Understanding Gender: Some Implications for Science and Technology

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Gender relations and gendered power relations are major defining features of science and technology. This article addresses the question of how to understand gender, and considers their various implications for science and technology. Gender and gender relations can be understood as operating and as relevant to science and technology at several levels: who does science and technology; how science and technology are organized; and the construction of knowledge in science and technology. We review five underlying formulations that inform both policy interventions and theorizing around gender and science – gender based on sex; masculinity/femininity and sex roles; categoricalism, structure and plural structures; poststructuralist, discursive and deconstructive approaches; the material-discursive.

One of the key aspects of contemporary and historical developments in interdisciplinary work in science and technology has been the ´noticing´ of gender. This insight, or set of insights, can be understood as part of the task of placing science and technology in their wider social and cultural context. In effect, this can mean that a *more scientific* view and understanding of science and technology can be elaborated.

While the whole of this special issue is on ´Gender in Science´, the question still remains of how to understand gender, and indeed its associates of gendering, gendered, gender relations, and gender power. We should begin by saying that gender relations and gendered power relations are major defining features of science and technology, and their social organization, but questions remain as to in what particular way. The exact ways in which gender, on one hand, and science and technology, on the other, intersect is a major site of debate. This is even so amongst feminists (Wajcman 2010), despite the fact that feminist scholarship has been at the heart of bringing gender into science and technology (Harding 1986; Schiebinger 1999). Science and technology are not just structured by gender but pervaded and constituted by and through gender. At the same time, scientific and technological realities construct, and sometimes re-form and even subvert, dominant gender relations.

First, there is the question of *gendered individuals in science and technology*: gender operates in terms of *who* does science and technology, who are the leaders, inventors, who are the followers, who are the workers. Women continue

to be a minority among researchers in global perspective. Currently somewhat more than a quarter (29%) of the world's researchers are women, according to the latest UNESCO data covering 121 countries. In 37% of the countries women account less than a third of researchers, and in only 15% has gender parity been achieved. Only a handful of countries have more female than male researchers (UNESCO 2010). Eight out of ten European professors, and nine out of ten University Rectors, are male (European Commission 2009).

In addition, there is the question of how those involved in science and technology are reported, represented, made into heroes, constructed in the history of science, or simply forgotten. A notable early example of women hired as science workers, with low pay and no opportunities to advancing in their career, were the astronomical ´computer´ women of the late 18th century. Observatories, such as Harvard College Observatory, hired numerous women as ´computer´, to perform star observation and counting work (Rossiter 1982). Science sociologists Robert K. Merton (1968) Harriet Zuckerman (1977) coined the term Matthew effect (´For whoever hath …´) to describe the accumulation of advantage enjoyed by already successful and visible scientists. Science historian Margaret Rossiter observed that for women, the reverse often is the case and launched the term ´Matilda effect´ (named after a forgotten 18th century thinker Matilda Joslyn Cage) to describe the systematic ´undercutting, undercounting and minimizing´ of women in scientific arenas, using examples from antiquity to Nobel laureates such as Rosalind Franklin and Lise Meitner, and scientific encyclopedias (Rossiter 1993, 325).

Then, there is the broader question of the *gendered organizing of science and technology*: how science and technology are managed, organized and practiced within organizations. This includes attention to what issues, problems, questions are studied, and indeed prioritized in science and technology. It is very important to understand that science and technology are conducted for the most part in organizations, such as research groups, research networks, laboratories, research institutes, and universities, with their own profoundly gendered features. Briefly, typical patterns of gendering in organizations include:

- *The valuing of work organization and management of work in the private domains.* Men's work is frequently valued over women's. Women typically carry the double burden of childcare and unpaid domestic work, and even a triple burden of care for dependents, old people, and people with disabilities (O'Brien 1981; Stacey and Price 1981).
- *Gendered divisions of labour and authority*, both formal and informal. Women and men may, through inclusion and exclusion, specialize in particular types of labour, creating vertical and horizontal divisions within organizations. Women and men may be valued differentially in terms of formal authority, post and position, and informal status and standing in organizations (Kanter 1977, 1993).

- *Gendered processes between the centre and margins*. These may be literally or metaphorically spatial in distributions of power and activity between the centre and margins of organizations. ´Front-line´ activities are often staffed by women; ´central´ activities more often by men. The ´main aim´ of organizations tends to be dominantly defined by men (Cockburn 1991).
- *Gendered processes in sexuality.* Most organizations reproduce dominant heterosexual norms, ideology and practices. Indeed (hetero)sexual arrangements in private generally provide the base infrastructure for organizations, principally through women's unpaid reproductive labour (Hearn and Parkin 1987/1995).
- *Gendered processes in harassment, bullying and physical violence* have been a relatively neglected aspect of gendered organizations, but one that impacts on all the other features in profound and constraining ways (Hearn and Parkin 2001)
- *Gendered processes in interactions, and individuals' internal mental work*, that maintain, or disrupt, other gendered patterns, and concern how people make sense of gendering (Acker 1992)
- *Gendered symbols, images and forms of consciousness*, for example, in media, decor, and material, technical and scientific objects (Acker 1992).

Third -- and now we enter an arena of great debate -- there is the question of the *gendered knowledge in science and technology*: the relevance of gender for the construction of scientific knowledge itself. Here, we move from the ´women question´ in science to the ´science question´ in feminism (Harding 1986, 29; Wajcman 2010, 146). How are the theories, concepts, logics, methodologies, and language used in science and technology gendered? Feminist methodological debates have been very important here, most obviously in the humanities and social sciences, but increasingly also in the natural, medical and technological sciences (Harding 1991). It might also be argued that the relevance of this kind of gendering (of knowledge) varies with different kind of scientific and technological endeavours. Compare, for example, building a bridge that stays up and does not collapse, with theorizing on the very nature of organic/inorganic matter itself, and possible differences, or not, between such organic/inorganic ´matters´. An often-cited example comes from the field of cell biology and the metaphors used to describe conception. Until the 1970s, conception was described in textbooks by depicting an active sperm pursuing a passive egg, in fight with rivals. Later research has corrected this view with evidence on complex egg and sperm co-operation towards fertilization (Schiebinger 1999).

What is sex? What is gender?
There is no single or simple definition of gender, or kindred terms, such as gendered and gendering. When ´gender´ is considered in approaching science and technology it is common to focus on ´women´, ´men and women´ or

´relations between them´. There is a vast body of research that focuses on this two-gender model, and examines differences, social and otherwise. While these men-women differences are certainly key aspects of gender relations, they are only part of it. Gender is just as relevant in relations between women, and between men (Carrigan et al. 1985; Collinson and Hearn 1994), for example, in gendered hierarchies within genders, and indeed in considering the relations of gender, sex and sexuality.

These wider understandings of gender are both contested and central to analyzing science and technology, including recognition of intersections with other social divisions. Indeed it might be argued that as gender relations have become more recognized in studies of science and technology, the very notion of gender has itself become more problematized.

In reviewing some of the various ways in which gender, and indeed sexuality, can be approached in science and technology, we suggest five underlying formulations that inform both policy interventions and theorising around gender and science – gender based on sex; masculinity/femininity and sex roles; categoricalism, structure and plural structures; poststructuralist, discursive and deconstructive approaches; the material-discursive. Though these are contrasting in many ways, they also overlap and intersect in specific analyses and situations, along with their implications for science and technology.

Gender based on sex
Sex and sex differences are often naturalized as fixed in biology. The sexed body can be understood as a given, determinate biological sex matter: the biological formulation of what is female and what is male. The idea of 'the natural body' is persistent in everyday, professional and academic discourses. Biological approaches to the female/male body have usually been founded on one or more of the following: instinct; territoriality and physical size; chromosomal difference; hormonal difference. Primary sex characteristics generally refer to chromosomal structure; secondary sex characteristics include: gonadal structure (ovaries/testes); internal genital ducts (fallopian tubes and uterus/vas deferens and prostate); external genital development (vagina, vulva, clitoris/penis); hormonal structure (preponderance of oestrogen and progesterone, or androgens, including testosterone); presence/absence of breasts and of certain body hair. Yet, up to 6-7 weeks gestation female and male embryos have externally identical genitalia - after that specific sexed development occurs. At every stage for the human the basic pattern is female away from which development proceeds to produce the male. The human embryo will be female unless it has a Y chromosome.

But as Nicholson (1993, 12) explains, ´Both sexes actually receive very similar genetic instructions … even for the features that tell them apart´. For example, both sexes receive sets of instructions dealing with breast development, but in only one sex are the instructions acted upon. The same applies for all the other

physical characteristics, which distinguish men from women: genitals, shape, muscle growth, voice-box development, body hair and so on. There are also major chromosomal variations beyond the main XX and XY types, with fifteen types of intersexuality, for example. A number of critical feminist biologists, such as Fausto-Sterling (2000), have developed sophisticated and grounded accounts of how biology itself does not neatly conform to a two-sex female/male model but is in fact much more variegated in many possible sexes among humans, and in other species.

Masculinity/femininity and sex/gender roles

The concept of gender has spawned some kindred terms, as in the notion of ´gendering´ or ´gendered´, referring respectively to how people, situations, objects, schemas can be given meaning, both empirically and analytically through gender and gender relations. For example, in the book *Why so slow?* Valian (1998) discusses the slow advancement of women in science compared to that of men in such terms. When ´sex´ as biological sex differences was distinguished from ´gender´ as socio-cultural constructions of sex differences (Oakley 1972), this led onto much research on sex/gender differences, their social assumption and perception, and detailed empirical studies of their relative absence (Maccoby and Jacklin 1974; Durkin 1978; cf. Barres 2006; Spelke 2006), linked with development of psychological scales for measuring '*masculinity-femininity*', *sex/gender roles and gender socialization*. Much of the research using these approaches has been conducted within what Sandra Harding (1991) has called *feminist empiricist epistemology.*

Understanding gender can be reconceptualized more explicitly in relation to (gender) policy and politics, in science and technology in terms of gender reform, gender resistance, and gender rebellion feminisms (Lorber, 2005). In the first case, the *liberal reform feminist* approach sees gender equality as a matter of realising the potential of women and men equally, albeit within the context of current gender order and social structures. To quote Judith Lorber (2005, 13): ´Gender reform feminists locate the source of gender inequality in women's and men's status in the social order, arguing that it is structural and not the outcome of personal attributes, individual choices, or unequal interpersonal relationships. … An overall strategy for political action to reform the unequal gendered social structure is *gender balance.*´ (emphasis in original). This can be seen as the dominant position in much science and technology governmental and corporate policy, including much gender equality politics. The implication is that men and women can contribute positively to (or can position themselves against) a programme of change towards the *abolition of gender imbalance* in science and technology.

There are, however, many problems with this position (Eichler 1980), including cultural specificity, relative lack of attention to power, change and social structures, as well as various methodological problems, for example, in the

construction of measurement scales, ethnocentrism, and reification of masculinity and femininity as singular qualities. Even with such difficulties, the sex/gender model has certainly prompted path-breaking work on gender relations, for example, on attitudes, self-concepts, identity, social categories, and structural relations. The focusing on masculinity-femininity and sex/gender roles has had, probably, most impact at the social psychological and interpersonal levels of analysis, but, as a major set of social perspectives, it has also influenced thinking more widely at the organizing level.

Gender categoricalism, gender structures, and structurally contextualized practices

In addition to the sex role approaches, some socio-cultural perspectives on gender have articulated *categoricalist and structuralist* concepts of gender relations (patriarchy, fratriarchy, gender systems, gender orders, gender contracts) and systems of male dominance. Sometimes these structural approaches have been seen in terms of what are often called *standpoint theory approaches* to gender (Smith 1987, 1990a, b), in which knowledge is linked directly and specifically to social positioning, and sometimes also to *sexual difference theories*, in which the social and bodily foundation of sex/gender is emphasized as a source of knowledge (Irigaray 1985).

In the late 1970s and early 1980s, critiques of the concept of patriarchy and of relatively fixed 'categorical' approaches to gender (Rowbotham 1979; Connell 1985) started to appear, resulting in a movement to *differentiated, pluralized approaches to gender*. This reformulation of gender fits in closely with revisions of patriarchy/ies as historical, multiple structures (Walby 1986, 1990; Hearn 1987, 1992).

These debates have been influential in showing that gender is also about men and masculinities: the naming of men as men (Hanmer 1990; Collinson and Hearn 1994), and their deconstruction. This is partly about identification and critique of different plural masculinities, including hegemonic, complicit and subordinated masculinities (Carrigan et al. 1985), seen as forms of power-laden gender practices within structural contexts. They also concern the very hegemony of men (Hearn 2004) that constructs men as a social category and forms men as individual and collective agents. This draws attention to the homosociality and cultural cloning of men and masculinities in science and technology.

In political and policy terms, more structural approaches tend to fit in with what Lorber calls *gender resistance feminism*, in which it is argued ´… that the gender order cannot be made equal through gender balance because men's dominance is too strong.´ (Lorber 2005, 14). Gender equality *per se* is not a feasible aim, or it is seen as necessary but far from enough; it may end up with women becoming like men if the organizational structures and dynamics are not questioned. A more radical transformation is necessary, with women's voices

and perspectives reshaping the gendered social order in a more fundamental way, including the *abolition of patriarchy* in science and technology.

Poststructuralist, discursive and deconstructive approaches

In recent years there has been growing attention to gendered practices and processes, multiple/composite masculinities and femininities, interrelations of gendered unities and differences; life stories and subjectivities; and the social construction of sexualities. Such insights are sometimes developed within more structural frameworks, more often within *poststructuralist approaches*. In the latter, gender is seen as formed and performed in and as discourse(s), with the concepts of 'subjectivity' and 'subject position' given emphasis.

Whichever way the variations of difference are understood, individual and collective differences in relation to age, class, ethnicity, and occupation may be formed intersectionally, resulting in views that can solidify difference, contest difference, or deconstruct difference (McCall 2005). Intersectional debates have been immensely important by pointing that this is not so much about identity or difference *per se*, but rather about validity of western mode(l)s of thinking about gender and women as a source of indigenous knowledge (Narayan and Harding 2000; Harding 2006, 2008; Schiebinger 1999, 42-4; for policy interpretation, see Harding and McGregor 1995).

A pervasive constraint in conceptualizing gender is the persistence of dualisms and dichotomies, such as female/male; woman/man; feminine/masculine; femininity/masculinity; girls/boys. While these are clearly important differentiations, they only speak to part of the possibilities of what gender is or might be in different situations and societies (Edwards 1989). The very distinction between sex and gender also brings difficulties. It may imply that biology is pre-social or free of the social, though biology is constituted in the social (Bondi 1998). Perhaps the greatest challenges to dichotomous views of gender (both from sex, and between gender categories) come from sexuality studies and queer theory. Gender and sexuality are intimately connected with each other; ´without the concept of gender there could be, quite simply, no concept of homo- or hetero-sexuality.´ (Sedgwick 1991, 31). The sex-gender distinction can be seen as a socio-cultural construction: gender is not the cultural arrangement of *given* sex difference; rather sex/gender difference is a cultural arrangement, dominantly constructed by way of the heterosexual matrix (Butler 1990). These perspectives have been reinforced through queer studies, transgender studies, and crip theory, which has brought together disability and queer theory (McRuer 2006).

Gender, or rather gendering, may be seen as an unfinished, performed process, in which gender is made by doing, not by being (of a certain gender). Interestingly, this returns understandings to the long established debates in sociology around the social, cultural and linguistic constructions of sex and sexual difference, as outlined by Garfinkel (1967), Kessler and McKenna (1967),

and indeed Goffman. Gender in this view is done in immediate practice, not from any essence or fixed categoricalism

These various ´post-´ positions seek to ´take apart the gendered social order by multiplying genders or doing away with them entirely´ (Lorber 2005, 12). Connections with other social divisions, differences and oppressions become central, as do deconstructions of categories of sex, sexuality and gender, and the dualities (re)produced through them (see Lorber 1994, 2000). ´Men´ becomes an outdated social category (Hearn 1998, 2004). More general implications include the *deconstruction, even abolition, of men and other taken-for-granted social-sexual-gender categories*. While this suggests a radical conceptualization of gender, this approach is often less directly translated into policy.

The material-discursive

Finally, the intersection of poststructuralist and materialist approaches to gender, science and technology is such that human-nature relations, and even matter itself can be reconceptualized as contingent processes. Humans can be understood in terms of combinations of social systems of production, including science and technology, the reproduction, however fragmentary, of ideas, ideology and discourse, and relations to non-human nature and things. An important influence in moves towards incorporation of the discursive in the material was Dorothy Smith's sociological work (1990a, b) – connecting political economy, texts and relations of ruling, and inspiring what might be described as the material-discursive (Hearn 1992). Similarly, Science and Technology Studies (STS) scholars have coined such terms as material-semiotic actors (Haraway 1992) and human-nonhuman assemblies (Akrich and Latour 1992) to address the realm of human-non-human, human-machine and similar relations.

Thus in recent studies of gender, science and technology, there is a turn to materialism but beyond the strict separation of the material and the discursive/semiotic, as in so-called ´new materialism´ (Alamo and Hekman 2008). Butler (1993) expounded how discourse comes to (become) matter as ´a process of materialization that stabilizes over time to produce the effect of boundary, fixity, and surface.´ Building on these approaches, Barad (2001) shifted focus onto how matter comes to matter, extending discussion of the material-discursive to the realm of non-human matter. In this perspective, gender and sex are not separable from bodily matter, and ´matter´ is itself social and constructed, in part through human/non-human species interactions (cf. Haraway 1989, 2008). Matter is both beyond humans and humanly made (Barad 2006) within an epistemological-ontological-ethical framework. In this thinking gender is not one ´thing´. It is complex and contested, material, bodily, and discursive. Nor can a focus on gender be isolated from other divisions, oppressions or discourses, in relation to which gender is formed. The policy implications of such thinking are less easy to articulate: ´gender, science and technology´ begins to dissolve as a separable arena for intervention.

Conclusion

The three ways in which gender and gender relations relevant to science and technology connect to the five broad approaches to gender outlined are summarized in the table below.

	Gender based on sex	M/f and sex roles	Gender structures and plural practices	Poststructuralism, discourse and deconstruction	Material-discursive
Gendered individuals in science & technology	Strong emphasis	Strong emphasis	Medium emphasis	Medium emphasis	Medium emphasis
Gendered organizing of science & technology	Weak emphasis	Medium emphasis	Strong emphasis	Strong emphasis	Medium emphasis
Gendered knowledge in science & technology	Weak emphasis	Weak emphasis	Medium emphasis	Medium emphasis	Strong emphasis

While all approaches are relevant to all realms, the increasingly broadening and ambitious range of gender studies has raised increasingly complex and far-reaching questions, including the very nature of science and technology itself. When investigating 'Gender in Science', whether in analytical, policy or indeed personal terms or agendas, it is necessary to stop and think: how do I understand gender, and what implications follow?

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