Sciences*. 60. Special Issue October; Linda Nieuwenhoven and Ineke Klinge. (2010) 'Scientific Excellence in Applying Sex- and Gender-Sensitive Methods in Biomedical and Health Research', *Journal of Women's Health*. 19(2); Nancy Krieger. (2002) 'Genders, sexes, and health: what are the connections—and why does it matter?', *Int. J. Epidemiol*. (2003) 32 (4).

[125] Chloe E. Bird and Patricia P. Rieker. (2008) cit.op.

[126] Ibid. Pg. 748

In other words, gender directs attention to social factors that affect the health of men and women and moves beyond simply adding women by disaggregating data by sex. It deconstructs dichotomous gender identities and reveals multiple and unequal social relations at the individual, institution, policy level that continually reproduce gender beliefs, behaviours and practices and impact health outcomes. Moreover, gender assists to explain causes, processes, and consequences of health and illness between men and women and provides a tool to ask novel questions that would otherwise never be asked.[127]

Women typically have been the focus when discussing health inequalities in relation to gender in an effort to rectify the omission of women in biomedical and health research. A gender-relations approach, however, allows for a critical understanding of men's health as well as women's.[128] A gender-analysis examines men's health in a "relational context—at the intersection of men's lives with women and with other men."[129] Studies that focus exclusively on men or women, as homogenous categories or specific populations of men and women, adopt gender as an identity category and obscure how gender operates. A gender-relations approach directs attention to how gender inequality and power expose men and women to different health risks within institutional settings such as the workplace and is constructed through symbolic representations of masculinity and femininity, which impact their health behaviours.[130] A gender-analysis of men's and women's health demonstrates that analyzing gender relations is just as vital to men's health as it is to women's health and vice-versa.[131]

Hence, incorporating a gender analysis in mainstream biomedical and health research requires the adoption of a new paradigm for scientific inquiry that is based on an alternative conception of the biological body, as is shaped by complex interactions with the social environment.[132] Specifically it requires conceiving biology as an "open system that is influenced by environmental and evolutionary factors" in which a variety of genetic, hormonal, physiological and social circumstances influence the development of male and female human organisms.[133] A gender analysis, therefore, approaches biological sex differences as connected to "the experiences of individuals growing, living, and dying in particular cultures and historical periods and under different regimens of social gender."[134] In doing so, a gender analysis expands understandings of mechanisms that cause differences in disease symptoms, outcomes, and susceptibility and results in more focused and accurate treatment.[135] Moreover, it leads to innovative health policy that not only treats biological differences between the sexes but also forces policy-makers to address inequities in the social environment that expose men and women to different health risk factors.[136]

Several gender theorists identify multiple levels of social organization in which gender operates, most notably Barbara J. Risman (1998). Risman identifies three levels of gender analysis 1) individual 2) interactional/cultural 3)institutional and demonstrates that these gender structures reinforce one another to

[127] P. Armstrong. (2006) 'Gender, Health and Care', in Dennis Raphael, Toba Bryant and Marcia Rioux (eds.) *Staying Alive: Critical Perspectives on Health, Illness and Health Care.* Toronto: Canadian Scholars' Press Inc.
[128] T. R. Schofield and Connell et al. (2000) 'Understanding men's health and illness: a gender –relations approach to policy, research, and practice', *Journal of American College of Health*. 48.
[129] W. H. Courtenay and R. P. Keeling. (2000) op.cit.Pg. 245.
[130] T. Schofield, R. Connell, et al. (2000) op.cit.
[131] W. H. Courtenay and R. P. Keeling. (2000) op.cit. Pg. 245; L. Doyal. (2001) 'Gender Equity in Health: Debates and Dilemmas', *Social Science and Medicine.* 51.
[132] Lynda Birke. (1999) *Feminism and the Biological Body*. Edinburgh: Edinburgh University Press. Kuhlmann and Babitsch, (2002) 'Bodies, health, gender—bridging feminist theories and women's health', *Women's Studies International Forum*. Vol. 25. No. 4.; Anne Fausto-Sterling. (2005) 'The Bare Bones of Sex-Part I Sex and Gender', *Signs*. Vol. 30 No. 2; Susan Philips. (2005)op.cit; M.J. Legato. (2003) 'Beyond women's health: The New Discipline of Gender-Specific Medicine', *Medical Clinics of North America*. 87. 5; I. Klinge. (2007). "Bringing Gender Expertise to Biomedical and Health-Related Research." *Gender Medicine*. 4(Supplement 2).
[133] T. Lagro-Janssen. (2007) op.cit.. Pg. 12.
[134] Anne Fausto-Sterling. (2005). op.cit. Pg 1510.
[135] M.J. Legato. (1998) 'Women's Health: Not for women only', *International Journal of Fertility and Women's Medicine*. 43. 2.; Legato, M. J. (2003)op.cit.
[136] P.E. Ostlin and Eckermann et al (2006) 'Gender and Health Promotion: A Multisectoral policy approach', *Health Promotion International*. 21. Supplement 1. Ellen Kuhlmann, and Ellen Annandale (eds.) (2010) op.cit.

constrain the behaviours of individuals in gendered ways, thus reproducing and reinforcing notions of gender difference and inequality. Other gender theorists have similarly suggested that to analyze gender requires a multi-level framework of analysis (Connell, 2002) (Lorber, 1994). However, Bird and Rieker (2008) are the only gender health scholars to date that have systematically outlined a multi-level framework of analysis for understanding how gender impacts the health of men and women. Bird and Rieker identify three levels of gender analysis that can be used to investigate how various gendered social structures impact the health of men and women. The levels of gender analysis include 1) social policy 2) community resources 3) work and family structures. These organizational contexts, are conceived as critical in differently "constraining the choices" of men and women to choose health. In doing so, this framework conceives of these structures as differently constraining the choices of men and women depending on their gendered social roles, rather than co-constructing gender as Risman suggests. Therefore, Bird and Rieker's framework offers a useful starting point to conceptualize how multiple levels of gendered social organization produce uneven health outcomes, but it fails to theorize how gender operates at these various levels and offers no framework for analyzing gender at the individual level. And so, in this paper, we will propose a new framework for a multi-level gender analysis in health and further delineate the theoretical conceptions of gender that inform each level of analysis and the corresponding methodologies.

A. Gender Norms

There are two dominant theoretical approaches to analyzing how socially constructed gender roles at the micro level impact the health behaviours of men and women. The first approach is influenced by psychological theories that assumed that healthy psychological development of men and women requires them to identify with their biological sex. Several measures, such as the California Personality Inventory (CPI) and femininity scale (Fe) have been created to determine sex-role conformity.[137] Critique of this approach, specifically its bi-polar gender conception of healthy men and women, eventually led to the development of androgyny theory, which claims that the most balanced men and women are able to draw on both masculine and feminine traits. Although this conception allows for men and women to have both masculine and feminine traits, research using this approach, specifically in field of health research, continues to use psychological measures of gender role orientation, such as the Bem Sex-role Inventory (BSRI), which simply measures the masculine and feminine characteristics of individuals and correlates them with health indicators, such as the use of health services or self-reported health.[138] The limitation of this approach is that it continues to conceptualize gender identity as fixed, static and unchanging socialized personality attributes thus making the individual the site of change rather than social institutions, policies, and/or structures. Gender is conceived as a risk factor and interventions aim at reducing risky behaviours among men and women, such as smoking or binge drinking, by changing gender role behaviours without considering the material and social conditions in which these behaviours are imbedded.[139] Subsequently, men and women are targeted with health advice, but the social circumstances that are causing them to adopt different negative coping behaviours, such as smoking and binge drinking, are never addressed.

The second approach was developed by gender theorists[140] and conceives gender not as a set of fixed roles, nor as a group of stable personality traits, but rather as something that is constantly being produced and reproduced by actions of individuals interacting with their social environments. Gender is something that does not solely reside in individual, but rather is continually (re)constructed through behaviours that have socially gendered meanings, including health-related beliefs and behaviours. A negotiated and tenuous gender identity is achieved only through repeated and shared practices and men and women engage in particular behaviours, not because of a socialized drive, but rather to achieve or resist

[137] E. Annandale and K. Hunt. (1990) 'Masculinity, femininity and sex: an exploration of their relative contribution to explaining gender differences in health', *Sociology of Health & Illness*, 12: 24–46.
[138] E. Annandale and K. Hunt. (1990) Ibid; M.H.J Bekker. (2003) 'Investigating gender within health research is more than sex disaggregation of data: A Multi-Facet Gender and Health Model', *Psychology, Health and Medicine*. Vol. 8. no. 2
[139] Östlin, et al op.cit.
[140] J. Butler. (1993) *Bodies that Matter: The Discursive Limits of Sex.* New York: Routledge. R.W. Connell. (1995) *Masculinities*. Berkley: California University Press

identification with culturally constructed ideal. This approach is able to explain variation among and between men and women, as they negotiate their gender identity through competing representations of gender, while also accounting for power relations that contribute to the construction of dominant ideals of masculinity and femininity in particular contexts.

Drawing on the work of theories of masculinity[141], U.S. Health Scholar Will H. Courtenay (2000) explains how cultural dictates and everyday interactions sustain and reproduce men's health risks.[142] The gendered health behaviours of men often endorse hegemonic notions of masculinity. The concept of hegemonic masculinity, as defined by R.W Connell and James W. Messerschmidt (2005) is defined as "the pattern of practice (i.e. things done, not just a set of role expectations or an identity) that allowed men's dominance over women to continue."[143] Courtenay (2000) demonstrates that men maintain or achieve a hegemonic masculine identity through health beliefs and behaviours, such as "the denial of weakness or vulnerability, emotional and physical control, the appearance of being strong and robust, dismissal of any need for help, a ceaseless interest in sex, the display of aggressive behaviour and physical dominance."[144] As a result, the normative ideal of hegemonic masculinity acts as a self-policing mechanism that leads men to act in ways that negatively impact their health.

Due to power relations related to class, race and sexual orientation, not all men are able to achieve hegemonic masculinity, and subsequently embody what Connell (1995) terms 'marginalized masculinities'. Courtenay (2000) uses this concept to explain that "when men and boys are denied access to the social power and resources necessary for constructing hegemonic masculinity, they must seek other resources for constructing gender that validate their masculinity."[145] In relation to health behaviours, the most readily accessible means of enacting masculinity involves rejecting health seeking behaviours and embracing risk. In fact, marginalized men often try to compensate for their subordinate status by adopting forms of hyper-masculinities that intensify these behaviours.[146] Demonstrations of these hyper-masculinities in heath-related behaviours can range from working-class men using the "physical endurance and tolerance of discomfort required of their manual labor as signifying true masculinity" to "gay men dismissing the risks associated with high numbers of sexual partners or unprotected anal intercourse."[147] Identifying men's gendered health beliefs are critical for not only improving the health of men and women but also for addressing the existing power structures that are preserved by them.

There has been an under theorization of femininity, both within and outside the field of health-related research.[148] However, New Zealand Feminist Health Scholar Antonia C. Lyons (2009)[149] draws on the work of gender theorists that have called for more attention on the practices of women, specifically hegemonic notions of femininity and multiple, hierarchical femininities, to explain how performances of femininity impact the health of women. Hegemonic femininity or emphasized femininity is a concept introduced by Connell (1995) and is defined as "the characteristics defined as womanly that establish and legitimate a hierarchical and complementary relationship to hegemonic masculinity and that, by doing so, guarantee the dominant position of men and the subordination of women."[150] In other words, women who perform hegemonic femininity adopt behaviours that place them in a subordinate, submissive, vulnerable, and dependent role in relation to men. Women who seek to challenge the gender order by engaging in what Schippers (2007) identifies as "pariah femininities" or assertive or independent behaviours that are

[141] R.W. Connell. (1995)Ibid; Connell and Messerschmidt. (2005) 'Hegemonic Masculinity: Rethinking the Concept', *Gender and Society*. Vol. 19. No. 6.
[142] W.H.Courtenay, (2000). 'Constructions of masculinity and their influence on men's well-being: a theory of gender and health', *Social Science & Medicine.* 50(10).
[143] Connell and Messerschmidt. (2005). op.cit. Pg. 832
[144] W. Courtenay. (2000). op.cit.Pg. 1389
[145] Ibid
[146] W. Courtenay. (2000). Ibid. Pg. 1392
[147] Ibid.
[148] Mimi Schippers. (2007) 'Recovering the Feminine Other: Masculinity, Femininity and Gender Hegemony', *Theory and Society*. 36: 85.
[149] A.C. Lyons. (2009) 'Masculinities, Femininities, Behaviour and Health', *Social and Personality Psychology Compass*. 3.
[150] A.C. Lyons. (2009). Ibid. Pg. 396-397.

then often contained by social sanctions, such as being defined as "bitch", "slut", "lesbian" etc.[151] Women's lives are organized in such a way that they continuously reconstruct or challenge ideals of femininity and hegemonic femininity through health behaviours and practices. Ideals of femininity, particularly in Western culture, place value on women who are slender and emphasize the 'thin ideal'[152], which result in poor nutrition, distorted eating patterns and extreme dieting regimes among women.[153] Research in the UK has found that constructions of femininity have significant negative impacts on the participation of adolescent girls in sport, regardless of the gender composition of the participants.[154] Constructions of femininity connected to motherhood have been found to limit women's capacity to deal with challenges and conflicting emotions related to motherhood.[155] Different versions of femininities and masculinities are constantly being negotiated and reproduced through routine health behaviours and by researching and identifying them, policy-makers may be able to promote healthier ways of 'doing gender'.[156]

There are few studies that examine how men *and* women perform gender through health behaviours. As mentioned prior, most studies adopt gender as an identity category and examine the health behaviors of men and women separately or examine the health behaviours of specific groups of men or women. This study was selected as an example of a good practice of micro-level gender-relations health research because it included *both* men and women and examined the impact of gender-relations on individual beliefs and behaviors. In doing so, it reveals how notions of gender impact on the alcohol treatment seeking practices of men and women. Moreover, rather than simply describe the differences in treatment seeking behaviour patterns between men and women it investigates how beliefs about gender lead to differences in alcohol treatment seeking behaviours. In doing so, it provides an explanation for why the health disparities in treatment for alcoholism exist between men and women and therefore how they can be changed.

Example Study
Swedish health researchers Annika Jakobsson et al. (2008)[157] explore how gendered conceptions impact alcohol treatment seeking in men and women. Jakobsson et al. (2008) note that significant gender differences have been found in treatment seeking behaviours. For instance, men have been found to be 50 percent more likely to receive treatment for their alcohol problems than women and subsequently women are far worse off than men in reports of symptom severity and functioning indices when entering treatment.[158] However, why these gender differences exist remains unexplained.

To determine how ideas of masculinity and femininity impact the treatment seeking behaviours of men and women, Annika Jakobsson et al. (2008) conducted in-depth interviews with five women and seven men from open specialist treatment facilities in a Swedish city. The results indicated that ideas of masculinity and femininity differently mediated similar alcohol treatment seeking behaviours. For instance, for women, avoiding treatment allowed them to maintain their femininity as "alcohol problems per se were perceived as unfeminine" while men continued to drink because "the inability to handle alcohol was perceived as unmasculine."[159] However, men also indicated that seeking treatment would allow them to restore their masculinity. For instance, "some of the reasons expressed by men in this study for seeking treatment were the desires to keep their driver's license, to become a good father, to improve their financial situation and to return to the labour market, all of which can be regarded as attributes of

[151] Mimi Schippers. (2007). op.cit. Pg. 95.
[152] Susan Bordo. (1993) 'Feminism, Foucault and Politics of the Body', in Caroline Ramazannoglu *Up Against Foucault Explorations of some Tensions between Foucault and Feminism.* New York: Routledge.
[153] Lyons, A. C. (2009) op.cit.
[154] Bathan Evans. (2006) ''I'd Feel Ashamed': Girls' Bodies and Sports Participation', *Gender, Place, and Culture.* Vol. 13. No. 5
[155] Choi and Henshaw et al. (2005) 'Supermum, superwife, supereverything: performing femininity in the transition to motherhood', *Journal of Reproductive and Infant Psychology*. Vol. 23. No. 2
[156] Lyons, A. C. (2009), op.cit.
[157] Annika Jakobsson, Gunnel Hensing and Fredrik Spak (2008) 'The role of gendered conceptions in treatment seeking for alcohol problems', *Scand J Caring Sci*. 22. 196.
[158] Ibid.
[159] Ibid. Pg 199.

masculinity."[160] Seeking treatment did not allow women to restore their femininity in the same way, which could partially explain why women are more reluctant to seek treatment. For instance, one woman explained, "if a woman says…yes, I'm an alcoholic…I have a problem…because as a woman you're not supposed to…you're supposed to take care of children…you're supposed to be a good girl…"[161] There was no room in the ideal of femininity ascribed to women for alcohol problems, which makes it difficult for women to maintain their feminine identity and admit they have a problem with alcohol.

A gender analysis at the individual level reveals that culturally constructed gender norms impact the behaviours of individual men and women. Socially constructed and unequally valued norms for men and women create cultural expectations for both sexes. These norms and expectations define desirable behavior for males and females and function as self-regulating mechanism in which individuals evaluate and define themselves. Therefore, a gender analysis at a micro-level is critical for understanding and changing the health behaviours of men and women.

B. Gendered Social Institutions

A gender health analysis at the institutional/structural level examines how economic gender inequalities in decision-making powers, income, employment, working environment, education, and housing affect the health of both men and women[162]. In other words, structural level gender analysis of health situates men and women "within the broader social, cultural and political contexts that also condition their health."[163] By doing so, many gender and health researchers argue that accounting for gender inequality of institutions within and outside of healthcare sector is critical for effectively addressing the health of men and women.[164]

Gender inequality within an institution directly related to the healthcare sector, which has been found to impact the health of men and women, is the institutions of scientific medicine.[165] P. Verdonk et al. (2007)[166] review the four types of gender bias found in medical education and practice and the consequence for the health of women and men. Gender bias continues to 1) produce incomplete clinical research studies 2) produce gaps in understandings about female and male health 3) affects how health care is provided and results in less than optimal care 4) leaves men and women with different levels of access to care. Institutionalized gender inequality in medical education and practice result in a range of health consequences including negative drug reactions and misinterpretation of symptoms followed by inappropriate or unnecessary treatments or undiagnosed health conditions.

Similarly, workplace policies have also been shaped by gender inequality and normative beliefs about gender. Subsequently, "men and women differ in their employment status, jobs, tasks and assigned responsibilities."[167] Yet occupational health researchers have historically paid little attention to women's

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[160] Ibid.
[161] Ibid. Pg 200.
[162] P. Ostlin et al. (2006). op.cit.
[163] Jen'nan Ghazal Read and Bridget K. Gorman. (2010) 'Gender and Health Inequality', *Annual Review of Sociology*. 36.pg. 381
[164] P. Ostlin, Gita Sen and Asha George. (2004) op.cit.
[165] K. Alexanderson, G. Wingren & I.Rosdahl. (1998). 'Gender analyses of medical textbooks on dermatology,epidemiology, occupational medicine and public health', *Education for Health,* 11. G.R. Chiaramonte & R. Friend (2006). 'Medical students' and residents' gender bias in the diagnosis,treatment, and interpretation of coronary heart disease', *Health Psychology*. 25.
C. Foss & J. Sundby. (2003). 'The construction of the gendered patient: Hospital staff's attitudes to femaleand male patients', *Patient Education and Counseling*, 49. G.D. Donoghue (2000). 'Introduction. Women's health: A catalyst for reform of medical education', *Academic Medicine,* 75, 1056–1060., P. Verdonk, A. Harting, & T. Lagro-Janssen. (2007b). 'Does equal education generate equal attitudes? Gender differences in medical students' attitudes toward the ideal physician', *Teaching and Learning in Medicine,* 19.
[166] P. Verdonk, A. Harting, & T. Lagro-Janssen. (2007b) Ibid.
[167] Lucıa Artazcoz, Carme Borrell, Imma Corte` s, Vicenta Escriba` -Aguir, Lorena Cascant (2007) 'Occupational epidemiology and work related inequalities in health: a gender perspective for two complementary approaches to work and health research', *J Epidemiol Community Health*. 61.

occupational health problems.[168] There is very little gender comparative occupational health research and few studies documenting health effects of domestic work and the low paid and low status work environments that women predominantly occupy.[169] The male bias in occupational health research separates the workplace from the home and obscures the gender division of labour within and outside the workplace.[170] Feminist analyses of women's experiences illustrate how the gendered domestic divisions of labour and gender inequality in the workplace are intimately linked. Women burdened with the extra responsibilities of domestic work are often limited to "low-status, low-paid, often part-time jobs."[171] Moreover, as women enter the workplace, they experience what feminists have termed a "double shift" and become responsible for performing work inside and outside the home. Several studies have found that the "double shift" creates role-strain, role-conflict and limits opportunities to engage in exercise and relaxation, which has adverse affects on health.[172] Over the life course, disadvantages in the workplace and burdens of domestic work accumulate to make older women increasingly financially insecure and vulnerable to poor health.[173] The quality of working conditions, namely flexible and family supportive work environments, have been found to have significant effects on perceived health and quality of life[174] and "are particularly important for people who break out of traditional gender roles and have a high total workload."[175] A gender analysis reveals that a failure to account for the complex connections between gender divisions in the family and workplace has resulted in critical gaps understandings of gender health risk exposures. To address these gaps, future occupational health research needs to examine "how socioeconomic circumstances, together with marital and parental roles" influence health differences between women and men.[176]

Neighborhoods have been identified as another critical social structure that is shaped by beliefs about gender and gender inequality and limits the health choices of men and women[177]. Although neighborhood socioeconomic characteristics have an important influence on health outcomes, few studies have included a gender analysis. Rather studies that examine the impacts of neighborhood or community deprivation on health "simply adjust for gender, assuming that the neighborhood deprivation is equivalent for both men

[168] Karen Messing et al. (2003) 'Be the fairest of them all: Challenges and recommendations for the treatment of gender in occupational health research', *American Journal of Industrial Medicine.* Vol. 43. No. 6.

[169] Jan Angus. (1999) 'Women's Paid/Unpaid Work and Health: Exploring the Social Context of Everyday Life', *Canadian Journal of Nursing Research*. Vol. 26, No. 4. Kate Hunt and Ellen Annandale. (1993) 'Just a Job? Is the relationship between the health and domestic and paid work gender-specific?', *Sociology of Health and Illness*. Vol. 15 No. 5; Lucıa Artazcoz, et al (2007) op.cit; Payne and L. Doyal. (2010) 'Older women, work and health', *Occupational Medicine*. 60: 172.

[170] Lesley Doyal. (1999) 'Sex, Gender, and Health: A New Approach', in Watson and Lesley Doyal (eds.) *Engendering Social Policy*. Buckingham: Open University Press.

[171] S. Arber and Gilbert, N. (1992) 'Re-assessing women's working lives: an introductory essay', in S. Arber and N. Gilbert (eds.) *Women and Working Lives: Divisions and Change*. London: Macmillian.

[172] Lesley Doyal. (1995) *What Makes Women Sick: gender and the political economy of health*. London: Macmillan. Martha MacDonald, Shelly Phipps, and Lynn Lethbridge. (2005) 'Taking its Toll: the Influence of Paid and Unpaid Work on Women's Well-Being', *Feminist Economics*. 11(1), Sara Arber. (1991) 'Class, Paid Employment and Family Roles: Making Sense of Structural Disadvantage, Gender and Health Status', *Social Science and Medicine*. 32., Mel Bartley et al. (1992) 'Domestic Conditions, Paid Employment and Women's Experience of Ill Health', *Sociology of Health and Ilness*. 14., Lyndall Stradins and Gabriele Brammer. (2004) 'Women, work and musculoskeletal health', *Social Science and Medicine*. 58.

[173] Margaret Denton and Linda Boos. (2007) 'The Gender Wealth Gap: Structural and Material Constrains and Implications for Later Life', *Journal of Women and Aging*. Vol. 19 (3/4)

[174] Sharon Matthews et al. (1998) 'Gender Work Roles and Psychological work Characteristics as Determinants of Health', *Social Science and Medicine*. Vol. 46 no. 11

[175] Annika Harenstam and Eva Bejerot. (2001) 'Combing professional work with family responsibilities—a burden or a blessing?', *International Journal of Social Welfare*. 10. Pg. 212

[176] Sara Arber and Hilary Thomas. (2001) 'From Women's Health to a Gender Analysis of Health', in William C. Cockerham (Ed.) *The Blackwell Companion to Medical Sociology*. Oxford: Blackwell Publishers Ltd. Pg. 107

[177] Flora I. Matheson et al. (2006) 'Urban neighborhoods, chronic stress, gender and depression', *Social Science and Medicine.* Vol. 63 no. 10; Lore van Praag, Piet Bracke, Wendy Christiaens, Katis Lavacque and Elise Pattyn. (2008) 'Mental health in a gendered context: Gendered community effect on depression and problem drinking', *Health and Place*. 15; Susan J. Popkin, Tama Leventhal and Gretchen Weismann. (2010) 'Girls in the 'Hood: How Safety Affects the Life Chances of Low-Income Girls', *Urban Affairs Review.* 45: 735.

and women."[178] However, feminist geographers have demonstrated that unequal gender relations mediate access to physical and social features of neighborhoods.[179] However feminist health-researchers argue that the gendered structure of neighborhoods has significant effects on the health of men and women. For instance, built features such as the presence of secure, open green space, sidewalks and street lighting, limits accessibility to recreational safety for women in relation to men and influences their participation in leisure time physical activity. The segregation of wealthy and impoverished residents also creates different health barriers for men and women, as disadvantaged neighborhoods have higher turnover rates, less social cohesion and more disorder. These negative neighborhood characteristics, have been found to present specific risks to the mental and physical health of females and males, namely placing females at risk to "early sexual activity, teen pregnancy, victimization and coerced sex" and males to "substance abuse, delinquency, and crime."[180] In addition, the proximity of public transportation networks, affordable healthy food stores and accessibility to tobacco and alcohol, might affect different dietary patterns between men and women. [181]

Example Study

The following study has been selected as an example of a best practice for gender health research at the institutional level, namely because it is among the few studies that includes a large sample of *both* men and women from a range of ages and analyzes the interrelated demands of low-wage work an unpaid work structures. Lucía Artazcoz et al. (2007) conduct a model study investigating the effects of long workhours (>40 hours per week) on a variety of health outcomes and health-related behavior among men and women. The data used was from a subsample of all salaried contract workers aged 16–64 years (1658 men and 1134 women) from the 2002 Catalonian Health Survey (CHS). The study analyzes the gender differences in family and job characteristics among those working long hours in an effort to determine if differences in work and family structures help to explain gendered health differences in men and women working long workhours.[182]

The results of the study found striking gender differences in long-work hours and health outcomes. The only health outcome that was positively associated with long workhours for both genders was shortage of sleep. Otherwise, women working long workhours were found to suffer from six of the seven health outcomes and poor health-related behaviours, including poorer mental health status, hypertension, low job satisfaction and higher rates of smoking.[183]

Lucía Artazcoz et al. (2007) measured differences in work environments and domestic responsibilities to try to explain the differences in health-related outcomes among men and women working long hours. The results indicate that the type of work, women working over forty hours per week, was qualitatively different than the type of work men engage in, which might partially explain the poorer health outcomes among women. For instance, the study found that women were more likely to report, "that their work had little variety and was monotonous and repetitive (44.4% versus 25.5%).[184] The same pattern was observed when the women who worked >40 hours a week were compared with those who worked 30–40 hours. The former were more likely to report high demands (57% versus 23.6%) and low variety (44% versus 30.2%)."[185] In relation to domestic responsibilities, women in the highest category of domestic workload, and long workhours engaged in sedentary behavior during leisure time.[186] These results indicate that

[178] Flora. I. Matheson et al (2006) op. cit. Pg 705.
[179] Robin Law. (1999) 'Beyond 'women and transport': towards new geographies of gender and daily mobility', *Progress in Human Geography* Vol. 23. No. 4*;* Carolyn Whitzman. (2007) 'Stuck at the front door: gender, fear of crime and the challenge of creating safer space', *Environment and Planning*. Vol. 39.no. 11; M. P. Kwan.(1999). 'Gender and Individual Access to Urban Opportunities: A Study Using Space, Time Measures', *The Professional Geographer*. 51(2).
[180] Susan J. Popkin, Tama Leventhal and Gretchen Weismann. (2010). op.cit. Pg. 716.
[181] Bird, Chloe E. and Patricia P. Rieker. (2008) op.cit.; Flora I. Matheson et al. (2006) op.cit.
[182] L. Artazcoz, I. Cortès, C. Borrell, V. Escribà-Agüir, L. Cascant. (2007) op.cit. Pg.347
[183] Ibid.
[184] Ibid. Pg. 348.
[185] Ibid.
[186] Ibid. Pg. 349.

domestic work places an addition burden on women's long workhours and prevents them from engaging in physical activity during their leisure time, which negatively affects their health.

The authors suggest that further research needs to be done to confirm the results, particularly the relationships between a shortage of sleep and long workhours, large amounts of time devoted to housework, long workhours and lack of physical activity during leisure time, particularly for women. The gendered outcomes indicate a need to apply a gender analysis when researching the health effects of occupational characteristics and employment status. Specifically, the poor health among women with long exposure to poor working conditions point out the need to "pay more attention to occupational health in some of the economic sectors largely occupied by women, such as hotels and restaurants, retailing, and building cleaning."[187]

A gender analysis at the structural level highlights the gendered aspects of social institutions and how these structural inequalities influence chances of health and well-being, as well as the opportunities of men and women to improve those chances through positive health behaviours. Moreover, it provides employers and local and national policy-makers with specific information about the gendered health consequences of institutional policies and programmes and provides direction to change them.

C. Gendered Social Policy

U.S sociologist Ann Orloff (1996) explains that feminist researchers have demonstrated that national social and public policies and regulations have significant and differential impacts on the lives of men and women and their relationships. Using Esping-Andersen's classification of welfare systems, feminists have been conducting systematic comparative research on the gendered impacts of welfare state policies. Although the mainstream typology on welfare states only incidentally takes account of gender differences, feminist scholars have used the schema to "make sense of gendered relations and patterns using the regime-type framework, evaluating whether or not liberal, conservative, and social-democratic regime types have distinctive effects on gender relations."[188] The results suggest that different regime types have different effects on gender relations. For instance, Gustafsson et al. (1996)[189] did a comparative analysis of childcare policies in the United States, the Netherlands, and Sweden and found "that public services are best developed in Sweden, market provision of services is prominent in the United States, and the Netherlands offers little public provision, in effect opting to support mothers' caregiving work rather than offering daycare."[190] Using Esping-Andersen's regime model, some feminist researchers have also found varying gender effects within regime types. For instance, Leira (1992)[191] found various levels of supports for public child provision with corresponding differences in women's participation in paid labour in Social-democratic countries.

Orloff explains that some feminist scholars argue that to more accurately capture the state's effects on gender relations a new regime typology must be constructed "based on an understanding of gendered interests."[192] In doing so some scholars have shown that gender dimensions do not always correlate neatly with established regime types.[193] Some recent scholars have rejected the regime model completely for a framework that accounts for specific gender social and political contexts while conducting a systematic comparative analysis of particular welfare or health policies.[194]

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[187] Ibid.
[188] Ann Orloff. (1996). op.cit. Pg. 66.
[189] Gustafsson et al. (1996) 'Women's labor force transitions in connection with childbirth: A panel data comparison between Germany, Sweden and Great Britain', *Journal of Population Economics*. Vol. 9 no. 3.
[190] Ibid.
[191] A. Leira (1992) *Welfare States and Working Mothers: The Scandinavian Experience*. Cambridge: Cambridge University Press.
[192] Ann Orloff. (1996). Pg. 70
[193] Jane Lewis. (1992) 'Gender and the Development of Welfare Regimes', *Journal of European Social Policy*. Vol. 3. No. 2.
[194] Viola Burau, Hildegard Theobald and Robert H. Blank. (2010) 'Old Age Care Policies: Gendering Institutional Arrangements Across Countries', in Kuhlmann, Ellen and Ellen Annandale (eds.) (2010) op.cit.

Example Study

The following study was chosen as an example of a best practice for a policy-level gender analysis of health because it is the first and only study to use the regime-type model to systematically compare gendered health outcomes between countries. In doing so, it provides an excellent template for further research. Using an updated form of Esping-Andersen's regime typology, UK health geographers Bambra et al. (2009) demonstrate how the regime framework can be adopted to systematically compare relationships between welfare policies and gendered health outcomes. Bambra et al. (2009) restrict their study to thirteen European countries and using a modernized regime typology that identifies four core welfare state regime types: Social Democratic (Denmark, Norway, Sweden and, to a lesser extent, Finland and Holland); Corporatist (Belgium, France, Germany); Liberal (England, Ireland); and Southern (Italy, Spain, Portugal). (39) The study was funded as part of the tackling health Inequalities in Europe (EUROTHINE) project and used data from various national health surveys of adults carried out between 1998- 2004. The data was used to conduct two descriptive analyses. "The first explored the relationship between self-assessed health (SAH) and gender in each country, adjusting for age. The second stratified the analysis according to the four educational ranks."[195]

The results of the first analysis corresponded to the regime typologies. It was found that "women who are moderately more likely to report 'bad' or 'very bad' SAH are those in social democratic countries of Denmark, Holland, Norway and Sweden; women in the Southern regimes of Portugal and Italy (and to lesser extent Spain) are highly likely to report worse SAH; whereas those countries in which there appear to be no gender differences are the corporatist countries of Belgium, France and Germany."[196] Nevertheless, the findings do not follow the assumption that there would be smaller gender differences in Social Democratic states because of progressive gender equity interventions of income redistribution and extensive public provisions. Bambra et al. (2009) draw on feminist literature to explain that the outcome could be a result of "dual roles experienced by women in Social Democratic states. A high proportion of women work and, although public policy is progressive in terms of childcare and paternity leave, women are still responsible for the majority of domestic work and family care."[197] Bambra et al. (2009) suggest, "another factor behind the results is the higher proportion of lone mothers in Social Democratic states." [198] Although the results suggest that states, which promote restrictive gender roles face extremely adverse effects on gender differences in health, further analysis is needs to explore the consistency of these findings.

The results of the second analysis, supports the finding that women experience poorer health when faced with demands of a dual-role. When stratifying the gender differences in SAH by educational rank, the most educated women in many European countries experience poorer health. For instance, "in Southern regime countries of Italy and Portugal (but not Spain), the increased risk of poor SAH in women appeared to be greatest among the most highly educated."[199] The same finding was also found "in Social Democratic Sweden."[200] Similarly, "in England, reduced risk of poor SAH reported by women was only among the least educated."[201] However, not all the findings corresponded to this pattern. For example, in the "Social Democratic Countries (Denmark, Holland, and Norway), there was no clear relationship between increased risk of poor SAH in women and educational rank."[202] Further research, using other measures of socioeconomic position or workforce participation, is necessary to further investigate health outcomes of women and men faced with dual roles.

A systematic macro-level gender analysis of policies and regulations can show how policies indirectly or directly affect women and men's health by limiting or broadening their opportunities and access to

[195] C. Bambra, D. Pope, V. Swami, D. Stanistreet, A. Roskam, A. Kunst & A. Scott-Samuel. (2009). 'Gender, health inequalities and welfare state regimes: a cross-national study of thirteen European countries', *Journal of Epidemiology and Community Health* 63(1) pg. 39.
[196] Ibid. Pg. 40.
[197] Ibid. Pg. 40.
[198] Ibid.
[199] Ibid. Pg. 41.
[200] Ibid.
[201] Ibid.
[202] Ibid.

resources. Public policies that determine labour standards, access to social security benefits, paternity and maternity leave shape gender norms, women's and men's work-related patterns and lifestyle choices. Patterns of health, illness and diseases among men and women vary among countries with different policy regimes, indicating that macro-level policies influence gendered health outcomes.

SECTION IV: Integrating Intersectionality into a Gender and Sex Analysis

Canadian feminist health researchers have been at the forefront of developing an intersectional gender analysis that investigates health disparities *among* women and men, rather than just between women and men. Using the Canadian context as an example, Canadian Health Researchers Olena Hankivsky et al. (2010) explains the limitations of the gender approach.

> *Canadian health research on women tends to essentialize the category of women (that is, assumes that all women, regardless of age, cultural backgrounds, geographical location, socioeconomic status, religion, sexual orientation and other categories of difference, share exactly the same experiences, views and priorities), and further, gives too much primacy to gender over other key determinants and does not adequately address the interactions among all determinants of health. Consequently, the issues and priorities of many vulnerable women, including members of ethnic, racial and linguistic minorities, Aboriginal women, low-income women, lesbians, and women with disabilities are usually excluded from mainstream women's health research.*[203]

The utility of intersectionality, is that it seeks to understand the perspective and needs of women and men who remain invisible under mainstream gender analyses. As Shields (2008)[204] explains, the intersectionality perspective was developed from Black, Lesbian and Postcolonial Feminists critiques [205],of the tendency of mainstream second wave feminist scholarship to universalize middle-class, heterosexual, educated, white women's experiences. By emphasizing differences among women, these critiques revealed how "lived experiences of oppression cannot be separated into those due to gender, on the one hand, and race, on the other, but rather are simultaneous and linked."[206] Intersectionality conceptualizes various forms of social stratification, such as race, class, and gender as a "matrix of domination"[207] or "complex inequality"[208] that are inherently connected and intertwined.[209]

Feminist health researchers have been careful to distinguish the intersectional approach from the co-variate approach, which is often adopted by most mainstream biomedical and health researchers. The co-variate approach typically assumes that categories such as gender or race are independent analytic categories that can simply be added together and compared. This approach is largely based on the belief that "the more marginalized statuses that the individual identified with (or was identified as occupying), the greater the oppression."[210] Although this is often the case, as "poor men of colour have worse health than

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[203] Olena Hankivsky, Colleen Reid, Renee Cormier, Colleen Varcoe, Natalie Clark, Cecilia Benoit, and Sahri Brotman. (2010) 'Exploring the Promises of Intersectionality for Advancing Women's Health', *International Journal for Equity in Health*. 9:5. Pg. 1

[204] Stephanie A. Shields. (2008) 'Gender: An Intersectional Perspective', *Sex Roles*. Vol. 59.No. 5-6.

[205] Patricia Hill Collins (1989) 'The Social Construction of Back Feminist Thought', *Signs.* Vol. 14 No. 4; Kimberle Crenshaw. (1989) 'Demarginalizing the intersection of race and sex: black feminist critiques of antidiscrimination doctrine, feminist theory and antiracist politics' *The University of Chicago Legal Forum*. Vol. 139; C. Moraga and G. Anzaldúa (*1981*) *This Bridge Called My Back: Writings by Radical. Women of Color.* Watertown, MA: Persephone Press. Bonnie Thornton Dill. (1983) 'Race, Class, and Gender: prospects for an all-inclusive sisterhood', *Feminist Studies*. Vol. 9 No. 1 A. Lorde, (1984). *Sister Outsider.* California: Crossing Press.
Chandra T. Mohanty. (1991) *Third World Women and the Politics of Feminism.* Indiana: Indiana University Press.

[206] H. Y. Choo and M.M. Ferree, (2010). 'Practicing Intersectionality in Sociological Research: A Critical Analysis of Inclusions, Interactions, and Institutions in the Study of Inequalities', *Sociological Theory*. 28.pg. 133

[207] Patricia Hill Collins. (2000) *Black Feminist Thought: knowledge, consciousness, and the politics of empowerment*. New York, Routledge.

[208] Leslie McCall. (2001) *Complex Inequality: gender, class, and race in the new economy.* New York: Routledge.

[209]H. Y. Choo and M.M. Ferree, (2010). (2010). Pg. 129

[210] Stephanie A. Shields. (2008) op.cit. Pg. 303

prosperous men of colour,"[211] these comparative macrolevel analyses assume for each minority status there is a simple accumulation of disadvantage and obscure the nuances of experience when gender, race, class, and sexual orientation intersect. For instance, "white, straight, well-to do men have longer life spans than men of color, for example, that does not mean they live healthy lives or that they experience wellbeing."[212] An intersectional analysis demonstrates how the meanings and social inequalities produced by gender, race and class as socially constructed concepts change in relation to one another to affect the health of men (and women) differently.

The intersectional perspective probes beneath single identities to account for a complex set of social relations, rather than equate identity categories with individual differences. Mainstream biomedical researchers often used concepts such as race, gender, class, and sexual orientation uncritically as indicators of biological or cultural differences between human beings[213]. Intersectional scholars acknowledge that "race", "class", and "gender" as a biological concept have long been challenged by social and natural scientists and instead conceptualize them as socially constructed concepts.[214] For instance, "race" refers to "social groups, often sharing cultural heritage and ancestry, that are forged by oppressive systems of race relations."[215] The concept of "race" doesn't explain differences itself but rather is used to investigate and "describe how racial relationships structure people's lives and experiences of health and disease."[216] Similarly, class is often used in mainstream biomedical and health research using "socioeconomic status (SES), a depoliticized term suggesting that one's ranking in society reflect[s] individual differences rather than exploitative political and economic relationships."[217] In other words, intersectional analyses investigate how racial, gender, class, sexual orientation classifications have emerged from various historically unequal social relations. Therefore, broad systems of inequality connected to the public policy, healthcare economy, jobs, education and law become the target for intervention, rather than individuals or groups.

The focus on unequal social relations rather than identities allows researchers to consider how unequal social relations operate, intersect, overlap, and reinforce to produce health disparities, rather then simply describe health disparities between or among assumed separate groups. [218] As Weber and Fore (2007) demonstrate mainstream biomedical health research typically "seeks to track (not necessarily explain) differences in health outcomes across some measure of social inequality (most commonly race/ethnicity)."[219] The intersectional perspective provides a framework to identify and *explain* these differences in outcomes. For instance, Fish (2007) in her intersectional analyses of how multiple inequalities impact the health of black gay men, finds that "the very meaning of being gay may vary when applied to one's own racial group as compared to another."[220] In other words, the various meanings ascribed to gay men from different racial groups affects a variety of daily experiences, with partners, family, and friends, which ultimately also affect their health. Research on the "mental health of gay and bisexual Latino men, [found] that many men reported experiences of racism within the gay community, discomfort in spaces primarily attended by whites and being sexually objectified owing to their race/ethnicity."[221] These experiences of discrimination have more negative effects on the mental health of Latino than other gay and bisexual men.[222] The intersectional approach doesn't simply want to describe

[211] W.H. Courtenay & Keeling, R.P. (2000).op.cit. Pg. 244
[212] Ibid.
[213] Amy J. Schulz and Leith Mullings (Eds) (2006). *Gender, Race, Class & Health: Intersectional Approaches*. Francisco: Jossey-Bass.
[214] K. Lisa Whittle and Marcia C. Inhorn. (2001) 'Rethinking Difference: A Feminist Reframing of Gender/Race/Class for the Improvement of Women's Health Research', *International Journal of Health Services*. Vol 31. No. 1. Pg. 156
[215] Ibid.
[216] Ibid.
[217] Ibid. Pg. 154
[218] Olena Hankivsky and Ashlee Christiffersen. (2008) 'Intersectionality and the determinants of health: a Canadian Perspective', *Critical Public Health.* 18: 3. Pg. 276.
[219] L. Weber and M. E. Fore. (2007) 'Race, Ethicity and Health: An Intersectional Perspective', in V. Hernan and J.R. Feagin. *Handbooks of Sociology and Racial and Ethnic Relations*. New York: Springer. Pg. 26
[220] Julie Fish. (2007) 'Navigating Queer Street: Researching the Intersections of Lesbian, Gay, Bisexual and Trans (LGBT) Identities in Health Research', *Sociology Research Online*. 13. 1. Pg. 8
[221] Ibid.
[222] Ibid. Pg. 9

differences between groups, but rather identify linkages between social identities and explain how those linkages define and shape one another to produce disparities in health and illness.

Qualitative and Quantitative Intersectional Biomedical and Health Research

Hankivsky et al. (2010) explains that the models and methods to measure and investigate multiple intersectionalities are only in their infancy and have yet to be fully developed. Hankivsky et al. (2010) argues that "mixed method approaches are considered the most suited to the intersectionality paradigm because they can produce both macro and mirco-level data and provide the opportunity to examine their concurrent production"[223] The implementation of these mixed method approaches, which identify complex connections between biological conditions and historical, political, social and economic contexts, requires not only combination of quantitative and qualitative research methods, but also collaborations across disciplines.[224] Several of emerging intersectional methods will be explained and analyzed below to contribute to the further development intersectional research that can pinpoint how multiple and intersecting social relations affect women and men in their daily lives and interact in specific situations to condition health.

Quantitative Intersectional Methods

There are many examples of how to do an intersectional analysis using qualitative methods, but very few using quantitative methods. Gita Sen, Aditi Iyer and Chandan Mukherjee (2010) provide the best example to date. They are among the first to try to develop a quantitative approach that accounts for health effects of multiple and intersecting social relations. Much of the quantitative research that explores the impact of social inequality on health view different dimensions of social inequality as separable processes. For instance, "those who work on class often do not acknowledge the importance of gender, and vice versa."[225] Subsequently, as Sen et al. (2010) explain, "we still do not know, with a lot of empirical backing, how gender affects class inequalities, for instance, or how gender relations are modified by class, let alone how these intersections influence health inequalities."[226]

Most quantitative analyses that measure the impact of multiple variables on health outcomes, such as gender and class, "measure gender differences within class, and/or class differences by gender."[227] These studies often examine if health outcomes among certain classes are the same for men and women, but they do not explain how gender and class interact to impact health. Sen et al. (2010) propose a method using dummy variables to measure and test for the effects of intersectionality on health. The method requires researchers to "create a set of dummy variables for each intersecting category."[228] To measure intersections of gender and class inequalities, four categories could be created: non-poor men, non-poor women, poor men and poor women. Non-poor men would be used as the reference variable and each variable can be tested relative to the reference group. This allows researchers to "test for differences between all categories, including those at the extremes and in the middle of the social scale."[229] It also allows researchers to "test for the significance of the differences in the gender gap between non-poor and poor; or the significance of the differences in the class gap between men and women."[230] As Sen et al. (2010) explain the method allows for the creation of "as many dummies as needed, depending on the intersections being analyzed. For instance, gender versus class, gender versus caste versus class, and so forth."[231]

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[223] Olena Hankivsky, Colleen Reid, Renee Cormier, Colleen Varcoe, Natalie Clark, Cecilia Benoit, and Sahri Brotman. (2010) op.cit. Pg. 5

[224] Dankwa-Mullan et al. (2010) 'Moving Toward Paradigm-Shifting Research in Health Disparities Through Translational, Transformational, and Transdisciplinary Approaches', *American Journal of Public Health,* Supplement 1, Vol 100, No. S1

[225] Gita Sen, Aditi Iyer, and Chandan Mukherjee. (2010) 'A Methodology to Analyze the Intersections of Social Inequalities in Health', in *Journal of Human Development and Capabilities*. Vol. 10, No. 3. Pg 397.

[226] Ibid. Pg. 398

[227] Ibid. Pg. 399.

[228] Ibid.

[229] Ibid. Pg. 403.

[230] Ibid.

[231] Ibid.

Sen et al. (2010) illustrate the power of their approach by using an example analyzing the impact of gender and class on non-treatment and the discontinuation of health treatments for men and women suffering from long-term illness. The quantitative analysis, using the dummy variables, indicates that "women [are] more than three times as likely to not be treated as men" but this is only part of the story, as significant class and gender interactions were found. The most striking finding was that class was not "relevant at all for men—non-poor, poor and even the poorest men are not significantly different from each other in the likelihood of non-treatment."[232] In other words, not all the poorest households are similarly affected and the class differences in treatment are "entirely due to the weak position of the poorest women."[233] These findings indicate that gender and class are not independent, but rather interact in significant ways to allow men to employ their gender advantage regardless of their class position and the poorest women to face extreme levels disadvantage.[234] In relation to the discontinuation of treatment, the findings indicated that once the hurdle of access to treatment has been crossed, class differences intersect with gender in significant ways, particularly for low-income households. It was found that poor men and non-poor women have similar discontinuation rates, while "poor women and the poorest women *and men*, are more like each other"[235] (my emphasis). The poorest men appear unable to use their gender advantage, while poor men continue to gain advantages based on their gender compared to poor women. The nuances of this quantitative analysis indicates that gender and class interact and intersect to significantly impact the health treatments available to men and women and using only a class or gender analysis would mask these critical relationships of social inequality.

Qualitative Intersectional Methods

Olena Hankivsky and Ashlee Christoffersen (2010) explain that a critical aspect of qualitative intersectional research is the conceptualization of identities as manifestations of social inequalities. For instance, the practice of homogenizing the Aboriginal communities by using the categories Aboriginal and non-Aboriginal would be rejected for contextualized approach to the variable political and economic circumstances within aboriginal communities that give rise to variations in health problems.[236] And so, analysis at the macro level considers the impact of policy decisions, such as reforms to the welfare state and healthcare on differently situated citizens, and identifying individuals and groups that benefit and those that experience further marginalization and oppression. An analysis at the micro level requires analyzing daily social and health realities of those living on the margins. Although group identification is often fluid and unstable, narratives allow for the identification of "cross-cutting categories of experience and oppression" and make it possible "to recognize how individuals shape their own existence."[237] Therefore, qualitative intersectional research provides the data that helps to explain *why* and *how* multiple determinants influence health and illness.

There are few examples of truly qualitative intersectional health research examples that effectively analyze how multiple social relations of inequality interact to impact health outcomes. Many studies examine the health of select marginalized populations and/or adopt the additive approach and reinforce essentialized social identities of race, class, sexual orientation by simply describing differences in health outcomes rather than connecting them to unequal relations of power. For instance, U.S psychologists John A. Schneider et al. (1995) simply describes different attitudes towards food between men and women that self-identified as heterosexual and homosexual.[238] Studies like these fail to use the concepts of gender and sexual orientation in any meaningful way, beyond using them as descriptors of individual identities. Therefore, these types of studies provide little insight for policy-makers into how norms about gender and sexuality intersect and interact to impact individual ideas and attitudes and offer zero insight

[232] Ibid. Pg. 405.
[233] Ibid.
[234] Ibid.
[235] Ibid. Pg. 410.
[236] Olena Hankivsky and Ashlee Christiffersen. (2008) op.cit. Pg. 277
[237] Ibid Pg. 278
[238] John A. Schneider, Ann O'leary and Sharon Rae Jenkins. (1995) 'Gender, sexual orientation, and disordered eating', *Psychology & Health*, Volume 10, Issue 2.

into how institutions and public policies regulate gender and sexual orientation to impact the behaviours of gay and straight men and women[239].

Micro-Level Example Study
UK health researchers John F Morgan and Jon Arcelus (2009) and Australian Social Scientist Duane Duncun (2007) examine the relationship between body image, eating behaviours, exercise and ideals of masculinity and sexual orientation through in-depth interviews. The reason these studies were chosen, as examples of a best practice for micro qualitative intersectional research, was because they identify how norms of masculinity and sexuality operate to produce physical ideals that impact the health behaviours of men. Many qualitative studies on body image, eating behaviours, gender and sexuality, focus on a selected homogenous group of men[240] and/or merely describe differences in beliefs about body image, and/or exercise and eating practices.[241] These types of studies reify sexual and gender identities rather than interrogate how men perform masculinity or sexual orientation through their body images beliefs, exercise and eating practices.

John F Morgan and Jon Arcelus (2009) found heterosexual and homosexual men shared the same ideals of masculinity in their constructions of the ideal male body as "a proportionate body, and avoiding excesses of muscularity or adiposity."[242] Both gay and straight men felt pressure from the media and their peer groups "not solely arising from body image but also factors such as clothes style."[243] Subsequently, both gay and straight men express dissatisfaction with their bodies and sought improvements, particularly in relation to muscularity, through exercise and diet modifications. The study suggests that both gay and straight men feel pressure to conform to normative physical representations of masculinity represented through peer groups and media images. John F Morgan and Jon Arcelus (2009) focus primarily on how both gay and straight men conform to a hegemonic ideal of masculinity through their exercise and eating habits, however, Australian Social Scientist Duane Duncun (2007) demonstrates that often gay men seek to achieve this ideal for different reasons than heterosexual men, namely to appear like a normal "heterosexual" men. Duncun (2007) explains how masculinity intersects with sexuality to produce a particular "muscular, fat-free, hairless, Caucasian standard of gay male beauty."[244] His findings indicate that gay men draw upon cultural narratives of homosexuality, pride, masculinity, and social status to achieve or resist the ideal. Duncun's (2007) research demonstrates that health researchers need to examine how men resist and/or conform to normative cultural ideals of gender and sexuality through their bodily practices and how this produces uneven health outcomes among men.

Macro-Level Example Study
Marianne P. Brown (2006) conducted in-depth interviews that examined the perception of health and safety conditions of seventy-five primarily Spanish-speaking immigrant workers in Los Angeles County. The workers were chosen from six industries with low-paid, low-skilled jobs for which they were often compensated under the table and off the books. These occupations included: day labour (construction and gardening work), domestic (house cleaners), garment manufacturing, home care (personal assistance for the ill, elderly and disabled), hotel (room cleaners), and restaurant (waitresses and kitchen help) work.

This study was a chosen as a best practice example of an intersectional qualitative research study because the interviews describe how gender and racial inequality in the workplace intersect to place male and female immigrant workers in different high-risk and unhealthy working conditions. There are few examples of studies that examine the relationship between immigrant status, working conditions and

[239] Jane Edwards. (2010) 'The Healthcare Needs of Gay and Lesbian Patients', in Kuhlmann and Annandale (eds.) The Palgrave Handbook of Gender and Healthcare. New York: Palgrave Mcmillan.
[240]Example see: Maurice J. Levesque and David R. Vichesky (2006) 'Raising the bar on the body beautiful: An analysis of the body image concerns of homosexual men', *Body Image, Volume 3, Issue 1, Pages 45-55*.
[241] Example see: Sharon Gil. (2007), Viren Swami and Martin J. Tovée. (2008).
[242] John F Morgan and Jon Arcelus (2009) op.cit. pg. 437.
[243] Ibid.
[244] Duane Duncun. (2007) 'Out of the Closet and into the Gym: Gay men and Body Image in Melbourne Australia', *Journal of Men's Studies*. Vol 15. No. 3. Pg 331.

health, and none that systematically compare male and females from various immigrant groups.[245] Marianne P. Brown (2006) explains that Hispanic male immigrants suffer from fatalities, injuries and illness in the fields of construction, agriculture, transportation, public utilities and retail trade and services. Within these fields, Hispanic male immigrants are usually given the heavier work and jobs that are more dangerous jobs. While Hispanic women are primarily concentrated in the sales and services occupations, such as health care, home care, housekeeping, hotel, janitorial services, food processing and garment manufacturing that place them at risk to violence and ergonomic and toxic chemical disorders.

The results indicated that in the six industries studied, "employers provided little or no health and safety training, and workers themselves had to purchase protective equipment."[246] In addition, employers more often than not were found to not provide employees with health insurance or workers compensation insurance. And if they did, "they often do not let the workers know they have the right to use it if they are hurt or made ill by the job."[247] Gender and racial inequality in the workplace, result in different language proficiency levels between females and males. The higher-levels of education and language proficiency among immigrant females, places immigrant males at higher risk for job related illness or fatalities.[248] This study only begins to explore how mechanisms of racial and gender inequality intersect in the workplace to impact on health and illness, and indicates that further research needs to be done to identify pathways between multiple and intersecting inequalities in the workplace and to health disparities among men and women.

As mentioned by Hankivsky et al. (2010), it is critical in intersectional research to combine qualitative and quantitative research practices, as using one approach only partially explains the story. To date, descriptive quantitative research has dominated research on health disparities and without answers to *why* and *how* these disparities exist, policy makers are provided with little direction about the policy changes needed to address these inequities in health.

CONCLUSIONS: Recommendations for Future Research

The purpose of this paper was to provide European researchers and policy-makers a comprehensive review of efforts to integrate the concepts of sex, gender and intersectionality in biomedical and health research. By providing illustrative examples of best practices, policy-makers and researchers are given an understanding of the practical application and importance of implementing these concepts.

Although there is serious indications that integrating the concepts of sex, gender and intersectionality is much needed and could lead to more accurate research and more effective healthcare practices, methods and tools to do so are still being developed. This review demonstrates that integrating the concept of sex requires researchers to do more than simply add women to clinical studies. Rather it presents researchers with new questions about the hormone status, age, physiology, and chromosomes of their research subjects and the causes related to differences in disease onset, symptoms and recovery between men and women. Moreover, the concept of gender requires researchers to consider the complex interactions between the biological body and social environment when thinking about differences in health outcomes between men and women. Gender researchers within the social sciences have begun to develop practical research methods to analyze how gender relations operate, at different levels of social organization, impact the health of men and women. These methods need to be further refined and more widely implemented to develop a complete understanding of how socially constructed gender relations impact the biological body to produce uneven health outcomes. Finally, the intersectional perspective points out that a gender analysis is not sufficient. Often gender relations intersect with other social relations based on

[245] See: Benach, J., Muntaner, C., Chung, H. and Benavides, F. G. (2010), Immigration, employment relations, and health: Developing a research agenda. *American Journal of Industrial Medicine*, 53.
[246] Marianne P. Brown (2006).'Immigrant Workers: Do they fear workplace injuries more than they fear their employers', in Schulz, Amy J. and Leith Mullings (Eds). *Gender, Race, Class & Health: Intersectional Approaches*. Francisco: Jossey-Bass. Pg.239.
[247] Ibid. Pg. 250.
[248] Ibid.

race, class, sexual orientation, age etc. Intersectional methods of analysis provide a more complicated and accurate account of the social factors that lead to poor health outcomes among men and women.

It is clear that the absence of a gender, sex and intersectional analysis in biomedical and health research has left some critical gaps in understanding and promoting health among men and women. To ensure that the gender and sex research agenda, and theoretical and methodological innovations continue to develop and build on existing research, will require renewed leadership on behalf of the EU.

SUMMARY POINTS

- Efforts to translate feminist concepts into practical methods and research tools for those working and researching in the field of biomedicine and health have opened new directions for understanding the biological body and innovative prevention models for health policy.
- Feminist scholarship has been central to the development of critical frameworks for analyzing biomedical and health research.
- Europe has become an international leader in its efforts to ensure that issues of gender and sex are mainstreamed into publicly funded scientific research projects.
- A feminist concept of sex allows researchers to investigate the biological body with a new lens and account for variations in the biological that they previously missed or ignored.
- The concept of gender directs researchers attention to how men's and women's lives and health are shaped by multiple and unequal gender relations and, in doing so, provides contributing factors that explain uneven health outcomes.
- Advancements have been made in developing three levels of gender analysis for biomedical and health researchers to better understand the impact of gender on health.
- An intersectional perspective can pinpoint how multiple and intersecting social relations, based on race, sexual orientation, and class, affect women and men in their daily lives, and interact in specific situations to condition health.
- The persistence of sex bias in biomedical and health research can be brought to an end, and new innovative lines of research can opened, if researchers are required to work collaboratively to integrate the concepts of sex, gender and intersectionality into their work.

III. ENGINEERING AND TECHNOLOGY

Londa Schiebinger and Addison Arlow

This essay reviews literature devoted to issues surrounding women and gender in engineering and technology over the past three decades with a focus on current approaches. We identify six overarching topics and review relevant literature and examples of application under each topic. These themes are:

I. The Masculine Image of Technology

II. Women as Designers

III. The Co-Construction of Gender and Technology

IV. How Users Matter

V. Rethinking Theory: Redefining Technology

VI. Gendered Innovations: Mainstreaming Methods of Sex and Gender Analysis into Engineering and Technology

This field is known variously as gender studies of technology or feminist technology studies. Gender is not just about women. As stated in the introduction, gender refers to the rules, traditions, and social relationships in cultures that together determine and sanction feminine and masculine behaviours. Gender relations also determine how resources are allocated between, and used by, women and men. This paper analyzes sex and gender in relation to science, technology, and innovation.

I. The Masculine Image of Technology and Engineering[1]

"Technology" in a general sense refers to the entire body of human-made tools extending back to prehistory. In common usage, however, technology is associated with industrialization, transportation, the military, and, more recently, with processing information (information technology, or IT). Research has identified the gendering of engineering and technology masculine as a key explanation for the low numbers of women in those fields. In the West, "industrial machinery and military weapons, the tools of work and war," are considered "technological," and this has contributed substantially to gendering technology male.[2] In the early days of the Industrial Revolution, "technology" meant the industrial tools of resource extraction and processing, such as mines, sawmills, and steel mills, and an "aggressive" or "swaggering" masculinity grew alongside this physically arduous, often dirty and dangerous work. This type of masculinity emphasized muscular, athletic bodies and disempowered women *and* men who did not fit the image.[3]

Information technologies (IT) differ from industrial technologies in significant ways, yet they too are often gendered masculine.[4] Computing has its roots in two cultures. First, women were the original "computers,"

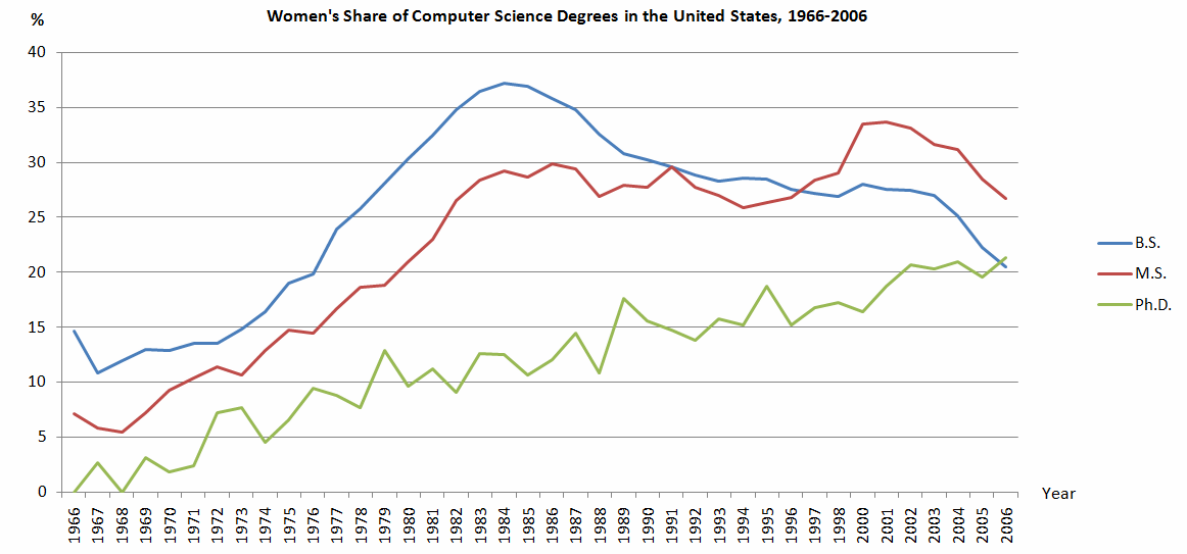
[1] See also Sagebiel, F.and Vázquez, S. (2010), Topic Report Stereotypes and Identity, Meta-Analysis of Gender and Science Research, CIREM, manuscript.

[2] Wajcman, J. (2010). Feminist Theories of Technology. *Cambridge Journal of Economics, 34,* 143-152; Wajcman, J. (1991). *Feminism Confronts Technology.* Philadelphia: University of Pennsylvania Press.

[3] Oldenziel, R. (1999). *Making Technology Masculine: Men, Women and Modern Machines in America, 1870-1945.* Amsterdam: Amsterdam University Press; Quam-Wickham, N. (2001). Rereading Man's Conquest of Nature: Skills, Myths, and the Historical Construction of Masculinity in Western Extractive Industries. In Horowitz, R. (Ed.), *Boys and their Toys? Masculinity, Technology, and Class in America*, pp. 91-111. New York: Routledge.

[4] Gansmo, H., Lagesen, V., & Sørensen, K. (2010). Out of the Boy's Room? A Critical Analysis of the Understanding of Gender and Information and Communication Technology (ICT) in Norway. *Nordic Journal of Feminist and Gender Research*, *11 (3),* 130-139.

performing precise calculations before the advent of electronic computers. Women were also well represented among computer science undergraduates in the U.S. in the mid 1980s, earning 37% of Bachelor's degrees in computer science in 1984. However, women's share of these degrees has declined steadily ever since, to only 20% in 2006—see graph below.[5]



Women's declining share of computer science degrees is atypical: women's share of all other science degrees has grown continually if slowly over the past 50 years.[6] Scholars have linked this unique decline to a re-gendering of computer culture. During the 1980s, computing became less associated with clerical work (traditionally performed by women) and more associated with "hackers" and "geeks," stereotypically lonely and isolated nerds. [7] Companies began to select programmer trainees based upon the results of employee surveys which privileged "masculine" characteristics. Managerial journals suggested that, in identifying trainees, human resources directors should "look for those who like intellectual challenge rather than interpersonal relations […] look for the chess player, the solver of mathematical puzzles."[8] Another journal noted matter-of-factly that a typical programmer is "often egocentric, slightly neurotic […] he borders upon a limited schizophrenia. The incidence of beards, sandals, and other symptoms of rugged individualism or nonconformity are notably greater among this demographic group."[9] During the 1980s, software became much more complicated and placed an ever-increasing load on computers; in response, companies began operating their computing machinery 24 hours per day such that computing potential would not be wasted during the night. Programmers were often required to work night shifts and follow erratic schedules, which tends to disadvantage women.[10]

[5] National Science Foundation (NSF). (2010). *Science Resource Statistics Table 34: Computer Science Degrees by Degree Level and Sex of Recipient, 1966-2006*. http://www.nsf.gov/statistics/nsf08321/tables/tab34.xls. Data for 1999 not available.

[6] Misa, J. (2010). Defining the Problem. In Misa, J. (Ed.), *Gender Codes: Why Women are Leaving Computing,* pp. 3-24. Hoboken, New Jersey: John Wiley & Sons, Inc.

[7] Turkle, S. (1984). *The Second Self: Computers and the Human Spirit.* New York: Simon and Schuster. But see also Gansmo, H., Lagesen, V., & Sørensen, K. (2003). Forget the Hacker? A Critical Re-Appraisal of Norwegian Studies of Gender and ICT. In Lie, M. (Ed.), *He, She, and IT Revisited: New Perspectives on Gender in the Information Society,* pp. 34-68. Oslo: Gyldenal Akkademisk.

[8] O'Shields, J. (1965). Selection of Electronic Data Processing (EDP) Personnel. *Personnel Journal, 44 (9),* 472-474.

[9] Brandon, R. (1968). The Problem in Perspective. In Blue, R., & Rosenberg, A. (Eds.), *Proceedings of the 23rd Association for Computing Machinery (ACM) National Conference,* pp. 332-224. New York: ACM Press.

[10] Ensmenger, N. (2010). Making Programming Masculine. In Misa, J. (Ed.), *Gender Codes: Why Women are Leaving Computing,* pp. 115-141. Hoboken, New Jersey: John Wiley & Sons, Inc.

The masculine image of information technology is pervasive but not universal. At the University of Malaysia, for example, women made up 53% of undergraduates in computer science and 64% in specialized IT programs between 1998 and 2006. Sex ratios in Malaysian Master's programs in computer science similarly favor women; only at the Ph.D level are women under-represented in IT fields, and this may be due to the presence of foreign students. The University of Malaysia's percentage of women in computer science Ph.D. programs is nevertheless high, averaging 36%, compared to 18% in Europe and 15% in the U.S. The majority of computer science and IT lecturers and department heads at Malaysia's largest public university are also women.[11]

There are several reasons for the high numbers of women in Malaysian computer science. First, students do not describe IT as a "masculine" field; for them, masculinity is more often associated with jobs which involve physical labor, travel, and exposure to the elements.[12] Second, the Malaysian government has promoted "large-scale entry of women into mass education and industry" over the past two decades, and has supported adoption of information and communication technologies (ICTs) in order to achieve goals of modernization and national unity.[13]

In recent years, gender studies of technology have focused on masculinities, not from the point of view of how masculinities exclude women from engineering, but from the point of view of what pleasures men derive from technology. In rural Malaysia, for example, automotive mechanics' tools, such as wrenches and drills, provide men with an economic livelihood and also an important sense of masculine lineage. These tools, and the knowledge of how to use them, are transferred from father to son. Such transfer allows boys to establish their manhood in incremental steps: a son typically begins by cleaning his father's workshop, then uses simple tools such as ratchets, and eventually moves on to more complex powered tools. These technologies are milestones and are critical to the rites of passage from boyhood to manhood.[14]

The gendering of technology has another side: just as tools readily identified as "technology" are gendered masculine, tools that are gendered feminine are often discounted and identified as *not* technology.[15] The hermetically-sealed tin can, for example, was exhibited at the 1851World's Fair as a military technology but lost its status as a technology when it became widely used for domestic cannery, a traditionally female endeavor.[16]

Engineering is the process of producing and adapting tools or technologies. Women continue to be underrepresented in engineering, earning only 22% of engineering doctoral degrees in the European Union in 2006.[17] In the U.S., where such data are available, women cluster in certain subfields of engineering (biomedical, environmental, and architectural) but continue to be underrepresented overall (see chart in Introduction: Women's Share of Doctoral Degrees in Engineering). The difficulty of recruiting more women into engineering is typically attributed to stereotypes that construct technology as masculine, something men do well and enjoy, and that marginalize innovations relating to spheres of life where women are in a majority. In addition, biases in school curricula and teaching practices which steer girls

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[11] Othman, M., & Latih, R. (2006). Women in Computer Science: No Shortage Here! *Communications of the Association for Computing Machinery (ACM), 49 (3)*, 111-114.

[12] Lagesen, V. (2007). A Cyberfeminist Utopia? Perceptions of Gender and Computer Science among Malaysian Women Computer Science Students and Faculty. *Science, Technology, and Human Values, 33 (1)*, 5-27.

[13] Stivens, M. (2000). Becoming Modern in Malaysia. In Edwards, L., & Roces, M. (Eds.) *Women in Asia: Tradition, Modernity and Globalisation*, pp. 16-38. Leonards, Australia: Allen & Unwin Publishing; Ong, A. (1995). State Versus Islam: Malay Families, Women's Bodies, and the Body Politic. In Ong, A., & Peletz, M. (Eds). *Bewitching Women, Pious Men: Gender and Body Politics in Southeast Asia*, pp. 159-194. Berkeley: University of California Press.

[14] Mellström, U. (2003). *Masculinity, Power, and Technology: A Malaysian Ethnography.* Hampshire, England: Ashgate Publishing Limited.

[15] Kramarae, C. (1988). Gotta Go Myrtle, Technology's at the Door. In Kramare, C. (Ed.), *Technology and Women's Voices: Keeping in Touch*, pp. 1-11. London: Routledge.

[16] Naylor, S. (2000). Spacing the Can: Empire, Modernity, and the Globalisation of Food. *Environment and Planning, 32,* 1625-1639; Hopkins, P. (1998). The Intersection of Culture, Gender, and Technology. In Hopkins, P. (Ed.), *Sex/Machine: Readings in Culture, Gender, and Technology*, pp. 1-16. Bloomington: Indiana University Press.

[17] European Union Research Commission. (2009). *Statistics and Indicators on Gender Equality in Science, Table 2.3: Evolution of the Proportion of Female PhD (ISCED6) Graduates by Narrow Field of Study.* http://ec.europa.eu/research/science-society/document_library/pdf_06/she_figures_2009_en.pdf

away from mathematics and the sciences play a role, as does the perception by some girls that engineering is dominated by men and not "woman friendly."

As a community of practice, engineering continues to be seen and experienced as "masculine." In part this is attributed to a "long-hours culture" in many engineering workplaces that tend to discriminate against those with pursuits and responsibilities, such as family, outside of work. In addition, subtle "taken-for-granted" dynamics in both education and workplaces make engineering more comfortable and more supportive to men than women.[18] Topics of conversation, social networks and ways of interacting all contribute to who "belongs" and who gets marginalized—not just socially but also in terms of getting the job done. A key problem here are the conventional gender stereotypes that tend to mean women engineers are highly visible *as women* but struggle to gain recognition *as engineers*—what Wendy Faulkner calls the in/visibility paradox.[19]

Other significant negative consequences of gender stereotypes are that they limit workforce diversity and creativity: Stereotypes that exclude women necessarily also exclude particular knowledges they develop, often through gendered division of labor (see Introduction, Methods of Sex and Gender Analysis #12). Gender stereotypes also reinforce narrow definitions of masculinity. Yet men as a group are not homogenous; masculinities differ by region, religion, class, national culture, and other key social factors (see Introductions, Methods of Sex and Gender Analysis, #3). Associating engineering and technology with one form of masculinity excludes other types of knowledge and limits creativity and innovation in an increasingly globalized workplace.

Efforts are currently being made to change engineering stereotypes as the field itself changes. Engineers were once trained on the shop floor where physical strength was an advantage, but modern engineering often requires more "brain"—a combination of technical and interpersonal skills—than "brawn." Faulkner has emphasized that classic Western stereotypes of engineering are simplistic and out of date. Her research shows that the actual work of engineers extends far beyond the narrowly "technical" education characteristic of engineering education. Because engineering is never "just technical" or "just social," engineers need both social and technical skills. And because of this heterogeneity, she argues, engineering needs to train, recruit and promote people with diverse constellations of skills and experience. At the same time, Faulkner and others criticize campaigns that play up the "social" aspects of engineering in an effort to recruit more women to engineering, when many women experience the deep pleasure in working with technology so often seen as a "masculine" trait, and when many men engineers demonstrate excellent people skills.[20] A number of organizations, including the International Institute of Electrical and Electronics Engineers (IEEE) and the U.S. National Academy of Engineering, are emphasizing new skills, such as "big-picture thinking" and the potential for engineers to contribute to human welfare, in efforts to bring new recruits—including women and different types of men—to technology design.[21]

[18] Faulkner, W. (2006). Genders In / Of Engineering: A Research Report. *Institution of Civil Engineers Economic and Social Research Council*, March.

[19] Faulkner, W. (2000). The Power and the Pleasure? A Research Agenda for "Making Gender Stick" to Engineers. *Science, Technology, and Human Values, 25 (1)*, 87-119; Yoder, J., & Schleicher, T. (1996). Undergraduates Regard Deviation from Occupational Gender Stereotypes as Costly for Women. *Sex Roles*, *34 (4)*, 171-189; Bagilhole, B. (1993). Survivors in a Male Preserve: A Study of British Women Academics' Experiences and Perceptions of Discrimination in a UK University. *Higher Education*, *26*, 431-447.

[20] Faulkner, W. (2006). Genders In / Of Engineering: A Research Report. *University of Edinburgh Economic and Social Research Council*, March.

[21] International Institute of Electrical and Electronics Engineers. (2008). *IEEE Women in Engineering*. New York: QMags; Wolffram, A., & Winker, G. (2004). "Challenging Gender Stereotypes in Engineering Education." International Symposium of the Internationale Gesellschaft für Ingenieurpädagogik (IGIP), September 27 – September 30, Fribourg, Switzerland; U.S. National Academies. (2010). Turn Imagination into Reality with a Career in Engineering. http://www.engineergirl.org.

II. Women as Designers

A commonly held belief is that women "do science differently" or that there are "women's ways of knowing" (see Introduction).[22] It is true that gendered divisions of labor mean that including women in engineering may bring new perspectives, priorities, and ideas. Workforce diversity is important, but does not, in and of itself, guarantee innovation or gender-responsible design. A prominent conference in 1995 posed the question of how participation impacts research results.[23] Today this issue is often discussed as the "business case" for diversity; an excellent example of this latter type of research is the European Commission's 2006 *Women in Science and Technology—the Business Perspective.*[24] Future research needs to identify clear mechanisms to understand how diversity contributes to creativity and innovations.

Including women does not, in and of itself, guarantee gender-responsive design. Women are not immune from gender bias. Nor does an interest in "women's issues" automatically translate into expertise in gender analysis. As discussed below, expertise in gender analysis requires systematic training as in any other field of intellectual endeavor. Take for example Volvo's Your Concept Car (YCC), developed in 2002 as the first concept car designed by an all-female team. In concert with difference feminist thinking (see Introduction), the car was designed "by women and for women"— in this case, female luxury car buyers. The car featured, for example, a modified hood to improve visibility, theft-resistant storage in the door jamb, good storage for purses and other personal items, minimal maintenance with capless filling points for petrol and windshield washer fluid, and an interior that customers could personalize. Specialized gull-wing doors provided easy entry, especially with hands full of packages.[25]

Despite these innovations, Volvo's YCC project raises a number of problems from the point of view of gender analysis. First, certain features of YCC tended to reinforce gender stereotypes. The YCC hood (or bonnet), for example, provided no user-access, and suggested that the car's hypothetical female owner, "Eve," would not desire (or not possess the skill required) to inspect the engine.[26] Second, the much repeated sales motto for the YCC, "If you meet the expectations of women, you exceed the expectations of men," suggested that women are "more demanding" or have higher standards than men.[27] Finally, scholars have also identified the YCC project as a form of tokenism, whereby Volvo made temporary concessions to women while ignoring deeper issues.[28] Volvo employees reported that the project had little internal influence. One interviewee described "a huge disconnect between how much attention it [the YCC project] generated externally and how little it influence [it had] internally."[29]

[22] Goldberger, N., Tarule, J., Clinchy, B., & Belenky, M. (Eds.) (1996). *Knowledge, Difference, and Power: Essays Inspired by Women's Ways of Knowing.* New York: Basic Books; Belenky, M., Clinchy, B., Goldberger, N., & Tarule, J. (1986). *Women's Ways of Knowing: The Development of Self, Voice, and Mind.* New York: Basic Books; Gilligan, C. (1982). *In a Different Voice: Psychological Theory and Women's Development.* Cambridge: Harvard University Press.

[23] Kohlstedt, S., Longino, H., & Lerman, N. (1995). The Women, Gender and Science Question: What do Research on the History of Women and Science, and Research on Science and Gender Have to Do with Each Other? Conference, May, University of Minnesota.

[24] European Commission (2006). *Women in Science and Technology—the Business Perspective.* Luxembourg: Office for Official Publications of the European Communities; Goh, A. & Recke, H. (2008). *Successful Women, Successful Science*. CIGAR Working Paper 48, 7-9.

[25] Temm, T. (2008). Volvo, Women Customers, and the YCC Concept Car. In Schiebinger, L. (Ed.), *Gendered Innovations in Science and Engineering*, pp. 131-149. Stanford: Stanford University Press.

[26] Styhre, A., Backman, M., & Börjesson, S. (2005). The Gendered Machine: Concept Car Development at Volvo Car Corporation. *Gender, Work, and Organization, 12 (6),* 551-571.

[27] Temm, T. (2008). *Volvo, Women Customers, and the YCC Concept Car*. In Schiebinger, L. (Ed.), *Gendered Innovations in Science and Engineering*, pp. 131-149. Stanford: Stanford University Press.

[28] Styhre, A., Backman, M., & Börjesson, S. (2005). YCC: A Gendered Carnival? Project Work at Volvo Cars. *Women in Management Review, 20 (2)*, 96-106.

[29] Quoted in Elmquist, M. (2007). Vehicles for Innovation and Learning: The Case of a Neglected Concept Car Project. *Knowledge and Process Management, 14 (1)*, 1-14.

III. The Co-Construction of Gender and Technology

The late 1980s saw the development of co-constructionism, a scholarly approach to technology that continues to produce fruitful insights. Co-construction was developed to avoid the dual problems of:

1. **Gender essentialism**, the notion that "fixed, unified, and opposed" female and male natures influence technological development.[30]
2. **Technological determinism**, the idea that the inevitable march of technology shapes gender roles.[31] This literature tends to view women as victims of men's technology. Biotechnologies, for example, are often seen as commodifying women's bodies.[32]

Co-constructionism, by contrast, stresses that technology is simultaneously material, discursive, and social; scholars emphasize that gender and technology are "co-constructed"; that is to say, technology shapes gender relations while, at the same time, gender relations shape technology. As Wendy Faulkner writes, technology is "both a source and consequence of gender relations and vice versa."[33] In a similar vein, Judy Wajcman notes that "gender relations can be thought of as materialized in technology, and gendered identities as produced simultaneously with technologies."[34] In other words, people and artifacts co-evolve. Neither gender nor technology is taken to pre-exist; both are malleable and subject to change.

Several technologies illustrate co-constructionism—and, indeed, study of these technologies has contributed to co-constructionist theory:

Example 1. The Male Birth Control Pill. While the ethics of reproductive technology and its relationship to gender relations are complex, the female birth control pill is often hailed as one of the major technological innovations of the twentieth century.[35] The female birth control pill was co-constructed by both technology and gender. Technology reinforces gender roles: pharmaceutical contraceptives for women—from oral tablets to injections to implants—make reproduction a woman's, rather than a man's, responsibility.[36] At the same time female contraception is constructed by gender: it is often argued that women "need" contraception more than men because women often have less control over sex and yet greater responsibility for unintended pregnancies.[37] Gender manufactures need, and, in turn, drug companies manufacture products that further enforce needs that divide along gendered lines.

Nelly Oudshoorn has examined in detail the fact that no drugs are currently labeled for contraception in men—nor are drugs commonly used off-label for this purpose.[38] While a technological-determinist might argue that the male pill does not exist because the technology is unfeasible, Oudshoorn documents how the absence of a male pill is co-constructed by both gender and technology. She points out that

[30] Trauth, E. (2006). Theorizing Gender and Information Technology Research Using the Individual Differences Theory of Gender and IT. In Trauth, E. (Ed.), *The Encyclopedia of Gender and Information Technology,* pp. 1154-1159. Hershey, Pennsylvania: Idea Group Publishing; Wajcman, J. (1991). *Feminism Confronts Technology*. University Park: Pennsylvania University Press.

[31] Williams, R. (1994). The Political and Feminist Dimensions of Technological Determinism. In Smith, M., & Marks, L. (Eds.) *Does Technology Drive History? The Dilemma of Technological Determinism,* pp. 217-236. Cambridge: MIT Press.

[32] For a recent review of this field, see Molfino, F. & Zucco, F. (2008). *Women in Biotechnology: Creating Interfaces*. New York: Springer Science and Business Media.

[33] Faulkner, W. (2001). The Technology Question in Feminism: A View from Feminist Technology Studies. *Women's Studies International Forum, 24 (1)*, 79-95.

[34] Wajcman, J. (2007). From Women and Technology to Gendered Technoscience. *Information, Communication, and Society, 10 (3),* 287-298.

[35] Ranga, M, & Etzkowitz, H. (2010). Athena in the World of *Techne:* The Gender Dimension of Technology, Innovation, and Entrepreneurship. *Journal of Technology Management & Innovation, 5 (1)*, 1-12.

[36] Oudshoorn, N. (2003). *The Male Pill: A Biography of a Technology in the Making.* Durham: Duke University Press; Oudshoorn, N., Saetnan, A., & Lie, M. (2002). On Gender and Things: Reflections on an Exhibition of Gendered Artifacts. *Women's Studies International Forum, 25 (4)*, 471-483.

[37] Miyai, N. (2000). Friendly Persuasion? Legislative Enforcement of Male Responsibility for Contraception. In Tong, R., Anderson, G., & Santos, A. (Eds.), *Globalizing Feminist Bioethics: Crosscultural Perspectives,* pp. 135-150. Boulder, Colorado: Westview Press; Amaro, H. (1995). Love, Sex, and Power. *American Psychologist, 50 (6)*, 437-447.

[38] Oudshoorn, N. (2003). *The Male Pill: A Biography of a Technology in the Making.* Durham: Duke University Press.

technological feasibility itself results from research priorities (see Introduction, Methods of Sex and Gender Analysis #5), and that these priorities are influenced by gendered ideology. Several specific gendered beliefs have interfered with research and development of modern forms of male contraception: that a male pill would not be widely used by men because gender ideology casts contraception as inconsistent with masculinity and because women would not trust their partners to take it. Studies show, however, that over 98% of women surveyed in a variety of countries stated they *would* trust their partners to take a pill.[39] Yet such thinking discourages pharmaceutical companies from developing new male contraceptives.

Oudshoorn has observed that gender roles also interfere with the testing of pharmaceutical contraceptives in men, especially in Europe and the U.S. An extensive infrastructure of clinics exists to serve women's reproductive needs, from contraception to prenatal care, because contraception is commonly viewed as a female responsibility. These clinics become important recruitment points for pharmaceutical companies testing contraceptives in women. No extensive infrastructure exists for men, and so recruiting men for contraceptive trials is more difficult. These problems are severe enough that the World Health Organization has established alternative R&D networks to advance research into male contraceptives.[40]

Example 2. Video Games. Gaming simultaneously emerges from and shapes culture. Though ostensibly recreational, gaming contributes to constructing user identities and computing technologies. Video games are used in education and, increasingly, in medical rehabilitation. Games are big business: the gaming industry has eclipsed the movie industry in earnings.[41]

Men have dominated the video game industry, both as inventors and players, since MIT student Nolan Bushnell created *Spacewar* on a mainframe computer in 1962. Scholars have used co-constructionism to understand why video games continue to be largely "masculine," even though they are produced in countries (primarily Japan, the U.S., Canada, and England) where women's use of computer technologies approaches men's.[42] Games which embed particular types of masculinities predominantly attract players who subscribe to the same brand of masculinity, and game playing is often a first step towards a career in game design. Thus the gendered characteristics of video games simultaneously construct video game culture, gaming workforce, and the future direction of game development.[43]

Video games influence users in other ways, with ramifications extending far beyond gaming itself. There is ample evidence that games requiring motion extrapolation, rapid response time, navigation, and visualization of three-dimensional objects improve spatial skills.[44] These skills, once honed, can be applied to tasks requiring dexterity, from soccer to surgery. Games involving these elements tend to be designed by, marketed to, and played by males, and may account for men's higher measured spatial skills in certain tests. Indeed, when men and women are both made to play action games in a laboratory setting, sex differences in spatial skills decrease dramatically.[45]

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[39] Heinemann, K., Saad, F., Wiesemes, M., White, S., & Heinemann, L. (2005) Attitudes toward Male Fertility Control: Results of a Multinational Survey on Four Continents. *Human Reproduction, 20,* 549–556.

[40] World Health Organization. (1996). *WHO Completes International Trial of a Hormonal Contraceptive for Men*. Geneva: WHO Press Release; Waites, G. (2003). Development of Methods of Male Contraception: Impact of the World Health Organization Task Force. *Fertility and Sterility, 80 (1)*, 1-15.

[41] Shaffer, D., Squire, K., Halverson, R., & Gee, J. (2005). Video Games and the Future of Learning. *Phi Delta Kappan*, *87 (2),* 104-111; Ivory, J. (2008). The Games, they are a Changin'. In Jamieson, P., & Romer, D. *The Changing Portrayal of Adolescents in Media since 1950*, pp. 347-377. Oxford: Oxford University Press.

[42] Rudden, D. (2010). Canada Boasts the Third-Largest Video Game Industry. *Network World*, April 6; Li, N., & Kirkup, G. (2007). Gender and Cultural Differences in Internet Use: A Study of China and the UK. *Computers and Education, 48 (2)*, 301-317.

[43] Kafai, Y., Heeter, C, Denner, J, Sun, J. (2008*). Beyond Barbie & Mortal Kombat: New Perspectives on Gender and Computer Games*. Cambridge: MIT Press; Haines, L. (2004). *Why are there so Few Women in Games?* Manchester: Media Training Northwest.

[44] Achtman, R., Green, C., & Bavelier, D. (2008). Video Games as a Tool to Train Visual Skills. *Restorative Neurology and Neuroscience, 26*, 435-446.

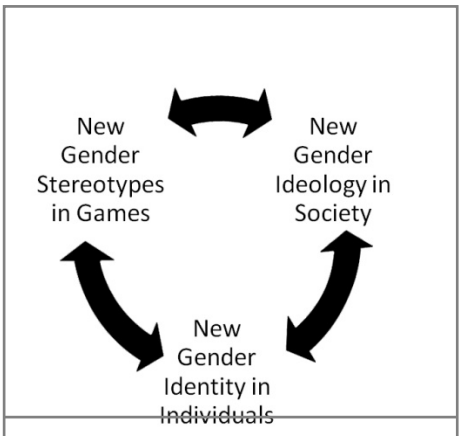
[45] Feng, J., Spence, I., & Pratt, J. (2007). Playing an Action Video Game Reduces Gender Differences in Spatial Cognition. *Psychological Science,18 (10)*, 850-855; De Lisi, R., & Wolford, J. (2002). Improving Children's Mental Rotation Accuracy with Computer Game Playing. *Journal of Genetic Psychology, 163 (3),* 272-282.

Co-constructionism also suggests how gaming might catalyze social change. If games (like songs, movies, literature, and media in general) simultaneously reflect and influence social behavior, they might also provide a virtual space where designers and players can experiment with gender identity, ideologies, and expression (see Introduction, Methods of Sex and Gender Analysis, #9). Games are a space where in-game play may allow for real-world change and vice versa.[46] There is speculation that online experiences may reconstruct player's own gender identities (see chart).[47]

While recognizing the transformative potential of video games, scholars such as Judy Wajcman also emphasize the dangers of these worlds. [48] *Second Life*, for example, is a sophisticated 3D space within which users create avatars, homes, and entire lifestyles using in-world currency, yet it is also a major source of virtual pornography and can promote sadomasochistic forms of sex.[49] A 2008 cross-sectional study of gamers found that 54% of men and 68% of women have ever represented themselves as a character of the opposite sex or gender—and not always with the best of intentions.[50]

IV. How Users Matter

"Users" are often viewed as passive consumers of technology: in this view, inventors or designers create technology; consumers use whatever is produced. More recently, technology studies have shifted away from a traditional focus on the artifact (design) and engineer (designer) to zero in on users and their roles in the development of technologies. Nelly Oudshoorn and Trevor Pinch have argued that feminist scholars played a leading role in these developments.[51]



Co-constructionism suggests that games provide a cultural space for experimentation with gender.

Historian of technology Ruth Swartz Cowan discusses how capitalism itself embeds the idea that users have power over technologies at the "consumption junction," the point at which they choose whether or not to purchase or use a particular technology, given their needs, resources, and the availability of competing artifacts.[52] However, the user-artifact relationship is more complex than users choosing technologies and designers creating products in anticipation of user's wants and needs. Gender comes into play on all levels: it influences how users evaluate technologies, as well as how designers conceptualize their target user base. Products can project gender roles onto users, but users can also gender artifacts, often in ways designers do not intend.

[46] Kafai, Y., Heeter, C, Denner, J, & Sun, J. (2008). Beyond Barbie & Mortal Kombat: New Perspectives on Gender and Computer Games. Cambridge: MIT Press.
[47] Huh, S., & Williams, D. (2010). Dude Looks Like a Lady: Gender Swapping in an Online Game. In Bainbridge, W. *Online Worlds: Convergence of the Real and Virtual*, pp. 161-174. London: Springer.
[48] Turkle, S. (1984). *The Second Self: Computers and the Human Spirit.* New York: Simon and Schuster.
[49] Wajcman, J. (2007). From Women and Technology to Gendered Technoscience. *Information, Communication, and Society, 10 (3),* 287-298;
[50] Hussain, Z., & Griffiths, M. (2008). Gender Swapping and Socializing in Cyberspace: An Exploratory Study. *Cyber Psychology and Behavior, 11 (1)*, 47-53.
[51] Oudshoorn, N., & Pinch, T. (2003). Introduction: How Users and Non-Users Matter. In Oudshoorn, N., & Pinch, T. (Eds.), *How Users Matter*: *The Co-Construction of Users and Technologies*, pp. 1-28. Cambridge: MIT Press.
[52] Cowan, R. (1989). The Consumption Junction: A Proposal for Research Strategies in the Sociology of Technology. In Bijker, W., Hughes, T., & Pinch, T. (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, pp. 261-280. Cambridge: MIT Press.

Example 1: Military and Commercial Cockpits. Rachel Weber has shown how changes in users required a redesign of military cockpits.[53] In 1993, the U.S. military began to admit women into limited combat roles. The acting Secretary of Defense issued a directive requiring that "the [armed] services shall permit women to compete for assignments in aircraft, including aircraft engaged in combat missions."[54] The problem was that military cockpits had been designed to fit men between the 5th and 95th percentiles for male height, weight, and other physical dimensions. This meant that a minimum sitting height of 94 cm. designed into cockpits excluded only 5% of men but 65% of women.

In response, the Air Force developed revised anthropometric data to include women—these were used to redesign military, and eventually commercial, cockpits. The key driving forces were pragmatic. Stakeholders recognized that strengthening the military, perhaps the most "masculine" of institutions, now required consideration of women users. Cockpits designed with both male and female users in mind were also more accommodating to male pilots of different nationalities and regions, as body size differs geographically. This superior compatibility increased the competitiveness of U.S.-made aircraft in the global marketplace.

Example 2: Electric Shavers. Ellen van Oost has described how everyday products, such as electric shavers, can project "gender scripts" onto users. [55] The Dutch corporation Philips Electronics introduced electric shavers in 1939, marketing them primarily to men. As fashions shifted, however, Philips saw opportunities to market to also women, and introduced electric shavers for women starting in 1950. Initially, women's shavers were similar to men's, differing mainly in packaging. Over time, however, designs diverged in fundamental ways: shavers for men were produced with increasing numbers of controls, indicators, and other electronic features, while women's shavers were built with fewer controls. Shavers for men were assembled with visible screws, which served as reminders that they were technological devices; shavers for women were held together with internal latches, creating a seamless appearance.

These divergent designs projected specific gender characteristics onto users: men were to actively engage with their shavers, women were not. Though Philips and other companies "manufacture" gender roles as well as products, van Oost notes that users are free to accept, reject, or modify these roles—just as customers may accept, reject, or modify products. Women and men can choose not to shave, or can use products marketed to the opposite sex. Interestingly, the designs of men's and women's shavers may be converging. Industrial designers working on the Philips shaver have researched users' tastes and recommended minimal differences (mainly in color and grip shape rather than in mechanical function) between designs for men and women. Research shows that unisex designs may be preferred, especially by young people.[56]

How do users figure in technology design? Manufacturer may use focus groups or surveys to understand user preference. The results, however, can be unreliable. Sample groups studied by designers may poorly represent actual end users.[57] Or designers may not be able to test products due to concerns over trade secrets, especially in the software industry. Users are also often diverse groups located around the globe. Because of these many problems, designers frequently fall back onto gender stereotypes to create products.[58] Marketing textbooks are full of case studies on how gender stereotyping can lead to commercial failures and public relations disasters: cars with pink upholstery and matching

[53] Weber, R. (1997). Manufacturing Gender in Commercial and Military Cockpit Design. *Science, Technology, & Human Values, 22 (2)*, 235-253.
[54] Aspin, L. (1993). Policy on the Assignment of Women in the Armed Forces, April 28. Washington, D.C.: Department of Defense.
[55] van Oost, E. (2003). Materialized Gender: How Shavers Configure the Users' Femininity and Masculinity. In Oudshoorn, N., & Pinch, T. (Eds.), *How Users Matter*: *The Co-Construction of Users and Technologies*, pp. 193-208. Cambridge: MIT Press.
[56] Bakker, J. (2006). "Redesign of an Electrical Shaver using Gender Differences." Industrial Design Engineering Conference, Student Course on 'Design and Emotion,' University of Twente, Enschede, Netherlands.
[57] Schot, J., & de la Bruheze, A. (2003). The Mediated Design of Products, Consumption, and Consumers in the Twentieth Century. In Oudshoorn, N., & Pinch, T. (Eds.), *How Users Matter*: *The Co-Construction of Users and Technologies*, pp. 229-245. Cambridge: MIT Press.
[58] Oudshoorn, N., & Pinch, T. (2003). Introduction: How Users and Non-Users Matter. In Oudshoorn, N., & Pinch, T. (Eds.), *How Users Matter*: *The Co-Construction of Users and Technologies*, pp. 1-28. Cambridge: MIT Press.

parasols that do not sell, Barbie dolls that utter the phrase "math class is tough," and provoke boycotts and recalls.[59]

When products do not meet users' needs, users may take matters into their own hands and commandeer technologies for uses designers did not intend.[60] The home landline telephone, for example, was initially developed in the U.S. as a costly and technically complex tool for businessmen, who would be able to communicate between office and home with the device and contact clients whenever necessary.[61] Women were at first viewed as secondary users, and some companies created explicit policies that made business use a priority. Yet women soon became the major users of telephone landlines, and drove the widespread adoption of telephones.[62] Scholars have found that the same pattern occurred with mobile phones: initially expensive business tools used mainly by men, they are now equally popular with women.[63]

The opposite can also occur; men may adopt technologies designed for women. Pharmaceuticals known as aromatase inhibitors, for example, were initially developed in the 1980s to treat cancer in women.[64] Once aromatase inhibitors became widely available, however, a number of men began using them to increase androgen levels to build muscle. Men's misuse of these drugs is prevalent enough that the International Olympic Committee and World Anti-Doping Agency have specifically prohibited their use and have instituted testing to detect violations.[65]

Participatory research is a powerful tool that can help designers understand users' needs. In participatory research, designers act as ethnographers and observe users at work (observational interviewing). In effect, designers become "apprentices" and absorb the day-to-day knowledge of users in the users' actual workplaces. Simultaneously, future users are recognized as researchers with key knowledge to contribute to product design—even if these users do not possess the qualifications typical of researchers in Western-style science.[66]

Example 3: Call Center Software: Analyzing Gender. Susanne Maass and Els Rommes show how taking users into account revolutionized software for customer-service and marketing call centers. In so doing, they shed light on the "productivity paradox"—the phenomenon that new technologies often lead to a drop in productivity. Mass and Rommes found that mainstream call-center software supports stereotypically "masculine" functions (gathering and dispensing information) but not stereotypically "feminine" functions (interacting with customers and understanding their needs).[67]

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[59] Barletta, M. (2003). *Marketing to Women: How to Understand, Reach, and Increase your Share of the World's Largest Market Segment.* Chicago: Dearborn Trade Publishing; Smith, J., & White, P. (2002). An Examination of Implicitly Activated, Explicitly Activated, and Nullified Stereotypes on Mathematical Performance: It's Not Just a Woman's Issue. *Sex Roles, 47 (3)*, 179-191.

[60] Mackay, H., & Gillespie, G. (1992). Extending the Social Shaping of Technology Approach: Ideology and Appropriation. *Social Studies of Science, 22,* 685-716; Wajcman, J. (1986). Technological Choice and the Politics of Production. *Social Studies of Science, 16,* 746-756.

[61] Fischer, C. (1988). Gender and the Residential Telephone. *Sociological Forum, 3 (2)*, 211-233.

[62] Kline, R. (2003). Resisting Consumer Technology in Rural America: The Telephone and Electrification. In Oudshoorn, N., & Pinch, T. (Eds.), *How Users Matter*: *The Co-Construction of Users and Technologies*, pp. 51-66. Cambridge: MIT Press.

[63] Geser, H. (2004). *Towards a Sociological History of the Mobile Phone*. Zurich: Soziologisches Institut der Universität Zürich.

[64] Smith, I., & Dowsett, M. (2003). Aromatase Inhibitors in Breast Cancer. *New England Journal of Medicine, 348,* 2431-2442; Marsh, D., Brodie, J., Garrett, W., Tsai-Morris, C., & Brodie, A. (1985). Aromatase Inhibitors: Synthesis and Biological Activity of Androstendione Derivatives. *Journal of Medicinal Chemistry, 28,* 788-795.

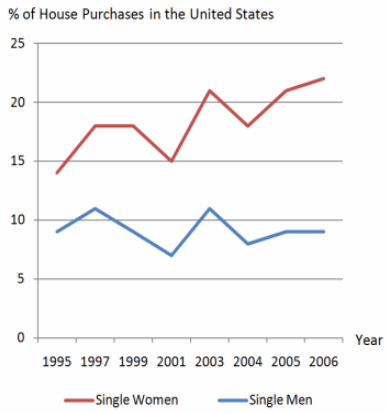
[65] Sjöqvist, F., Garle, M., & Rane, A. (2008). Use of Doping Agents, Particularly Anabolic Steroids, in Sport and Society. *The Lancet,* 371 (9627), 1872-1882; Mareck, U., Sigmund, G., Opfermann, G., Geyer, H., Thevis, M., & Schänzer, W. (2005). Identification of the Aromatase Inhibitor Letrozole in Urine by Gas Chromatography / Mass Spectrometry. *Rapid Communications in Mass Spectrometry, 19 (24)*, 3689-3693.

[66] Kindon, S., Pain, R., & Kisby, M. (Eds.) (2007). *Participatory Action Research Approaches and Methods: Connecting People, Participation, and Place.* New York: Routledge.

[67] Maass, S. & Rommes, E. (2007). Uncovering the Invisible: Gender-Sensitive Analysis of Call Center Work and Software., In Zorn, I., Maass, S., Rommes, E., Schirmer, C., & Schelhowe, H. (Eds.) *Gender Design IT,* pp. 97-108. Berlin: Verlag Für Sozialwissenschaften.

Using techniques of participatory research, Mass and Rommes observed, interviewed, and worked with call center employees to understand their needs. Analyzing gender led to new call center software that also supports agents' interactive work with customers, ultimately allowing agents to provide friendly, flexible service. Gender analysis has produced software that is better-received by users and boosts productivity. [68] Participatory research, combined with gender analysis, has helped designers produce better software that boosts employee efficiency, customer satisfaction, and ultimately business profits. [69]

User Design in Industry. User centered design is now routine in many industries. Increasingly, user-centered design involves considering women, whose education levels, earnings, and buying power have risen dramatically in recent years (see chart).[70] In the U.S., single women's purchasing power has driven both builders and mortgage lenders to research this demographic and design products—whether houses or financing packages—with women in mind.[71]



Women's buying power has grown rapidly in Europe as well. For example, women make two-thirds of computer purchases in the UK, and constitute the majority of online shoppers who purchase items at least once a week. In 2006, British women's personal wealth was 48% of all privately-held wealth nationally, and women constituted a majority of millionaires under age 44 (it should be remembered that women also make up a majority of the poor).[72] Women held 45.8% of the disposable income in Denmark in 2008.[73]

In response to these overall changes, the Danish government, for example, has funded "Female Interaction," a program devised to make Danish industry more competitive by promoting user-driven innovation [74] In Germany, the Fraunhofer Institute, Europe's largest application-oriented research organization, developed their project, "Discover Gender," with much the same purpose.[75] In both instances, the goal is not to have products designed "by women, for women" (as in the case of the Volvo YYC) but to set out design principles, strategies, and guidelines that all designers—men and women—can use to better serve all users.

[68] Maass, S., Theissing, F., & Zallmann, M. (2002). Unterstützung von Interaktionsaebeit in Call-Center: Neue Fragen für die Arbeitsorientierte Softwareentwicklung. *Zeitschrift für Interaktive und Kooperative Medien, 3*, 4-11.
[69] Belt, V. (2002). A Female Ghetto? Women's Careers in Call Centres. *Human Resource Management Journal, 12 (4),* 51-66.
[70] Produced with data from National Association of Realtors (NAR). (2008). *NAR Profile of Home Buyers and Sellers*. Chicago: NAR Publications.
[71] Bady, S. (2008). Numbers Don't Lie. *Professional Builder, 73 (7),* 30; Real Estate Information Systems (RIS) Media. (2007). *As the Nation Changes, So Do Home Buyers*. February 13.
[72] Cunningham, J., & Roberts, P. (2006). *Insider Her Pretty Little Head.* Littlehampton, United Kingdom: Cyan Communications; Pantazis, C., Gordon, D., & Levitas, R. (eds.) (2006). Poverty and Social Exclusion in Britain: The New Millennium Survey. Bristol: University of Bristol Policy Press.
[73] Gunnersen, S., & Bisgaard, M. (Eds.) (2010). Statistical Yearbook 2010. Cophenagen: Statistics Denmark, see Table 207: Disposable Income by Sex and Age.
[74] Schroeder, K. (2010), Gender Dimensions of Product Design, United Nations Division for the Advancement of Women, Expert Group Meeting: Gender, Science, and Technology, 28 September-1 October, Paris France.
[75] Schraudner, M. & Lukoschat, H. (Eds.) (2006). *Gender als Innovationspotenzial in Forschung und Entwicklung.* Munich: Fraunhofer.

V. Rethinking Theory: Redefining Technology

Gender studies of technology have broadened definitions of technology from "heroic technologies" associated with the military and industry, such as steam engines, automobiles, suspension bridges, and space stations, to "everyday" objects, such as washing machines and microwaves, and braziers.[76] In many instances, gender studies of technology brings to light artifacts previously discounted as insignificant or hidden completely from history, such as vibrators or menstrual products. In other instances, gender studies reevaluate entire fields of study, such as Home Economics, that have disappeared because they are not seen as "science."

Example 1: Home Economics. Just as artifacts associated with women's work have been dismissed as not "real" technologies, academic fields associated with women's knowledge have been dismissed as not "real" science. Such is the case with domestic science, historically known as "home economics" and more recently as "human ecology," "human health and development," and a host of other nomenclatures.[77]

Home economics programs were established at many U.S. universities, including the University of California, Berkeley, Cornell, and Iowa State, by the early 1900s.[78] In Scotland, schools in Edinburgh and Glasglow trained domestic scientists as early as 1914.[79] The International Federation for Home Economics (IFHE) was founded in Switzerland in 1908, and during the 1920s and 1930s, domestic science colleges were founded in Finland as well.[80] From the beginning, these programs were grounded in the physical and life sciences: Berkeley's home economics department was inaugurated by organic chemist Agnes Morgan, who assembled a curriculum that included general chemistry, organic chemistry, biochemistry, physiology, bacteriology, quantitative analysis, and statistics.[81] Iowa State's program incorporated similar courses, requiring chemistry, botany, physics, geology, physiology, and meteorology.[82] In Britain, domestic science was sufficiently developed that the British Medical Bulletin recommended textbooks in the field to educate the public about foodborne illness.[83]

Domestic science gained prestige during the early twentieth century, when domestic science institutions did important basic research (for example, elucidating the nutritional roles of the "E" vitamins) and advised government ration programs during the First and Second World Wars.[84] Home economics programs rapidly collapsed, however, after World War II. By 1970, most U.S. institutions had eliminated home economics as a field of study, often by absorbing the scientific components into traditional science departments. [85] In the United Kingdom the field also declined. [86] Scholars have articulated several reasons for the fall of domestic science:

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[76] Bray, F. (2007). Gender and Technology. *Annual Reviews of Anthropology, 36,* 37-53; Faulkner, W. (2001). The Technology Question in Feminism: A View from Feminist Technology Studies. *Women's Studies International Forum, 24 (1)*, 79-95.

[77] Stage, S. (1997). Home Economics: What's In a Name? In Stage, S., & Vincenti, V. (Eds.), *Rethinking Home Economics: Women and the History of a Profession*, pp. 1-14. Ithaca: Cornell University Press.

[78] Berlage, N. (1998). The Establishment of an Applied Social Science: Home Economists, Science, and Reform at Cornell University, 1870-1930. In Silverberg, H. (Ed.), *Gender and American Social Science: The Formative Years.* New Jersey: Princeton University Press.

[79] Mitchell, J. (2008). Cookbooks as a Social and Historical Document: A Scottish Case Study. *Food Service Technology, 1 (1)*, 13-23; Craig, M., Wyllie, R., Coutts, E., Nettleship, I., Phillip, F., Sandison, H., & Stevenson, M. (1948). The Fat Required for Good Cooking and to Make Food Palatable. *British Journal of Nutrition, 2,* 187-190.

[80] McGregor, S. (2008). 100 Years of the International Federation for Home Economics. *International Journal of Home Economics, 1 (2)*, 99-103; Ollila, A. (1995). Women's Voluntary Associations in Finland during the 1920s and 1930s. *Scandinavian Journal of History, 20 (2)*, 97-107.

[81] Nerad, M. (1987). *The Academic Kitchen: A Social History of Gender Stratification at the University of California, Berkeley*. New York: SUNY Press, 1987.

[82] Eppright, E., & Ferguson, E. (1971). *A Century of Home Economics at Iowa State University*. Ames, Iowa: Iowa State University Press.

[83] Garrod, L. (1947). Bacteria in the Kitchen. *British Medical Bulletin, 1126*, 237-238.

[84] Rossiter, Margaret. *Women Scientists in America: Struggles and Strategies to 1940.* Baltimore: Johns Hopkins University Press, 1982.

[85] Eppright, E., & Ferguson, E. (1971). *A Century of Home Economics at Iowa State University*. Ames, Iowa: Iowa State University Press.

Feminist Criticism of Domestic Science: Some feminists strongly opposed domestic science programs, describing their existence as "little more than a conspiracy to keep women in the kitchen."[87] Others disagreed, but the fact remains that many scholars have criticized home economics on the grounds that it promoted traditional gender roles.[88]

Opening of Physical Science Programs to Women: The decline of home economics occurred simultaneously with increases in women's enrollment in natural science programs at the university level; the appeal of home economics may have decreased as women interested in fields such as chemistry were able to enroll directly in those majors.[89]

Fewer Opportunities for Home Economists in the Professional Workforce: At the same time, changes in industry eliminated many professional opportunities for home economics graduates. In the early twentieth century, companies that produced products for the home typically hired home economists to provide marketing advice, perform quality control, and organize product demonstrations. By the 1940s, however, these mostly-female home economists were replaced by mostly-male employees with academic degrees in psychology, marketing, and sociology.[90] In 1934, for example, the Dutch-British giant Unilever hired home economics teacher Riek Hillebrand to support its research efforts; by the 1960s, however, Unilever replaced female home economists with male marketing specialists.[91]

The collapse of domestic science meant that the scientific aspects of the home—traditionally the domain of women—would not be viewed as "real science." The European Union Statistics division does not collect data on domestic science programs. Korea is unusual in collecting data regarding domestic science, known as "Living Science," and distinct from biology and other life sciences.[92]

Gender studies of technology have also been important in bringing to light technologies that were "hidden from history." Such technologies have not merely been marginalized to make room for "heroic" military and industrial technologies; rather, they have been actively concealed because of their associations with women's sexuality and reproduction.

Example 2: Vibrators. Historian Rachel Maines has explored the history of vibrators within the contexts of medical practice and women's personal use.[93] Historically, physicians recommended orgasms as a treatment for "hysteria," a disease thought to affect about 75% of all women. Producing orgasms, however, was not a task that physicians wanted to entrust to women. Nor was it a task that a male partner (if any) was deemed responsible for. Instead, hysteria treatment was to be performed in a physician's office.

As early as 1752, engineers produced time-saving medical equipment to aid physicians in bringing their female patients to orgasm. These included "hydrotherapeutic appliances" that provided stimulation with jets of warm water.[94] Mechanical vibrators were also common. Some were "wind-up" types; others were continuously powered by foot pedals or, later, even by steam engines. Engineers incorporated emerging

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[86] Manthorpe, C. (1986). Science or Domestic Science? The Struggle to Define an Appropriate Science Education for Girls in Early Twentieth-Century England. *History of Education, 15,* 195-213.
[87] Stage, S. (1997). Home Economics: What's In a Name? In Stage, S., & Vincenti, V. (Eds.), *Rethinking Home Economics: Women and the History of a Profession*, pp. 1-14. Ithaca: Cornell University Press.
[88] Thompson, P. (1986). Beyond Gender: Equity Issues for Home Economics Education. *Theory into Practice, 25 (4)*, 276-283.
[89] Kohlstedt, S. (2004). Sustaining Gains: Reflections on Women in Science and Technology in 20th-Century U.S. *National Women's Studies Association Journal, 16 (1)*, 1-26.
[90] Oldenziel, R., de la Bruhèze, A., & de Wit, O. (2005). Europe's Mediation Junction: Technology and Consumer Society in the 20th Century. *History and Technology, 21 (1)*, 107-139.
[91] Schot, J., & de la Bruheze, A. (2003). The Mediated Design of Products, Consumption, and Consumers in the Twentieth Century. In Oudshoorn, N., & Pinch, T. (Eds.), *How Users Matter—The Co-Construction of Users and Technology* , pp. 230-242. Cambridge: MIT Press.
[92] National Institute for Supporting Women in Science and Technology (NISWIST). (2009). *Report on Women in Science and Engineering, 2008*. Seoul: Ministry of Education, Science and Technology.
[93] Maines, R. (1998). *The Technology of the Orgasm.* Baltimore: Johns Hopkins University Press.
[94] Pope, C. (1909). *Practical Hydrotherapy: A Manual for Students and Practitioners.* Cincinnati: Lancet Clinic.

technologies quickly: electrically-powered vibrators tethered to massive batteries became available even before widespread electrification.

The "taboo" nature of these technologies is clear in the language of medical textbooks and direct-to-consumer advertisements, and this taboo similarly excluded them from mainstream academic study—an exclusion that persisted until challenged by gender studies of technology.[95]

Example 3: Menstrual Hygiene Products. Sharra Vostral and others have examined menstrual hygiene products as "hidden artifacts," often excluded from everyday definition of technology.[96] Women have managed menstruation using improvised materials since prehistory; sanitary napkins were first manufactured by Johnson & Johnson in 1896. These cotton napkins were reusable through laundering, and though they were manufactured specifically as menstrual products, they were technologically identical to materials that women improvised, and consumers were slow to adopt them.[97]

The first substantial change in menstrual technology came when textile engineers at Kimberly-Clark learned that field nurses had adapted cotton bandages (at the time the company's main product) for use during menstruation.[98] Kimberly-Clark began manufacturing disposable sanitary napkins in 1920; the products were extremely profitable and ignited fierce competition with other firms. Tampons were first patented in 1927, though they were not commercially successful until 1931, when manufacturers solved technical problems, using special stitching patterns and cotton fillers to make tampons easier to apply and remove. Further technological developments have been made in absorbent materials, selection of additives to reduce the risk of infection, and adhesives to hold sanitary napkins in place. Despite this, menstrual products continue to have low visibility as technologies.[99]

Example 4: Brassieres. Historian Judith McGaw has examined the brassiere as "one of the many feminine technologies about which technological history tells us virtually nothing."[100] As is the case with menstrual hygiene technologies, devices with similar form and function to modern manufactured bras have existed for centuries, often hand-made and improvised.[101]

In the early twentieth century rapid changes in brassiere technology occurred. Bras are more physically complex than most clothing and have often been the first consumer articles to incorporate new materials, such as the elastomers and synthetic fabrics.[102] Important advances in brassiere technology also include seamless manufacturing and computer models to predict the amount and tolerability of pressure a bra applies to a wearer.[103] Bra makers face specific technological challenges: bras are manufactured from large numbers of material types and often dozens of panels of fabric, yet must be produced to narrower tolerances than other clothing. As a result, bra manufacturing has driven advancements in textile engineering as a whole.[104] Despite this, bras have largely remained "unmentionables" in the history of technology.

[95] Maines, R. (1998). *The Technology of the Orgasm.* Baltimore: Johns Hopkins University Press.
[96] Vostral, S. (2008). *Under Wraps: A History of Menstrual Hygiene Technology.* Lanham, Maryland: Lexington Books.
[97] Delaney, J., Lupton, M., & Toth, E. (1988). *The Curse: A Cultural History of Menstruation*. Urbana: University of Illinois Press.
[98] Spurgeon, A. (1988). Marketing the Unmentionable: Wallace Meyer and the Introduction of Kotex. *The Maryland Historian, 18*, 17-30.
[99] Vostral, S. (2008). *Under Wraps: A History of Menstrual Hygiene Technology.* Lanham, Maryland: Lexington Books.
[100] McGaw, J. (2003). Why Feminine Technologies Matter. In Lerman, N., Oldenziel, R., & Mohun, A. (Eds.) *Gender and Technology: A Reader*, pp. 13-36. Baltimore: Johns Hopkins University Press.
[101] Cunnington, C., & Cunnington, P. (1992). *The History of Underclothes*. London: Faber & Faber.
[102] McGaw, J. (2003). Why Feminine Technologies Matter. In Lerman, N., Oldenziel, R., & Mohun, A. (Eds.) *Gender and Technology: A Reader*, pp. 13-36. Baltimore: Johns Hopkins University Press.
[103] Yu, W., & Fan, J. (Eds.) (2006). *Innovation and Technology of Women's Intimate Apparel.* Sawston, United Kingdom: Woodhead Publishing Limited.
[104] Luk, T. (2003). Multi Panel Molded Brassiere Cup. U.S. Patent 6,805,612. October 19.

VI. Gendered Innovations: Mainstreaming Methods of Sex and Gender Analysis into Engineering and Technology

Gender bias in research limits the potential benefit of science and technology to society.[105] It is important to identify gender bias and understand how it operates in science and technology. But analysis cannot stop there: focusing on bias is not a productive strategy. Gender experts in science and technology are now shifting emphasis away from critique and toward a positive research program that employs gender analysis as a *resource* to stimulate gender-responsible science and technology.[106] Methods of sex and gender analysis for science, medicine, and engineering are now being developed (see Introduction).

Sex and gender analysis act as yet further controls—one set among many—providing critical rigor in science, medicine, and engineering research, policy, and practice. Gendered Innovations—fueled by sophisticated gender methods—stimulates the creation of gender-responsible science and technology, and by doing so enhances the lives of both men and women around the world.

Methods of sex and gender analysis serve to enhance objectivity in science and medicine, and to improve technology design. As with any set of methods, new ones will be fashioned and others discarded as circumstances change. Some transfer easily from project to project, others do not. The value of their implementation depends, as with any research methods, on the creativity of the research team. There is no recipe that can simply be plugged into research design. Researchers will want to consider all methods and think creatively about how these methods can enhance their own research.

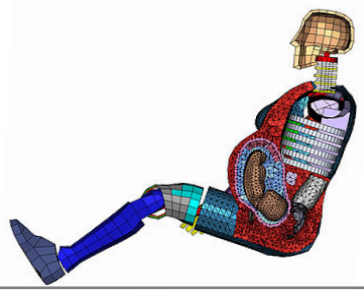
This section presents short case studies showcasing innovations in engineering and technology design that came about through sex and gender analysis—in addition to the many examples presented in the text above. Each section presents a case study highlighting a problem, a method of sex or gender analysis important to overcoming the problem, and solution, or gendered innovation.

[105] Biology and Gender Study Group. (1989). The Importance of Feminist Critique for Contemporary Cell Biology. In Tuana, N. (Ed.), *Feminism and Science* (pp. 172-187). Bloomington: Indiana University Press; Schiebinger, L. (1993). *Nature's Body: Gender in the Making of Modern Science*. New Brunswick: Rutgers University Press; Spanier, B. (1995). *Im/partial Science: Gender Ideology in Molecular Biology*. Bloomington: Indiana University Press; Schiebinger, L. (1999). *Has Feminism Changed Science?* Cambridge, Mass.: Harvard University Press; Wyer, M. (Ed.) (2001). *Women, Science, and Technology: A Feminist Reader*. New York: Routledge; Wajcman, J. (2007). From Women and Technology to Gendered Technoscience. *Information, Communication & Society, 10 (3),* 287-298.

[106] Schiebinger, L. (Ed.), *Gendered Innovations in Science and Engineering*. Stanford: Stanford University Press; Klinge, I. (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.

Example 1. Technology Design: Pregnant Crash Test Dummies

a. The Problem: Conventional seatbelts do not fit pregnant women properly, and in the U.S., 82% of fetal deaths with known causes result from motor vehicle collisions.[107] Because millions of pregnant women drive every year, the use of seatbelts in pregnancy is a major safety concern.[108] When a lap belt is placed over (rather than under) the pregnant belly, force transmitted through the uterus increases three to four-fold.[109]



"Linda" by Volvo. A virtual pregnant crash-test dummy designed in 2002.

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 for fetuses. Even today, many nations do not use pregnant crash test dummies in government-mandated automobile safety testing.

b. Methods of Analysis—# 8 Standards and Reference Models: 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 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 complete redesign of the conventional 3-point seatbelt to accommodate pregnancy.[110] From the start, devices should be designed for a broad population—this will help ensure safety and a broad user base.

c. Gendered Innovations: 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. "Linda" generates data modeling the effects of high-speed impact on the woman and fetus. Automobile manufacturers, however, have yet to implement an alternative to the 3-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 #7) encourages designers to study user populations —and to include both males and females in design development. These males and females should represent people from different regions, social classes, ages, reproductive status, etc. Analyzing sex (method #2) encourages designers to look at sex-specific characteristics of men and women. Pregnancy should not be overlooked.

[107] Weiss, H., Songer, T., & Fabio, A. (2001). Fetal Deaths Related to Maternal Injury. *Journal of the American Medical Association, 286 (15)*, 1863-1868.
[108] Ventura, S., Mosher, W., Curtin, S., Abma, J., & Henshaw, S. (2001). Trends in Pregnancy Rates for the U.S., 1976-97: An Update. *National Vital Statistics Report, 49 (4)*, 1-9.
[109] Pearlman, M., & Viano, D. (1996). Automobile Crash Simulation with the First Pregnant Crash Test Dummy. *American Journal of Obstetrics & Gynecology, 175,* 977-981.
[110] Duma, S., Moorcroft, D., Gabler, H., Manoogian, S., Stitzel, J., & Duma, G. (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.

Example 2. De-Gendering the Knee: When Over-Emphasizing Sex Differences is a Problem

a. The Problem: Total Knee Arthroplasty (TKA) is a common knee replacement procedure. In 2007, an estimated 500,000 total knee arthroplasty (TKA) procedures were performed worldwide—about two-thirds in women[111] In the 1990s, with an increased attention to women's health research, manufacturers began producing "gender-specific" knees, and marketed them directly to women. Does this lead to better healthcare quality for men and women?

b. Methods of Analysis—#3 Covariates: It is important to study sex differences but overemphasizing sex can also be a problem. Current research suggests that height is more important than sex in determining the size of knee implant a patient should receive.[112] Evaluating sex alongside other covariates is critical.

Piggy-backing on the women's health movement and difference feminism, Zimmer® proudly tells women consumers that a knee prosthesis has been designed specifically for them (see sample ad). These consumers, however, are not informed of the controversy surrounding sex-specific prostheses. Nor are they told that female-specific prostheses do not completely fit "female" knee anatomy and may still result in medial-lateral femoral overhang.[113]

Zimmer´s Gender Solutions™ Knee advertizing campaign. Zimmer® makes a connection between gendered preferences for clothes and entertainment and sex differences in knee anatomy—differences that research shows to be controversial.

Overemphasizing sex differences in knee prostheses may lead female patients to choose a more costly (but unnecessary) specialty prosthesis. Moreover, problems can arise when a male patient is advised that the best implant for him is a "female-specific" knee.[114]

c. Gendered Innovation: Analyzing sex (method #2) in knee anatomy marks a gendered innovation; sex differences cannot be ruled out without careful analysis. Studying sex is crucial; overemphasizing sex to the exclusion of other key factors is a problem.

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[111] Kurtz, S., Ong, K., Lau, E., Widmer, M., Maravic, M., Gómez-Barrena, E., de Fátima de Pina, M., Manno, V., Torre, M., Walter, W., de Steiger, R., Geesink, R., Peltola, M., & Röder, C. (2011). International Survey of Primary and Revision Total Knee Replacement. *International Orthopaedics*; Blunt, L., Bills, P., Jiang, X., & Chakrabarty, G. (2008). Improvement in the Assessment of Wear of Total Knee Replacements using Coordinate-Measuring Machine Techniques. *Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine, 222 (3)*, 309-318.

[112] Merchant, A., Arendt, E., Dye, S., Fredericson, M., Grelsamer, R., Leadbetter, W., et al. (2008). The Female Knee: Anatomic Variations and the Female-specific Total Knee Design. *Clinical Orthopedics and Related Research*, *466*, 3059-3065.

[113] Clarke, H., & Hentz, J. (2008). Restoration of Femoral Anatomy in TKA with Unisex and Gender-specific Components. *Clinical Orthopedics and Related Research*, *466*, 2711-2716.

[114] Blaha, J., Mancinelli, C., & Overgaard, K. (2009). Failure of Sex to Predict the Size and Shape of the Knee. *Journal of Bone and Joint Surgery*, *91 (Supplement 6)*, 19-22.

Example 3. Civil Engineering to Secure Water Supplies

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

b. Methods of Analysis: Analyzing gendered divisions of labor helps researchers understand who in a community holds the knowledge required for a particular project (#12). Women, as traditional water fetchers, often have specialized knowledge concerning water sources. Participatory research calls for women with specialized knowledge to be engaged in development projects from the start.

c. Gendered Innovations: Social divisions of labor in much of Africa make water procurement women's work. Consequently, women have detailed knowledge of soils and their water yield. A study of water projects in 88 communities showed that the most successful 15% of projects involved high levels of participation by both women and men. The least successful 15% of projects were those than excluded one sex. Including women in democratic decision-making more than doubled the chance that a project would be ranked in the top 15% of projects.[115]

Conclusion and Recommendations

Gender studies of technology have the potential to enhance engineering and technology design. It is interesting that both the German Fraunhofer Institute's "Discover Gender" project and the Danish "Female Interaction" project seek to operationalize insights from gender scholarship in technology through checklists and methods sections for designers.[116] The Stanford University and European Union Gendered Innovations project additionally seeks to distill and translate sometimes complex insights from gender studies into methods readily useful to engineers and technology designers: Systematic methods of sex and gender analysis will be produced through a series of expert meetings in 2011. Understanding how sex and gender inform and impact a particular engineering or design project will lead to gendered innovations of the sort highlighted in this article.

Once these methods are in place, there are a few next steps:

1. The current generation of engineers, designers, and evaluators needs to be trained in gender methodology.
2. Senior management needs to oversee evaluation standards that take into account proper implementation of gender analysis in engineering and design.
3. Granting agencies can require that all applicants include gender methodology in research design.
4. Hiring and promotion committees in industry and academia 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.
5. Editors of peer-reviewed journals can require sophisticated use of sex and gender methodology when selecting papers for publication.
6. The next generation needs to be trained in gender methodology. Sex and gender analysis should be taught throughout the curriculum, including engineering and design labs. Textbooks should be revised to integrate materials from the gender studies of science and technology.

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[115] Gross, B., van Wijik, C., & Mukherjee, N. (2001). *Linking Sustainability with Demand, Gender, and Poverty: A Study in Community-Managed Water Supply Projects in 15 Countries.* Delft, Netherlands: IRC International Water and Sanitation Centre.

[116] Schroeder, K. (2010), Gender Dimensions of Product Design, United Nations Division for the Advancement of Women, Expert Group Meeting: Gender, Science, and Technology, 28 September-1 October, Paris France.
Schraudner, M. & Lukoschat, H. (Eds.) (2006). *Gender als Innovationspotenzial in Forschung und Entwicklung.* Munich, Fraunhofer.

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Innovation has been placed at the heart of the Europe 2020 strategy.[117] Innovation is seen as a way to address major social problems. Gendered innovations in science, medicine, and public health 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 essay suggests, gender analysis sparks creativity by asking new questions and opening new areas to research. Can we afford to ignore such opportunities?

[117] *Europe 2020 Flagship Initiative*: Innovation Union at http://ec.europa.eu/research/innovation-union/pdf/innovation-union-communication_en.pdf