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Researching UK Women Professionals in SET: A Critical Review of Current Approaches

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ABSTRACT

In the UK and elsewhere, progress and achievements in tackling the under-representation of women in science, engineering and technology (SET) are far outweighed by the investment in this area in terms of both research and initiatives. The authors attempt to explain this by presenting a critical analysis of the development of research on women professionals in SET. This critique is structured around four approaches identified in the literature: essentialist constructions of science and gender; barriers facing women professionals in SET; the assimilation of women in SET; and the business case for change. It is argued that existing research in the field does not always offer practical solutions for change and has a tendency to situate women as part of the problem. It concludes that future research and solutions must be multi-faceted, evidence-based and policy oriented if equality is to be perceived not only as a 'women's issue' and real cultural change is to be instigated in the sector.

KEYWORDS

Science, engineering and technology; professions; cultures; occupations; gender.

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INTRODUCTION

Over the last 40 years, numerous research studies and initiatives have attempted to redress the under-representation of women in science, engineering and technology (SET). These initiatives have been local, national and international in scale and have generally aimed to raise women and girls' awareness of career opportunities in SET, to establish membership groups and networks to support women working in SET (Phipps, 2008) and to promote a business case for gender equality among SET employers. However, the progress and achievements to date do not match investment in terms of the quantity and quality of research and initiatives in this area. For example, although there is a paucity of data on women employed in SET, statistics show that the proportion of women employed in SET professions is below average at only 14.2% (ONS, 2008), with little variation in recent years (see Table 1). In the engineering profession, the most male dominated in SET, recent UK Engineering Council figures on membership data for 2008 show that 3.3% of registrants were women, representing a clear rise in percentage terms of women registered with them over the last twenty years – as the figure was just 0.5% in 1988 (Barnard et al., 2010). Ellis (2003) and Phipps (2008), amongst others, suggest that we need to understand why there have been so few subsequent changes in SET employment for women. Thus it seems that despite efforts to attract more women to SET disciplines, SET cultures remain very male dominated, making SET professions problematic arenas for women to develop their careers within.

Table 1: Proportion of women in employment by occupation type (%)

	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Science professionals	43.6	41.7	40.6	41.9	38.7	38.7	39.4
Engineering professionals	5.6	5.3	4.7	5.4	5.4	5.4	6.9
ICT professionals	15.6	13.3	14.8	14.0	14.0	14.3	14.4
All SET professionals	**14.5**	**13.3**	**14.0**	**14.1**	**13.1**	**13.3**	**14.2**
All occupations	45.3	45.2	45.2	45.2	45.2	45.0	45.1

Source: ONS 2002-2007 Quarterly Labour Force Survey; compiled by UKRC 2009

This paper provides a critical analysis of the development of research on women professionals in SET, primarily from a UK perspective, with a view to understanding why it has had a limited impact. The authors propose that four key approaches have emerged in the development of women in SET research and that these are focused around i) essentialist constructions of science and gender; ii) barriers facing women professionals in SET; iii) the assimilation of women in SET; and, iv) the business case for change. Each of these approaches is summarized and

critiqued below along with some potential ways forward for this field of research that may lead to positive change for women in SET. Where there have been nuances in research approaches and findings, these are also noted. However, these approaches are not necessarily exclusive, and existing research has often adopted multiple approaches.

ESSENTIALIST CONSTRUCTIONS OF SCIENCE AND GENDER

A major theme in the literature on women in SET concerns the construction of SET as a masculine dogma. This research suggests that women's previous exclusion and persistent under-representation is rooted in the construction of science as rational, objective, neutral and in opposition to traditional notions of femininity or alternative modes of masculinities (Blackstone and Weinreich-Haste, 1980; Faulkner, 2000a; Rosser, 1998; Stepulevage and Plumeridge, 1998). In Western societies, SET professions are considered to be a man's domain, with strong cultural images and common-sense discourses that reinforce many SET careers as unsuitable for women. Although certain SET occupations have been 'feminised' through higher numbers of women in employment, for example biology and pharmacy (Crompton and Sanderson, 1990), women can often find that they are hierarchically segregated or 're-segregated' into occupational sub-fields (McIlwee and Robinson, 1992).

Alongside constructions of science as masculine, there is a continued dominance of traditional notions of gender. Benckert and Staberg (2000) argue that this stems from male SET employees' belief that women are different from them. Essentialist conceptions of gender not only juxtapose men and women, but also dichotomise the masculine and feminine in such a way that women who 'succeed' in traditionally masculine domains are perceived to 'fail' in supposedly feminine domains. Thus, as Moore et al. (2005) argue, this essentialist dichotomy of man/woman public/private makes it difficult for working-women to be accepted as a success in both spheres, as is demonstrated in the conflict between work and family life prevalent in the key issues mentioned below.

Not only do SET cultures express an essentialist construction of women, much research on SET also emphasises differences between men and women (see for example, Martin and Wright, 2005; O'Connor et al., 2006; Stepulevage and Plumeridge, 1998). This may mask similarities between men and women, and differences between women and between men. Furthermore, the focus upon difference may lead to 'the polarization of female and male, and to the subordination of women' (Benckert and Staberg, 2000: 86). For example, clear stereotypes exist within the SET professions relating to women's job performance and future potential. In particular, because of the dominant association between traditional notions of masculinities and technology (Adam et al., 2005; Cockburn, 1985; Faulkner, 2000b; Woodfield, 2000) women are perceived to be unsuitable for purely 'technical' careers (Webster, 2005). It is claimed they are better communicators and are thus directed towards management or the 'soft' side of SET professions, such as sales,

personnel, and desk-based work (Devine, 1992). Further, it is argued that where 'ghettoisation' occurs, those areas that are dominated by women (for example systems analysts in IT) are culturally understood as lower status (Panteli et al., 1997).

In the USA, Fox (1998) highlights how the 'problem of women' in SET is defined following individual and structural explanations – focusing on the 'nature' of women (conceptualised as distinctly different from men). This maintains the dominant culture in SET organisations: 'Attempts to fit individuals to existing structures of education and the workplace meet fewer barriers and obstacles than do efforts to change organizations and their hierarchies' (Fox, 1998: 221). Wajcman (1991) suggests this is part of the 'deficit model', which locates the problem of science and women in the women themselves, and ultimately fails to challenge the gendering of science as masculine. The 'problem' of women's presence in SET has formed a particular pattern of acceptance and acceptability that demonstrates how gendered cultures can bend and stretch to accommodate difference, without apparent change to the whole.

Sector Nuances

In terms of specific SET disciplines, a number of issues have emerged under the theme of the masculinity of science. In engineering, for example, there are clear distinctions made between 'real' male engineering (technicist) and other work in the sector (Faulkner, 2005).

Alongside the perceived unsuitability of women for the purely technical careers in SET occupations, the complementary and corresponding stereotype promotes women's ability as managers; 'employers often assume that women are more comfortable in management than technical roles' (Webster, 2005: 9). Research in SET organisations reveals that this perception is relatively common across the sector and is ultimately based on the stereotype that women are better at dealing with people. These stereotypes, however, reinforce essentialist notions of gender. Thus, as Devine (1992: 567) highlights: 'while managers claimed that gender stereotypes would be eliminated, they emphasised their commitment to equal opportunities by extolling the virtues of women as managers', clearly not recognising the contradictions this posed. Nevertheless it is still predominantly men who hold managerial positions in these organisations (Panteli et al., 1997) and the management structure itself is seen as a 'boys club' (Bennett et al., 1999) in which women managers may struggle to become fully established within the upper levels of the organisational structure.

The perceived suitability of particular organisational roles for women within the SET professions is relevant across the different sectors; but disciplines within SET can circulate rather different discourses whilst maintaining a 'male' image. For example, as a relatively new field, IT does not have the same historical associations as science or engineering; however, IT has nevertheless become deeply associated with technology,

technical ability and a 'geek' identity, such that it can act as a deterrent for women seeking a professional career (Grey and Healy, 2004; Siek et al., 2006). Whilst most SET occupations are generally seen as 'masculine' there are subsections that have been 'feminised' through higher numbers of women in employment, for example biology or pharmacy in the sciences (Crompton and Sanderson, 1990). As the gender-balance within these sub-sectors is altered, a challenge to the masculine-profession is deemed to have taken place. However, McIlwee and Robinson (1992) refer to women's 're-segregation', suggesting that even when women break into areas dominated by men, they often find themselves confined to 'female ghettos', sometimes suffering a loss of status the more that women succeed in that field. Further research is required to investigate differences between these apparently 'feminised' and 'male-dominated' occupations within SET, acknowledging vertical, as well as horizontal, segregation. This type of research would enable a greater understanding of the impact of greater numbers of women working in traditionally male spheres in terms of the organisational culture and experiences of professionals in those organisations.

While it is important to acknowledge the construction of science as masculine, one of the difficulties with this perspective is that the association between traditional notions of masculinities and technology are accepted within society's common-sense discourse and the cultures of SET organizations. Researchers who investigate SET may need to reflect upon the role they themselves play in the recycling of common-sense positions that are underpinned by essentialist conceptualizations of men and women. In addition, while analyses of essentialist discourse and the construction of science may be aimed at developing an understanding of SET cultures, this means potential solutions to the problem often remain unidentified. However, given that over-turning these associations are clearly problematic, it is important for such approaches to suggest policy solutions that may go some way to challenging these cultural norms.

Clearly there is room for more work on developing practical solutions to the issues raised. Some stakeholders have attempted to achieve this, suggesting ways of tackling stereotypes in SET promotional materials and promoting female role models in the industry (see for example, Education Engineering Alliance (EEA), 2004; Institute of Engineering and Technology (IET), 2008). Yet while these are positive measures that may have some long-term impact, they do not offer a 'quick-fix' for women already employed in masculine SET cultures, and the extent to which they really challenge the association of science/technology and masculinity is debatable. Policy solutions that are based on essentialist ideas suggest, for example, that in order to attract women into the sector there is a need to downplay technical elements, instead promoting the social and environmental benefits of SET. These kinds of solutions may be based on research, but they may also be based upon traditional ideas about what naturally interests men and women. This does not uncouple masculinity and technology, but rather reasserts this relationship. Again, the tackling

of stereotypes in promotional materials is but a first step towards changing the identity of the sector, and if done in isolation may be perceived as a cynical attempt to pay lip service to the equality agenda.

The use of female role models can offer inspiration to young women, but again if promoted in isolation from wider organizational change, these role models can be interpreted as exceptional, and therefore do not challenge gendered norms. Thus, it can be understood that policy solutions informed by this approach may have limited impact as common sense notions of gender difference.

BARRIERS FACING WOMEN PROFESSIONALS IN SET

The second major theme emerging in the literature on women in SET is identification of the different types of barriers women face in terms of entering and progressing in SET structures and cultures. These barriers invariably include issues around networking, work-life balance and gendered discourses.

The Boys' Club: Networking

Despite the need to 'fit in' with workplace cultures (Griffiths et al., 2006), informal networks within most SET organisations make this difficult for anyone who does not accept and display particular elements of dominant masculinities. Social networks often follow supposedly sex-based roles, revolving around traditionally masculine activities such as sport or drinking, spheres that have traditionally excluded women. Evidence suggests that networking is also based upon self-promotion, 'game-playing' and unwritten rules that have been constructed by men (Singh et al., 2002: 77). Benckert and Staberg (2000) found that women scientists felt excluded from the men's 'club' and that this had a clear impact on their chances of gaining promotions due to the fact that decision-making bodies remain dominated by men. Furthermore, participants in Davis's (2001) study talked about how unattractive the prospect of networking in the science community was for them, as they experienced it as 'competitive, aggressive, less than honest, discouraging and discriminatory' (Davis, 2001: 377-378). The women described how the 'schmoozing' and 'posturing' common in both professional and social settings in the sciences left them feeling uncomfortable. While these views are not disputed, they are problematic because once again they purport an 'us and them' culture, emphasising men and women as different.

Despite the importance of networking for career development and evidence suggesting that supportive networks in SET can have a positive influence on women's participation and retention (Kreinberg and Lewis, 1996), suggested solutions, such as women's networks and mentoring programmes, can be problematic. This is not least because many women in SET professions believe that it is hard work and reputation building that enables career development (Evetts, 1996) and do not see this type of 'politicking' as part of the job (Grey and Healy, 2004) despite evidence

that highlights the importance of networking for women's careers (Linehan, 2001).

Work-Life Balance and the Long Hours Culture

The conflict between work pressures and family responsibilities are keenly felt by professionals working in SET and the decision to spend time with family rather than working has real consequences for career progression (Davis, 2001), particularly for women, who continue to be, and be perceived as, the primary carers of family members. Measures of success in SET have not evolved with women's entry into the professions, and traditionally masculine values, such as total commitment to work without personal distractions, continue to be highly valued.

Research in this area has found that the dominant culture in SET is long-working hours, task or project oriented work and the expectation of total availability, with anything less interpreted as a lack of commitment to career, profession and organisation (Davis, 2001; DTI, 2005; Etzkowitz et al., 2000; Grant et al., 2000; Lingard and Francis, 2004; Woodfield, 2000). Even when staff can work 'normal' hours, there are 'hidden costs': 'the sense that you are not pulling your weight, that others are suffering for you, and that you are missing out on perhaps the most exciting and visible parts […] the inability or unwillingness to work long hours may be read as an insufficiency of organisational commitment' (Murray, 1993: 74). There is also 'considerable conflict between scientific careers and family life' (Grant et al., 2000: 63) and maternity leave and the return to work have been identified as problematic for women. SET cultures can also work against women with children, not only because of a lack of suitable policies to support working mothers. The lack of flexible working, the low status and negative consequences associated with changing to part-time work was cited as one of the main reasons women decide to leave, or think of leaving, the IT industry (DTI, 2005).

Cultural norms also make it difficult for men and women to take-up formal opportunities for family-friendly working policies (see for example, Brown, 1995; Devine, 1992; Elvitigala et al., 2006; Etzkowitz et al., 2000; Moore et al., 2005; Webster, 2005). Work-life balance policies and practices have the potential to enhance opportunities for men to be more involved in caring responsibilities, but these are often undermined by workplace cultures (Lewis, 2001). Respondents in Cross and Linehan's (2006) study of the high-tech sector also believed that the existence of such policies were very much viewed as a 'women's issue' (see also, Bagilhole, 2006). Many women perceive that to take up such policies would put them at a distinct disadvantage in comparison to their male colleagues, who rarely use such opportunities (Cross and Linehan, 2006). Thus, while most organisations, particularly the larger ones, have now adopted Equal Opportunities policies and diversity management strategies, these have had limited affect on employee behaviour or the persistent masculine cultures, which value total availability and commitment from employees. This highlights that top-down, policy-orientated approaches must be

accompanied by bottom-up approaches if they are to challenge the unspoken rules of SET cultures.

Gendered Discourses

A key cultural aspect of the ideology of the masculine sciences is expressed through language. Woodfield (2000) has suggested that the language used in IT is intrinsic to its cultures, consisting of technical jargon and aggressive terminology which alienates and excludes many women. Grundy (1996) describes widespread use of sex-biased language, e.g. using 'he' rather than 'he or she'. This is regularly done when jobs of high status are talked about. Faulkner (2006) also suggests that use of the 'generic he' to refer to engineers means that women engineers are both invisible and a non-entity (see for example, Frehill, 1997; McIlwee and Robinson, 1992). McIlwee and Robinson (1992) suggest that this behaviour can be considered a form of sexual harassment, undermining women's professional status and reinforcing men's views of women as merely sexual beings.

Grundy (1996), in her study of an ICT organisation, found that women were excluded from discussions about the operation of business by men, which effectively gave men a sense of dominance over women. While Grundy indicates that men assert their dominance through talking loudly, she also found that where there was an obvious benefit in gaining some information, men would conversely talk quietly. She suggests that men's volume and tone of voice, along with selection of the topic, all function to keep women in their place. Grundy also found that men maintained their dominant position by talking about non-work issues that are perceived to be appropriate for men (and not women), such as cars, drinking and sport (see also Faulkner, 2006 for evidence of this in engineering). When women stated their objections to the noise and conversational norms, they were found to be at fault. In addition, Grundy found that women were rarely heard discussing personal issues, such as family or childcare, and when they did, the so-called women's topics were a source of amusement to the dominant men. Adam et al. (2005) found that the nature of men's talk in IT could be isolating for women, with men often excluding women from conversation or discussing the women in their lives in a derogatory way. Men's conversational discourses in the workplace and the social sphere are dependent on the exclusion of women, thus social life is important because it is another context in which this power game is continued. Conversely, Faulkner (2005) suggests that the non-work conversations she witnessed in engineering companies were wide-ranging and inclusive, even where there were few women, although she does acknowledge that the more diverse a workplace, the more wide-ranging conversation topics are. Faulkner (2005) maintains that while many would probably argue the issues described above are 'only words', they send powerful subliminal messages to both women and men about gender norms and power within the organisation.

The issue of language in SET is particularly emphasised in research that discusses the use of humour and sexualised banter. Numerous research studies have addressed the teasing and joking faced by women in SET (see for example, Carter and Kirkup, 1990; Faulkner, 2005; McIlwee and Robinson, 1992; Powell et al., 2009; Womeng Consortium, 2006). Furthermore, such research exposes that women 'feel they can handle it,' and claim to see it as 'all in fun' (for example, Faulkner, 2001; Griffiths et al., 2006; Henwood, 1996). Most had learnt strategies to handle these situations in a way that they felt retained their professional dignity, without being seen as difficult or humourless, but in a few instances they felt defensive or even threatened. Whilst Faulkner (2006) points out that both men and women engineers can feel discomfort with 'dirty' humour, such behaviour is generally something that men do not have to deal with. Furthermore, men and women are deterred from challenging offensive humour by the perceived risk of alienating themselves from their male colleagues and, as a result, will often join in regardless (Faulkner, 2005, 2006). However, Faulkner (2005) also witnessed engineers 'self-policing' and women challenging others for being potentially offensive.

Nevertheless, research suggests such humour is a strategy to reinforce the 'in' and the 'out' group characteristics (Watts, 2007) and a way of reinforcing the boundary between engineers (the adept) and non-engineers (the inept) (Frehill, 1997). When ineptness is equated with women, a boundary between engineers (men) and women is emphasised. Holmes (2000) also suggests that humour is a means of embedding risky or unacceptable behaviour in superficially harmless statements, thus allowing the dominant figure to maintain authority while continuing to appear friendly. This factor may account for women's documented acceptance of workplace humour in SET. While this research is useful in developing an understanding of SET cultures and the importance of language in creating and reinforcing culture, the focus has generally been on the negative impact of language and humour on women. The research in this area rarely considers how women may use language and humour themselves in a more positive way, to subvert the power structures within which they work.

It is important to highlight and discuss the different types of barriers that women face in entering and progressing in SET, and research in the field has been able to uncover and analyse the different ways in which formal and informal structures in organisations can negatively impact on women. There are some issues with a focus on these aspects, not least in asserting how they may or may not impact on women differently from men in the organisation. For example, we can argue that work-life balance issues impact on men too, particularly as work is traditionally a key element of male identity. It could be argued that it is even more crucial for men in employment to demonstrate the primacy of work over family life as this is what is expected of them. So we can see that this barrier to women also has a major impact on all in these organisations. Similarly, the boys club, whilst automatically excluding women, can offer

problematic experiences for men who operate outside of the dominant masculine norms of the organisation; not all men are comfortable members of the boys club. So we can see that a simple identification of barriers for women in SET can gloss over similarities between all (both men and women), but also ignore how these issues are differentially experienced by women themselves; for example, how does class or ethnicity amplify or diminish these aspects?

ASSIMILATION OF WOMEN IN SET

Much of the research on women in SET has found that women develop various strategies to survive, which often involve adapting to male dominated cultures, rather than trying to change or challenge them (see for example, Evetts, 1996; Miller, 2002; Powell et al., 2009). This is commonly referred to in the literature as women's assimilation or socialisation into the SET workforce. Dryburgh (1999) argues that assimilation is a process of professionalisation by women and men, which requires adaptation to the professional cultures, values, norms and symbols, internalisation of the professional identity and solidarity with others in the profession. Faulkner (2006: 4) suggests that in 'learning the job', engineers are socialised into the occupation and the company in which they work, 'they must learn to be (or behave as) particular kinds of people'.

For women, the success of cultural adaptation, is also tied to the management of gender (Faulkner, 2009). Kanter (1977), for example, describes assimilation as the way in which dominants distort the characteristics and behaviour of tokens to fit their stereotyped images of how token women should behave. Numerous research studies indicate that women who seek entry into cultures dominated by men either have to act like men in order to be successful (becoming 'one of the boys'), leave if they are not adaptable to the cultures, or remain in the industry risking isolation and exclusion and often accepting positions of lower status (see for example, Bagilhole, 2002; Bennett et al., 1999; Whittock, 2002). Miller (2002) found that Canadian women engineers conformed to beliefs and values consistent with a masculine value system. Accepting traditionally masculine values was seen to be key to success both in engineering and in their organisations. In Grey and Healy's (2004) research with IT workers, respondents described gendered initiation rituals, where women's skills are put to the test by men colleagues. Powell et al. (2006) suggest that adopting an 'anti-woman' approach is a further way of dis-identifying with one's own sex, and arguably a strategy adopted in order to succeed in the workplace. In some instances this may result in a reluctance to associate with other women, coined by Sinclair (2005) as 'Queen Bee' syndrome. Sinclair suggests this is because 'these women enjoy the company of men, share interests and aspirations that are typically characterised as masculine, and perhaps seek their approval' (2005: 139) and acknowledge that to succeed in their chosen profession relies upon clear allegiances with male colleagues and identification with the masculine values of the job.

While evidence suggests socialisation into the professions occurs for men as well as women, assimilation is gendered because, as Miller (2002) argues, although women can learn masculine rules and behaviours, they cannot directly mirror them. Thus, while the coping strategies adopted by women may be extremely successful on a short term, individual basis, they serve to reinforce the gendered system, leaving little hope for long-term change (Miller, 2002). Faulkner (2005) argues that the occupational cultures communicate a clear way of 'becoming and belonging' as an engineer that often brings to the fore the question of gender authenticity that hangs over women engineers. In particular, research in this field suggests assimilation fails to question the status quo. Career success among assimilated women is unlikely to promote the interests of women in the sector generally (Greed, 2000). It also raises questions about the concept of a 'critical mass': the idea that once there is a sufficient proportion of women in engineering, the traditionally masculine cultures will no longer prevail. As Sinclair points out, by the time women achieve positions of formal power, they have learned and share similar influencing strategies to their men colleagues: 'they have become enculturated' (2005: 110) and have been successful *because* of their acceptance of the masculine norms of the profession.

There are a number of problems with this discourse, not least the fact that, for women working in SET, there is often 'an unawareness of the masculine nature of the context' (Miller, 2002: 157). This approach has a tendency to situate women as part of the problem, suggesting that women employed in SET are failing to challenge the status quo, albeit for understandable reasons. It also places pressure on these women to act as ambassadors for women in SET, a burden that men in SET do not have to endure. Women in SET reportedly assert that their individual identity, rather than their gender identity, carries most influence, citing personal failings, rather than structural inequalities when describing workplace problems (see for example, Adam et al., 2005; Carter and Kirkup, 1990; Dainty et al., 2000; French, 2005; Henwood, 1996; Jorgenson, 2002; Powell et al., 2009; Walker, 2001). Older generations of women working in SET, however, do appear to have greater awareness of the impact of their gender, as they realise that 'the playing field is not level after all and that they [have] paid a high price both personally and professionally' (MIT, 1999: 9). This does, however, raise questions about the appropriateness of particular research methods and enquiry, with Jorgenson (2002) questioning whether gender is the 'most valid frame of inquiry into how workers define themselves or orient toward others' (2002: 351), the appropriateness of imposing researchers' assumptions onto data in which gender may not be relevant (Stokoe, 2006; see also Ochs, 2003 and Weatherall, 2000) and whether other research methods – such as ethnomethodology, identifying 'gender' in everyday conversation (see for example, Stokoe, 2006) – may be more useful.

THE BUSINESS CASE FOR CHANGE

The final theme identified in SET research is the use of the business case to promote the commercial benefits of employing women in SET (see for example, Bagilhole, 1997; Dainty et al., 2004; Hewlett et al., 2008; Phipps, 2008). Key proponents of the business case include the UKRC, the British Science Association, The Royal Academy of Engineering and the Engineering Technology Board, amongst others. The advantages of a diverse workforce are purported to include tackling industry skills shortages, increased profitability and inward investment; increased effectiveness and customer satisfaction; reduced likelihood of litigation; reduced staff turnover and recruitment/training costs; reduced loss of corporate knowledge/intellectual capital; more motivated, committed and productive workforce; and, reduced absenteeism (UKRC, 2005). While these benefits are not disputed, over-emphasis on this perspective fails to uphold the ideal of social justice, equality and inclusivity for all (Noon, 2007). In particular, the business case implies that 'women are perhaps the 'last resort' – a suggestion that if some other source were available, WISE (Women into Science, Engineering and Construction) would not be needed' (Henwood, 1996: 200). Thus it is argued that it is the skills shortage, rather than the development of an inclusive approach, that has led more women into SET professions (Devine, 1992; Fielding and Glover, 1999).

This is important, as this climate clearly places the onus on women to fit into the existing, traditionally masculine cultures of organisations that are employing them out of necessity, rather than a real desire for change. The business case is primarily promoted in policy documents and literature aimed at government and industry practitioners, which may reflect the corresponding power of this approach. Understandably, it is economic benefits, rather than equality per se, that are seen to provide the most convincing argument for those not already 'on board' with the equality agenda. Yet, while it is important to engage business in the equality agenda, it is also necessary to promote a discourse of social justice within the sector. It is argued that it is problematic to sell diversity discourses to the business community, which can leave women vulnerable to political and socio-economic shifts (Griffiths et al., 2006). Etzkowitz et al. (2000), for example, suggest that economic conditions can impact on women's entry and retention in science. They suggest that barriers to entry in both industry and academia are most readily removed in periods of economic prosperity and expansion, and prove more difficult to shift in times of recession. They cite the US, Finland and Portugal as areas where the proportion of women in research and development positions increased post World War Two. However, during periods of increased competition, discriminatory attitudes and behaviours can re-surface. Therefore, while the business case has made some progress in changing employer perceptions, the use of a business argument alone is problematic. Research has found that women are only too aware of the preference for men employees by SET organisations (Devine, 1992), which leads to women questioning the good intent of equal opportunities policies that do

exist and what this means for their presence in SET professions dominated by men.

RECOMMENDATIONS FOR CULTURAL CHANGE AND FUTURE RESEARCH

This paper has set out to provide a critique of research on women professionals in SET and potential solutions to redress the balance of women in SET. It has analysed the development of this research through four thematic approaches, including essentialist constructions of science and gender; barriers facing women professionals in SET; the assimilation of women in SET; and the business case for change. However, these approaches are not necessarily exclusive, and existing research has often adopted multiple approaches. The wide-ranging focus of some research discussed above across these themes may actually undermine a clear theoretic base for empirical research. What are the assumptions? What is being tested? How does research challenge, rather than reinforce, gendered notions of men and women in SET?

A critique of current approaches can be summarised as: much research emphasises differences between men and women and therefore ignores similarities and potential arenas for positive solutions for all, using 'women' as a unit of analysis thus giving precedence to difference and homogenising women's experiences; focusing on individuals rather than organisations; a focus on stereotypes and the roles these play in whether women enter into the profession and the type of roles they adopt; a maintenance of the associations between masculinity and technology; and, a tendency to situate women as part of the problem. As discussed above, there are particular problems associated with the approaches described in this article that can do as much to reinforce the status quo as challenge it. Having identified some of the problems with these approaches that may have impacted on the success of initiatives aimed at supporting women in SET, recommendations for more effective future research are now offered.

It is critical that research on women in SET moves away from essentialist discourse and discourse that advocates 'us and them' differences between women and men. These discourses usually set out to develop an understanding of SET cultures, rather than providing practical solutions to the problems they identify. However, their approach often situates women as part of the problem and places unnecessary demands on women in SET to become ambassadors for all women. Future research in this area should therefore focus on developing practical and achievable policy solutions to tackle the issues identified.

Future research on women in SET needs to give greater voice to the views of the women being researched, some of whom are ambivalent or reject gendered explanations of their experiences. This may include acknowledging the positive aspects of working in SET, alongside the negative issues. It should also consider issues around the

conceptualization of gender, particularly in the design of research. Using innovative methods such as action research to actively engage the SET community in action and reflection may be more effective in addressing gender equity and creating positive change than traditional research methods (see for example, Reason and Bradbury, 2008). Research should also aim to adopt multi-faceted approaches, incorporating multiple stakeholder views (employers and employees), since it is clear that neither top-down nor bottom-up strategies for change are adequate by themselves. Similarly, where best practice has been identified, this needs to be properly evaluated using multiple perspectives, to identify what has really changed in organizations to improve gender equity and organizational cultures for women and how other organizations can emulate this in a practical way.

Greater attention should also be paid to those countries where women are numerically better represented and achieve higher levels of success in SET. Such research must, however, recognise the social, economic and political conditions which are critical to national context and may veil inequalities faced by women despite higher numerical representation (see for example Hossain and Kusakabe, 2005; Zengin-Arslan, 2002; Canel et al., 2000; Chatzis and Nicolaidis, 2000). Nevertheless, it is likely that lessons can be learnt from non-Western societies in terms of alternative methodologies, theoretical innovation and examples of cultural change.

Finally it is equally important that research considers the views of men, as well as women, to ensure that equality is not just a 'women's issue', as it is naïve to consider that traditionally masculine cultures are only problematic for women. Furthermore, as the majority in the SET workforce, it is crucial that men are engaged with the equality agenda in order to instigate real cultural change.

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