BRUSSELS ECONOMIC REVIEW - CAHIERS ECONOMIQUES DE BRUXELLES VOL. 54 (2/3)
SUMMER - AUTUMN 2011

CHANGING THE LANDSCAPE OF WOMEN IN SCIENCE, ENGINEERING AND TECHNOLOGY: THE EXPERIENCE OF THE UK

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ABSTRACT:

This paper presents the results of an evaluation of the UK Resource Centre for Women in Science, Engineering and Technology (UKRC). It discusses the UKRC's holistic approach to the issue of women's under-representation in science, engineering and technology (SET), and provides examples of its consequent activities. The UKRC's key achievements have been, first, in advancing this holistic framework, which has underpinned its work with educators, employers, and other organisations, and, second, in supporting cultural change within educational institutions and employing organisations. Its achievements clarify the possibilities and difficulties inherent in advancing women in SET through different national-level initiatives, and over the longer term.

KEYWORDS: Women's Under-Representation in SET; Policy Initiatives; Practical Measures; Evaluation

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INTRODUCTION

For thirty years, the UK has been attempting to improve the participation of its women in science, engineering and technology (SET) education and employment. If the statistical picture of women's presence in these areas is taken as the measure of success of these initiatives, they have plainly failed to achieve any improvements. Despite a wealth of different interventions at different levels in the UK, the trend in women's presence in SET education and employment has been steadily downward over the last decade.

In 2004, when central government finally acknowledged and committed itself to act on the persistent problem of women's under-representation in SET, it established the UK Resource Centre for Women in Science, Engineering and Technology (UKRC) to serve as the key institution working on the problem for government. With a substantial remit and significant central government funding, the UKRC developed interventions in many areas: in education and higher education, with employers, with women SET professionals, with professional associations, and with NGOs and campaigning organisations in this field. This was much better resourced and more comprehensive than the disparate initiatives that were pursued during the 1980s and 1990s, but it still appears to have made little difference to the numerical picture of women's participation in SET education and employment. There is clearly an obvious need for an examination of how such interventions are designed and implemented, whether and how they work, and whether they are transferable between different national, sectoral or organisational settings.

After its first funding phase, the UKRC commissioned a comprehensive evaluation of its activities, processes and practices. The purpose of the evaluation was to take stock of the successes and failures of the Centre, to assess the efficacy of its internal processes, and to make recommendations for its next phase of work. The evaluation covered particular areas of the Centre's work with different 'stakeholders', examined its activities in detail, and reviewed the effectiveness of these activities in both quantitative and qualitative terms: how many women were helped into SET education or employment, how the practices and culture of SET employers or other organisations were changed, and how the development and implementation of SET policies were influenced through the UKRC's work.

This paper discusses the findings of the evaluation on the design, delivery and efficacy of the different interventions of the UKRC. It describes the UKRC's holistic conceptual approach to the problem of women's under-representation in SET, with its emphasis on the interconnectedness of the different problem areas. It shows how this approach has influenced the ambitions and coverage of the UKRC's interventions. The paper then reviews examples of the UKRC's activities and assesses their achievements in moving women into SET or in altering the practices and policies of SET employers and organisations.

The paper concludes that the UKRC's most significant achievements have not been in directly increasing the numbers of women participating in SET education or employment. Instead, it has been effective in two more indirect ways. First, it has developed a holistic understanding of the scarcity of women in SET, which moves

beyond the 'leaky pipeline' approach and has informed its approach to SET educators, employers, and other organisations. Second, it has promoted and supported cultural change within educational institutions and employing organisations. These insights help us to understand some of the possibilities and difficulties inherent in changing the women in SET landscape. They may also provide a benchmark against which to assess different national-level initiatives, and support an assessment of the options for sustaining such initiatives over the longer term.

1. UK PUBLIC POLICY IN SET

In the early days of the information and communication technology (ICT) 'revolution', the 1980s, the British government was preoccupied with economic competitiveness. The key policy problematic was the issue of using new technologies to maximise the innovative and competitive potential of the UK economy. As a result, the main public priorities were to identify particular forms of technological activity or promising sectors, and support their growth. Science and technology policy at national level therefore focussed on maximising the capacity for technological innovation in the UK, on anticipating technological 'winners' for further development through technology foresight, and with promoting the diffusion and use of new ICTs across social groups and institutions. The project of promoting the knowledge-driven economy did not, however, extend to a concern with the human resources issues of the science, engineering and technology (SET) sectors; for example, improving participation or equalities in SET sectors and professions.

PUBLIC POLICY AWARENESS OF GENDER INEQUALITY

In the twenty years that followed the beginnings of the ICT revolution, there was a striking gender-blindness in UK national public policy. A series of policy papers (for example, the 1993 White Paper, *Realising Our Potential*, and the 1998 White Paper, *Our Competitive Future*) highlighted the importance of science and technology for the country's economic growth, but did not address the social arrangements within which science and technologies are developed and used. There was little or no awareness of the issues and obstacles which served to discourage or exclude women from engaging in ICT education or professional work. This blindness to the social, and particularly the gender, dimensions of the knowledge-based society persisted, despite the insights offered by a ten-year national programme of social research, the Programme on Information and Communication Technologies (PICT), which was funded by the national social science research council, the Economic and Social Research Council (ESRC), ran from 1985 to 1995, and was concerned with the social context, social dimensions and social policy implications of scientific and technological change.

By 1994, an imminent shortage of SET skills was starting to be recognised as a growing problem. The publication of a report by the Committee on Women in Science, Engineering and Technology, entitled *The Rising Tide*, stated that women were under-represented, under-used and under-valued in the knowledge-based

sectors of science and technology, particularly information technology, and made a series of recommendations to address this situation. However, at this stage, public policy continued to focus on promoting demand for ICT products: developing educated consumers of digital products and services, and developing innovative IT, electronics and communications supply sectors. Skills development for employment and promoting opportunities for all in SET areas were not national policy priorities.

However, the absence of women from SET was recognised elsewhere in the public sphere, and particularly in the private sector which was beginning to experience skills shortages. In the public sector, local authorities, professional associations, training organisations and academic institutions were the first organisations to take steps to deal with the low levels of female participation in SET. For varied reasons, usually connected to the need to augment the availability of skills, many of these organisations began to initiate campaigns to encourage women to enter science, engineering and technical education, training and employment. Examples of some of these initiatives are shown in Table 1. All of these campaigns had different organisational origins, and slightly different objectives, though their target groups were generally women and girls.

TABLE 1. EXAMPLES OF UK PUBLIC POLICY INTERVENTIONS TO IMPROVE GENDER BALANCE IN SET

Intervention name	Organisation	Objective of intervention	Target Group
Women into Science and Engineering (WISE)	Equal Opportunities Commission/ Engineering Council	To raise awareness of SET career options	Women
Women in Computing (WIC)	Academic institutions and professionals	To exchange knowledge through conferences	Academics
Web Wise Women	Training & Employment Agency of Northern Ireland	To train women in the skills and confidence necessary for a job in IT	Women returners
Take your daughters to work day	Leeds City Council IT Department	To encourage girls to consider IT careers by introducing them to the work	Girls
All-girl computer clubs in schools	eSkills National Training Organisation	To persuade more young women to take up IT careers	Girls

Source: adapted from data in D'Ouville and Collet 2004

These were the first attempts to address the gender imbalance in SET, and they were important correctives to the lack of national-level activity. However, these campaigns had several serious limitations which reduced their potential effectiveness. First, because they were fragmented, they lacked strategic coherence and a clear overview of their own effectiveness. So there was considerable duplication of effort in relation to the occupational areas and SET activities they covered. Second, as awareness campaigns, targeted at women and girls, they framed the problem as a lack of women's awareness of the possibilities open to them. Because these measures were aimed principally at plugging skills gaps, their ambitions were restricted to bringing more women into scientific and technological work, but did not address the conditions of the work, the nature of scientific or technical education and its delivery, or the wider social factors which inhibit women's entry to SET in the first place.

In terms of Rees's (1998) typology of equalities measures, the awareness-raising interventions of the 1980s and 1990s fell into the 'tinkering' category, focussing principally on the equal treatment of women and men but leaving alone the basic social relations within which technical work is constructed and performed. Henwood (1993) has criticised this type of approach for failing to address the culture of work in SET, and for overlooking the possibility that because of this, women themselves might make active decisions not to enter it. A review of the 'good practice' measures that were designed to attract women into SET work in five other European countries, and that were similarly limited in scope or short-term, found that only a small minority had any effect and that this effect was limited (D'Ouville and Collet 2004). In the UK, by 2000, the picture remained much the same as it had since the lack of women's representation in SET was first noticed in the early 1980s.

THE ESTABLISHMENT OF THE UKRC

By the early years of this century, there were approximately seventy organisations dedicated to increasing the participation of women in SET in the UK, including committees in professional societies, regional and national membership networks, initiatives and schemes funded by the public and private sectors. The lack of government strategy, and the plurality of different players created real problems for the delivery of their objectives: there was a lack of infrastructure, low levels of resources (in terms of both money and time), duplication of effort and often a lack of effectiveness.

The *SET Fair* Report, prepared for the UK Department of Trade and Industry by Professor Susan Greenfield in 2002, was the first instance of clear national government recognition and commitment to the problem of the gender imbalance in scientific and technical work (Greenfield 2002). Greenfield's report argued that the factors inhibiting women's entry to and retention in SET professions are complex, inter-related and very fundamental in nature, and it called for a joined-up and strategic policy approach to the problem which would draw together the disparate activities undertaken to date and co-ordinate them in a coherent and sustained way. It also questioned the effectiveness of previous efforts and of the disparate

organisations which were active in this field, all operating separately. Consequently, it advocated the establishment of a UK-wide institution to initiate, co-ordinate and support activities. The Government's response document, *A Strategy for Women in Science, Engineering and Technology* made provision for the establishment of this centre.

In 2004 the UK Government published its ten-year Science and Innovation Investment Framework, setting out a long-term vision for UK science and innovation, which included the objective that public and private investment in research and development was to reach 2.5 per cent of GDP by 2014. The establishment of the UKRC was part of this new policy approach. The Centre was established following a tendering process to the UK Department of Trade and Industry (now the Department for Innovation, Universities and Skills). The contract was won by a team based at Bradford College in Yorkshire, which established centres based in Scotland and Wales, and regional centres (called 'hubs') in the South East, and Yorkshire and Humber regions of the UK.

As this was a landmark attempt to address the women in SET problem in a comprehensive way, not only in the UK but Europe-wide, a review of its approach, its activities and its effectiveness in remedying the gender imbalance in SET is both timely and important. In 2006, the UKRC commissioned an internal evaluation of its structures and activities (Scott and Webster 2007). This included interviews with key stakeholders within and outside the UKRC, as well as a two-phase survey of one of its key beneficiary groups, women returners to SET. This paper draws on some of the material gathered in the course of that evaluation, as well as evidence from a similar exercise carried out by the Tavistock Institute for the Department of Innovation, Universities and Skills (DIUS) which has been the source of a significant proportion of the UKRC's funds. These unpublished, and other published materials discussed in this paper, show the distinctiveness of the UKRC's approach, the comprehensiveness of its activities, and the nature of its achievements. They suggest that these are particularly evident, first, in supporting cultural change in the SET employment sphere, and, second, in offering a corrective to the 'leaky pipeline' framework for action to redress gender inequality in SET.

2. THE UKRC APPROACH TO THE WOMEN IN SET PROBLEM

The contract for the establishment and running of the UKRC was won by feminist activists whose framework for change departed from that of most previous interventions, in the sense that it was not based on the central premise that women's enduring absence from SET was primarily a matter of women being unaware of the SET career options available to them. Rather, their overall approach drew on the tradition of socialist feminist scholarship which highlights the structural and institutional arrangements, and the entrenched gendered culture, of SET education and employment, and identifies the ways in which these combined structures and cultures act as obstacles to women entering SET. Rather than locating the problem solely in the supply side of SET labour - women's lack of awareness of potential SET careers - this perspective emphasises the ways in which the demand side operates in setting the conditions and culture of SET education and employment.

Many women actively and knowingly reject SET pathways because they are only too aware of these conditions (while others actively embrace SET work because they are comfortable with the gender culture of SET work). Structural barriers operate to prevent women from entering and remaining in SET work, in the formation and maintenance of gender stereotypes, the organisation and delivery of education, the organisation of work, and the accreditation and recognition of skills (Harding 1986; Kirkup and Keller 1992; Addis and Brouns 2004; Wajcman 2004; European Commission 2005). In other words, changing the gender balance of SET is not simply a question of adding more women but also of changing the institutional and organisational arrangements of SET education and employment.

The UKRC's framework for change was therefore different from that of other initiatives; it emphasised the need to address the social structures and gender cultures of SET, whilst at the same time implementing programmes to support individual women entering or returning to SET. The overall approach is expressed in the stated core values of the UKRC:

> … there has to be a change in the organisation and culture of SET learning and work environments. This includes changes in the institutional systems, processes and structures ...[Women] are often limited in their choice of career and the position they reach by external barriers that inhibit their true potential. Positive action […] is therefore an integral part of the approach as a tool for giving women improved access to careers in SET (quoted in Cullen, Junge and Ramsden 2008: 15).

The implication of this approach is that, to be effective in attacking the complex structural and cultural factors inhibiting women's participation in SET education and employment in numerous ways, a suite of interventions is needed to address issues at different stages of education, in different SET sectors, in different types of employment, and with different institutional and organisational stakeholders. The UKRC's particular approach to this issue was to establish a model for change which was holistic, to guide both the Centre's interpretation of the situation of women in SET and its activities. The model focuses on eight areas of intervention (Cullen, Junge and Ramsden 2008: 16):

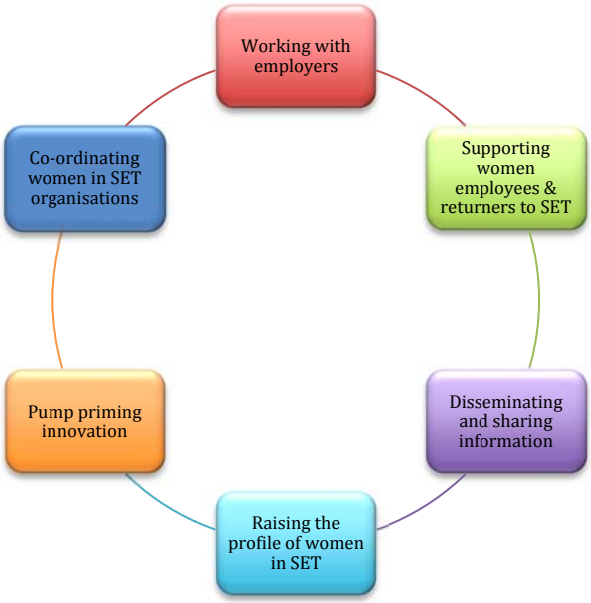
- Gender stereotyping and self-stereotyping by girls and women
- Family, friends and the media reinforcement of stereotyping
- School, options, qualifications
- Careers education and advice
- Education and training environments and pedagogy
- Employment policies and practices
- Professional institutes, membership bodies, networks
- Government legislation and policy.

These areas of intervention are treated as interconnected. The UKRC model "recognises the complex barriers and the shared responsibility for overcoming occupational segregation" (UKRC n.d.). It is not sufficient to address one area alone, and an intervention in one of these has to be complemented and supported by interventions in other areas. The UKRC's philosophy is that tackling gender

stereotyping of girls in schools alone is not likely to be effective if the overall role of the media and wider social institutions are not also addressed. So interventions in different areas, and by different actors, are necessary in order to dismantle these complex barriers.

This holistic model influenced, first, the selection of organisational and institutional stakeholders with whom the UKRC proposed to work, and, second, the design and implementation of its activity areas. As far as stakeholders and user organisations are concerned, the UKRC elected to target key sectors and organisations in the SET landscape: schools, further and higher education and training providers, employers, professional associations, the media and communicators, and policy makers. As far as the design of its activities was concerned, they are cross-disciplinary and cross-sectoral, they operate across both the demand and the supply side of the labour market, and they operate across both practice and policy. Figure 1 shows the core objectives of the UKRC which framed its activity areas:

FIGURE 1. CORE OBJECTIVES OF THE UKRC



Source: adapted from Scott and Webster 2007: 3-4.

3. THE ACHIEVEMENTS OF THE UKRC

In the analysis of UKRC activities and achievements that follows, I take the examples of two service areas - services for employers and services for returners to

SET - in order to consider the achievements of the UKRC. Within each area of work, the UKRC established a suite of activities and services, some offered in-house or through its regional hubs, some in partnership with external organisations (professional associations, universities and NGOs, for example), some effectively 'sub-contracted' to other women in SET organisations in the UK, for which the Centre was given the remit for overall co-ordination.

UKRC SERVICES FOR EMPLOYERS

The UKRC's work with employers was developed around a comprehensive set of services and activities, centring on advice and guidance, awards and recognition schemes:

- A cultural analysis tool for employers to assess their internal equality cultures
- Good practice guides
- Gender equality training
- Employer liaison
- A recognition scheme and 'Kite Mark' for good quality SET employers
- A UKRC Award for Diversity and Inclusion

Employers approach the UKRC for assistance in improving recruitment, retention and progression of women in their organisations, and to gain access to examples of good practice. They do so because they have broader strategic objectives of improving their organisational cultures, or becoming an employer of choice (Scott and Webster 2007). Do the UKRC's services lead to positive change in these organisations?

In the evaluation of UKRC activities and services (Scott and Webster 2007), we conducted three qualitative case studies of employers using UKRC services, in order to collect information on the ways in which UKRC interventions helped to create and support changes in their organisational practices designed to promote the employment, progression and retention of women in SET.

Organisation A used the UKRC's Cultural Analysis Tool (CAT), following which it made three key changes: first, it modified its recruitment practices, second, it introduced gender awareness training and engineering apprentice mentoring, and, third, it established a benchmarking group. Its recruitment procedures were altered to encourage women to apply for an annual apprenticeship scheme. (The organisation had never before received an apprenticeship application from a woman.) Advertisements and job descriptions were also redesigned on the basis of UKRC advice, employing positive imaging and gender-neutral language. Following this, 40 out of 1600 applications were received from women. However, of the 15 apprentices appointed, only one was a woman, though the organisation declared its intention to take on four new female apprentices the following year.

Gender awareness training was regularly provided to managers, union stewards and other workers. Among other things, training workshops supported these employees in the formation of local action plans. Staff reported that gender-awareness training

improved acceptance among existing employees of the presence of technically trained women. At the time of the evaluation, the organisation was planning to have 'apprentice mentors' provided with formal training in how to support new intakes of both female and male apprentices. A benchmarking group was also established to identify best practice across the engineering sector and to consider how to target potential female recruits.

Organisation B commissioned the UKRC to conduct a series of focus groups involving male and female procurement staff. These staff raised concerns about working conditions and working arrangements. Issues included the fact that part-time working was a barrier to career progression, that there were insufficient opportunities for home-working, and that the maternity leave package needed improvement. The company valued the face-to-face nature of the service offered by the Centre; it was thought to achieve fuller employee engagement and disclosure of their attitudes and perceptions.

The outcome of this exercise was the establishment of a Diversity Council, with an explicit remit to examine and address diversity-related issues within this department. This body was made up of a mixture of women and men, staff of different ethnic groups, and managers and non-managers. Its purpose was to take the concerns of employees and examine options for action. Its particular achievement was to improve their experience of working within the organisation, and in particular to make women engineers feel less isolated and marginalised, both as engineers and as women (see also Faulkner 2007).

Organisation C, an engineering skills regulator, used the UKRC's Cultural Analysis Tool, following which it implemented several measures to improve gender equality. These included:

- gender-awareness training workshops for internal staff, employers in the sector and training colleges,
- a review and modernisation of flexible working and maternity leave policies,
- creation of a 'dignity and mutual respect' policy, to reduce harassment and bullying, and
- establishment of a Careers and Diversity Interest Group among member trade associations and employers; the Group then developed a diversity action plan.

These three case studies, and the accompanying survey which was conducted among employers as part of the evaluation of UKRC services, all suggested that the main benefits of the UKRC's services in this area were cultural rather than calculable. Specifically, in different ways, the availability and provision of employer services and advice helped to raise awareness of the need for gender equality and develop in employers and staff alike the expertise needed to analyse their organisations. The CAT, for example, was designed to be used by staff as well as managers in order to uncover their perceptions of the gendered practices and gender relations of their employing organisation, and the process of completing the CAT survey was treated as an important awareness-raising device.

Moreover, these services provided employers with the tools and techniques they

needed to identify problem issues and develop plans for action themselves, even if they could not make immediate or radical changes in their organisational arrangements. One employer noted that using the CAT had "started a conversation", meaning that it acted as a primary stimulus for developing a gradual appreciation among skilled staff and union representatives of the case for equality in recruitment, and helped the organisation foster a commitment to this objective. A cultural shift in attitude against sexual harassment was also apparent. This is highly significant in the construction sector where sexual harassment has long been sanctioned.

The impact of the UKRC's work on the numbers of women entering SET occupations and careers is much harder to assess. The difficulties involved in creating last numerical change were aptly summarised by an employer interviewed during our evaluation of the UKRC:

> I think there's been some impact, but it's been very small in terms of numbers ... We've had many, many years of this type of stereotyping, and it is a huge cultural change we're looking at here. The elephant is so large it'll be several lifetimes before we see any real difference.

In the light of this and similar statements, together with the basic statistical evidence we received from employers, our evaluation concluded that the UKRC's main value for SET employers was primarily in raising awareness of the need for equality and in supporting organisations in their equality initiatives. It was much less successful in increasing the numbers of women recruited, retained or promoted in the SET workforce. In its subsequent evaluation of the UKRC's activities for the Department of Innovation, Universities and Skills (DIUS), the Tavistock Institute reached the same conclusion:

> It is clear that at an individual employer level, engagement with UKRC has made a difference, though this is not yet necessarily translated into the recruitment of a large number of women in the workforce (Cullen, Junge and Ramsden 2008: 84).

UKRC SERVICES FOR EMPLOYEES AND RETURNERS TO SET

UKRC services for women employees and SET returners are also comprehensive and interconnected. They are designed to dovetail with one another through a returner's job search process, effectively addressing each stage of the process with specialist services. Services for returners include:

- The provision of an online course delivered through the Open University which provides returners with job seeking skills in ICT
- CV support and review
- Mentoring support and peer mentoring support
- Networking events
- Placement services to employers through an industrial placement service
- One-to-one support and career advice

The package of returner services, known generically as 'Return' and centring on the Open University course, aim to support women through the transition period from career break to re-employment. The course includes practical help and advice, but is also designed to give women the time and space to review their lives and reflect on their experiences, and the implications of these for their forward planning (Herman 2006; Dale, Ellis and Jackson 2007). The Open University course is the lynchpin of the UKRC Return services. It is the single most used service, and from it course students are directed into other Return services (placement services, one-to-one support and so on).

Not all UKRC Return service users find SET employment immediately after using these services. A full one-third of the 2007 cohort went on to further study or training, and a substantial minority, 6.7%, went into other, non-SET, areas of employment. However, many women returners pointed to the indirect benefits which they derived from using these services, benefits which can be summarised under the rubric of 'employability gains'.

According to the accounts of service users themselves, the greatest indirect benefit of using the Return services was the increased self-confidence they attained (Webster 2007; Herman and Webster 2010). Lack of self-confidence is a problem for women returners to the labour market in general, and one that fundamentally inhibits them from applying for positions at the appropriate level of skill and seniority. Increasing returners' self-confidence is consequently a vital aspect of preparing them for self-sufficiency in job hunting. One SET returner commented:

> "I was considering going back into lab work ... I still haven't made up my mind whether to pursue this, but other opportunities have arisen through the returners' service and I have found it has increased my self-confidence and helped me to focus on the positive steps I can make to find satisfying employment" (Quoted in Webster 2007: 35-36).

Increases in other important practical job-seeking skills (CV writing, career development planning, networking) and improved knowledge of job opportunities) were also widely reported. Different services delivered particular benefits; for example, the Open University course was considered particularly useful for helping participants improve their CV writing skills, career development planning and planning for work-life balance, while networking events were identified as services which particularly built their self-confidence, as well as their networking skills, of course. Developing skills and confidence is of course valuable, because it is sustainable and empowers women to take charge of their own job search over the long term.

Women returners also valued company visits, which provided them with a clearer picture of the contemporary labour market, the working conditions in major companies, and the potential career opportunities open to them. One returner remarked:

> "It was useful to see this kind of commercial operation and the resources and

> facilities available, since it was very different from my previous experience of university research departments" (Quoted in Scott and Webster 2007: 32).

Transmitting information about the job market is a simple but essential intervention with clear, if indirect, benefits for SET returners. Improving their awareness about the conditions of the labour market, and the strategies they will need to circumvent the difficulties of access, means that the more they understand that there are widespread problems in SET job searching, the less they feel the need to personalise their difficulties in gaining SET employment, and to withdraw from the search. Another returner told us:

> "SET Return, [the Open University course] and being in contact with other women of my age, training and position has made me aware of the common problems faced by all of us. I have stopped blaming myself for lack of career success. Now I am more confident, more aware of the need to plan, and how the process of career change operates (how long it takes, the need to do some voluntary work to gain experience), and I have acquired greater confidence enabling me to do self-employed work" (Quoted in Scott and Webster 2007: 33).

The UKRC supplied a direct placement service to women SET returners, in addition to the Open University course, and the follow-up support services offered to its participants. Several large employers participated in this scheme, either offering a set number of places on training courses in key skills for women returners on an annual basis, or recruiting directly from the UKRC's pool of returners on a routine basis. The placement services were an important way of raising employers' (often poor) awareness of women returners as members of their available talent pool. Some came to see this service as a vital recruitment aid in a tight labour market. The placement service also influenced organisations' policies and practices in relation to the employment of women returners. Having hired several women returners through the scheme, one organisation began to revise its recruitment practices to provide for increased hiring of women returners, and it also established flexible working arrangements and crèche facilities. These kinds of practical changes by employers have considerable long-term potential to improve the opportunities for women returners to the SET sector.

Nevertheless, this service is very resource-intensive, requiring considerable one-to-one contact between the returner and the service provider. In the case of the UKRC scheme, relatively small numbers of women were actually placed in jobs. Although the scheme revealed considerable interest from employers in recruiting women returners, and in developing appropriate policies and practices to enable them to do so, it also showed that employers have very particular requirements which cannot always be met by women returners. Most want to be able to employ returners without them needing further training, and they only offer placements which have a clear business justification.

Women returners do not offer a similar 'talent pool' to that offered by graduates. Women returners to SET are generally less geographically mobile than other types of potential employees, and this limits their availability. Those with an established

career history tend to seek specific job opportunities which build on their earlier work, and are less likely to accept generalised placements or jobs. Some women express concerns that companies are not willing to be sufficiently flexible in their working arrangements, while others express concern that placements are not available at sufficiently senior levels for them. The result is that the number of placements which they can feasibly take up are limited. Furthermore, in the UK, placement opportunities are not evenly available throughout the country, but tend to be clustered where SET employers are predominantly located, mostly in the south east of England.

CONCLUSIONS

WHAT HAVE THESE INTERVENTIONS ACHIEVED?

Women remain stubbornly under-represented in SET courses and careers in the UK, despite thirty years of interventions, including those of the UKRC and many other organisations actively working on the issue today. The UKRC's own recent analysis of UK data shows that a man is six times more likely than a woman to work in a SET occupation, and that women make up just 12.3 per cent of those working in SET occupations (Kirkup et al, 2010). Although there has been a slight increase in women's representation in the five years between 2003 and 2008 (from 10.3 per cent), their participation levels remain terribly low and the gender gap in participation remains strikingly wide. In the light of this bleak assessment, can we point to any achievements that have been made in the women and SET landscape? Has anything at all changed in the SET labour market that might give grounds for optimism about the likelihood of improving gender equality in SET?

THE BEGINNINGS OF CULTURAL CHANGE IN SET EMPLOYMENT

Evidence from both our (Scott and Webster 2007) and Cullen, Junge and Ramsden's (2008) evaluation of the UKRC's work suggests that one of its major achievements has been in promoting, and creating, culture change in SET employment. Important though this is, it has not to date been possible to show any significant impact on the numbers of women working in SET occupations, or on their share of SET jobs in relation to men's share. First, both studies conclude that it is very difficult, if not impossible, to quantify cultural change, which cannot readily be translated into the recruitment or promotion of increased numbers of women in the SET workforce. Individual women are shown to have benefited from the services of the Centre, and there is considerable anecdotal evidence to this effect. Equally, individual employers report positive changes in their employment practices or diversity structures, which may have more discernible impacts on the presence of women in the longer-term. However, identifying the numerical impact of these measures beyond the level of the individual woman or workplace is far from straightforward. Cullen, Junge and Ramsden conclude that:

> … it is proving difficult if not impossible to come to any conclusive statement as to the impact of the organisation's activities on the

> participation of women in SET careers more generally (2008: 79).

Second, this is a social project that has only recently been addressed with both conceptual coherence and sustained resources, and it is an area in which the pace of social and cultural change is notoriously slow. It might seem as if the numbers of women working in SET are increasing at glacial pace, but in fact it is only in the last decade that serious practical attention has been devoted to challenging the entrenched masculine structure and culture of SET work, rather than focussing mainly on the deficient awareness of SET career possibilities held by women. Cultural change takes time and considerable effort to achieve, and in most organisations or societies there are substantial obstacles to its achievement. Existing organisational cultures, personal commitment and interpersonal dynamics within organisations are all decisive in determining the effectiveness of practical interventions. Conflicts of perspective, indifference, or outright hostility to equalities, all act as barriers or inhibitors to cultural change.

It may therefore be too soon for any intervention to have a discernible impact, and for this to be properly assessed. Just as long timescales are needed in order to achieve any enduring cultural change in organisations, so too, in society as a whole, this is a long-term endeavour, the outcomes of which are unlikely to be apparent for many years:

> This is a very long-term change process and the rate of change in the UK is extremely slow, regardless of the efforts of many different organisations, so given that UKRC has only been working in this field since 2005, I don't think that you can expect them to have had a quantifiable impact (Interviewee, quoted in Cullen, Junge and Ramsden 2008: 84).

IMPROVING ON THE 'LEAKY PIPELINE' MODEL TO ACHIEVE CHANGE

The importance of the UKRC's approach to changing the women in SET landscape should also not be underestimated. The 'holistic' model is very ambitious, a framework for action which is comprehensive in focus and implies engagement with a wide variety of sectors, institutions, organisations, and other stakeholders in the SET field: schools, education and training providers, employers, professional associations and institutions, and policy makers. Its emphasis on the need for structural changes throughout the SET landscape makes this model a far more transformative one than previous frameworks which have addressed only elements of the problem. Furthermore, its focus on the role of structures as a source of gender inequality provides a more realistic and nuanced picture of the myriad, complex and powerful obstacles to women's participation in SET education and careers. A continuing recognition of this complexity is likely to be vital if substantial improvements in the women in SET landscape are to be achieved and sustained.

The holistic approach taken by the UKRC has moved practical intervention well beyond the confines of the early awareness-raising initiatives undertaken by public policy bodies and by private sector employers to 'plug the leaky pipeline'. These initiatives focussed on the deficiencies of labour supply, and so were preoccupied

mainly with the problem of recruitment from a small talent pool. They were not concerned with confronting the structures and cultural practices in the sector, including those of employers, which create the conditions in which women engage with SET education and careers. This indeed is one of the major drawbacks of the leaky pipeline model, and for both conceptual and these practical reasons it has begun to invite sustained critique (Xie and Shauman 2003; Palmén, Webster and Castaño 2010).

Some of the achievements of the UKRC's interventions based on its distinctive holistic model are apparent from the accounts of women returners and employers given above. They can be summarised as improved employability among women returners to SET, and SET workplace arrangements which are becoming friendlier to women. If these achievements are to be consolidated and developed throughout the SET landscape, such that the holistic model can deliver wholesale change in women's participation in SET, several of the pre-conditions discussed in this paper are probably required.

First, substantial, long-term financial resources are required. As the single agency charged by the UK government with addressing the gender imbalance in SET, the UKRC had this level and extent of funding, but its funding was allocated for less than five years in the first instance, and the current Coalition Government has decided not renew it (Department for Business, Innovation and Skills 2010). The UKRC's ability to continue to deliver this coherent suite of services, with sustainable results, is certain to be heavily compromised as a result.

Second, long time-frames are needed in order to achieve serious transformations, and to assess them. Our evidence suggests that the achievement of both structural and cultural changes is a very slow process. Furthermore, in assessing the effectiveness of interventions, recognition has to be given to the distinction between numerical impact and cultural change. Cultural changes are hard to achieve and difficult to 'measure' in conventional terms, yet they are likely to be a vital precondition to bringing about sustainable increases in SET women. At the same time, however, a holistic model with a long timescale needs continual assessment, so that its efficacy and the possible need for modification in certain areas can be judged. In the UKRC, no provision was made for review of the model of change on the basis of the effectiveness of its elements or of the model as whole (Cullen, Junge and Ramsden 2008). It is possible that such a review might have allowed the UKRC to identify priority areas, duplication, or ineffectiveness, and so improve the design and configuration of its services.

Finally, the importance of addressing SET structures in all their complexity is clearly underlined, even though this is a notoriously difficult project and one that, as I have noted, requires considerable resources. Nevertheless, a holistic approach to the achievement of change in the SET landscape which focusses on several spheres of disadvantage has been vindicated by other international research into the effectiveness of public policy interventions; this research has concluded that the most effective measures for increasing the proportions of women in science are those which are developed and implemented in cohesive packages (Ruest-Archambault 2008). In other words, interventions in one area of disadvantage or

inequality are unlikely to be effective without parallel actions in other spheres. The somewhat depressing conclusion of a woman returner about her own prospects of getting a SET job can certainly be read as confirming the need for a sustained and multi-pronged effort to improve the position of women in SET:

> During [the course] the online and offline searching for suitable biotechnical jobs locally was very demoralising. There simply aren't any opportunities that would mean I could work part-time hours in a research/medical-related biotech field. Whilst [I've] not completely given up, I'm probably 90% certain that a return to SET will be impossible, and at my lowest ebb I have visions of a first-class honours degree graduate in a supposedly useful subject and with lab experience, [who] will actually end up stacking shelves in [a supermarket] simply because there are part-time opportunities for women there who want to combine work with home life! Sad, isn't it? (Student, quoted in Herman 2006: 7-8).

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