Women and Scientific Employment:
Current Perspectives from the UK

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In the first section of this paper I present a brief picture, using available data, of the current situation of UK women in scientific education and employment. I then discuss the need for new data and describe some of the initiatives which have been taking place, primarily at the European level, to redress this issue. In the third section, having listed the various arguments which can be found in the literature about why the 'women and science' issue matters, I focus particularly on a new development in European Commission thinking: the link with the 'science and society' perspective. Finally, I offer some thoughts about the limitations of gathering quantitative data only, arguing that qualitative research into the institutions of science is also required if we are to understand more about the cultural aspects of science that appear to be persistently alienating for girls and women.

Keywords: women, science, employment

The Women and Science Issue

Available data suggest that the pattern of women's representation in scientific education and employment in industrialised countries is persistent in two overarching ways. First, the increase in women's representation is slow, unlike other professions such as the law and medicine, where women's representation has increased markedly, particularly in the second half of the 20th century. Second, industrialised countries show similar patterns of both horizontal and vertical segregation (European Commission, 1999a). In horizontal segregation, women and men are concentrated in distinctive scientific fields. In vertical segregation, women and men within the scientific fields are not distributed equally in the hierarchy of jobs, with women typically being concentrated in the lower-level jobs and men in the higher-level ones. Segregation of both types are two of the factors underpinning a pay gap between women and men scientists, although the vertical segregation explanation has been weakened by the evidence in the Bett Committee Report that shows that *within* job grades in UK academic science, women are persistently paid less than men (Bett, 1999).

In the first section, I present a brief picture, using available data, of the current situation of UK women in scientific education and employment. I distinguish between four aspects: 1) qualifying, 2) translating scientific qualifications into scientific employment, 3) persistence and 4) advancement. The distinction between these four aspects is something which I argue elsewhere is important for several reasons: theoretically, conceptually, for policy formulation, and for data collection (Glover, 2000).

In the second section of my paper, I discuss the need for new data and describe some of the initiatives which have been taking place, primarily at the European level, to redress this issue. New data collection however, requires major resourcing and a conviction that the 'women and science issue' matters. I list the various arguments which can be found in the literature about why the issue matters, focusing particularly on a recent rationale, the 'science and society' perspective. Finally, I offer some thoughts about the limitations of gathering quantitative data only, arguing that qualitative research into the institutions of science is also required if we are to understand more about the cultural aspects of scientific education and employment. In taking this latter approach, we would be moving away from the perspective which seeks to 'blame' girls and women for lacking enthusiasm for or expertise in science, towards a research perspective that focuses on the scientific world, which apparently persists in lacking appeal for girls and women.[1]

The Empirical Picture

Qualifying for Scientific Employment

Over the past few decades in the UK, as in other advanced countries, the representation of women in scientific education has generally risen only slowly (Glover & Fielding, 1999). In some fields of scientific education, women and girls have been well represented for some time: if we define quantitative feminisation (the headcount of women, regardless of their vertical representation) as over 50% female representation, then the biological sciences and biochemistry at first degree level are feminised. There is however a marked difference between these scientific fields and fields such as physics and engineering, where women's representation remains persistently low, and in ITEC (information technology, electronics and telecommunications), where women's representation is decreasing (a feature which has also been noted in other advanced countries, including the USA). In all of the sciences, the higher the level of education, the lower the level of women's representation; this attrition happens particularly between first degree and post-graduate levels (Glover, 2000).

Overall the picture is characterised by slow change and stability, with some variation by scientific field. Table 1 illustrates this by reference to Advanced level physics and mathematics over a six year period in the 1990s in the UK. The table refers to post-compulsory secondary education.

The traditional patterning of gender in Higher Education at undergraduate level persists, with women's representa-

Table 1. Girls as a proportion of total applicants taking Advanced level physics and mathematics, 1992/3-1998/9, UK.

	1992/3	1995/6	1998/9
Physics	21.8%	21.0%	23.2%
Mathematics	34.9%	35.3%	36.5%

Source: Department for Education and Employment,
Data extracted from http://www.set4women.gov.uk/set4women/stats

tion in the biological sciences being contrasted with mathematics, physics and engineering in particular (Table 2). This illustrates horizontal segregation in scientific Higher Education.

Some change has occurred over time (although Table 2 does not show this). For example, taking engineering and technology, in 1973 only 3% of undergraduates were women; by 1984, this had risen to 8% and by 1994 to 14% (Glover, 2000). This represents quite a marked increase, but the very low base in 1973 needs to be taken into account. Furthermore, a slight decrease may have occurred in engineering (12%, see Table 2).

In important recent work, Blackwell (2001) has compared successive cohorts of science graduates in the UK, using linked census data for 1971 and 1991 contained in the Longitudinal Study[2]. Her analysis of qualified scientists born around 1930 and 1940, represented in both 1971 and 1991 data, confirms that

Table 2. Representation of women in different S&E subject areas, first year undergraduate degrees, 1995/6 and 1999/00, UK.

Subject area	**% women**	
	1995/6	1999/00
Biological sciences *	55	57
Mathematical Sciences	38	37
Chemistry	38	41
Computing Science	19	20
Physics	19	20
Engineering and Technology **	12	12

*includes biology, botany, zoology, microbiology and biochemistry
** includes general, civil, mechanical, aeronautical, electrical, electronic, production and chemical. There is a wide variation between these, with the lowest representation of women in mechanical and electrical and the highest in chemical.

Source: Higher Education Statistics Agency Student Records, 1996 and 2000.

women in later cohorts were as underrepresented in physics as the earlier cohorts had been, and feminisation rates in mathematics and the natural sciences were also moderate. In all the 'technology' subjects (computing, engineering, architecture and surveying) women's representation had increased most rapidly, though they continued to be a small minority because they started out in 1971 from such a low base.

Translating Scientific Qualifications Into Scientific Employment

I am referring here to the initial stages of scientific employment. The issue here is whether women and men translate their science degrees into professional scientific occupations to the same extent, and if they do not, what other outcomes are likely. Looking specifically at first destinations, Table 3 shows that 30% of women with science degrees enter professional scientific employment, 23% enter teaching and 13% enter associate professional scientific employment (for example as science technicians). The equivalent figures for men are 35%, 12% and 4% (Fielding *et al.*, 1997). These figures, from the longitudinal National Child Development Study (NCDS)[3] confirm that highly qualified women have a tendency to be in employment which is typically non-graduate, not just as a 'returner' occupation (which might have been expected given the well documented tendency for women returners to be employed in jobs for which they are overqualified) but also as a first destination.

There are two important methodological points here. First, the total numbers in Table 3 are small, particularly for women. Caution needs therefore to be exercised in drawing firm conclusions from these results. This illustrates a general problem with looking at small populations: secondary analysis of general labour force data yields rather

Table 3. First destinations of science graduates, 1991, UK.

Occupation	Men %	Women %
S&E professional	35	30
Management	11	9
Non-S&E professional	7	5
Teaching	12	23
S&E associate professional	4	13
Non-S&E associate professional	7	6
Other	24	14
Total	100%	100%
	(117)	(64)

Source: National Child Development Study, Sweep 5, 1991, reported in Fielding, Glover and Smeaton, 1997.

larger numbers than longitudinal data, but cross-sectional data are of limited use in trying to establish trends. This problem of data availability is a major one, not just in the UK (Glover & Bebbington, 2000) and I come onto this point in the second section of my paper. Second, first destinations are not necessarily a good predictor of subsequent employment. Nevertheless, there are marked sex differences here. Young women and men with equivalent qualifications show clearly distinct occupational outcomes at an early point in their employment trajectories.

Persistence in Scientific Employment: Exit and Continuity

Analysis of UK scientists in their twenties and early thirties in the National Child Development Study (NCDS) indicates that women's scientific employment is more short-term and discontinuous than men's (Fielding & Glover, 1999). Women are considerably more likely than men to exit from professional scientific jobs in the first two years of employment. Evidence from the USA suggests a similar pattern. Preston's study of the exit of women from scientific employment indicates that not only was their rate of exit from science markedly higher than that from other professions, but it was twice that of male exits from professional scientific jobs (Preston, 1994). Furthermore, the median tenure for men in their early thirties in professional scientific occupations in the NCDS is just under ten years, compared to just under four years for women in their early thirties (Fielding & Glover, 1999).

Women science graduates in their early thirties who are mothers primarily work part-time or are out of the labour market (Fielding & Glover, 1999). Recent work on the linked census data in the Longitudinal Study indicates that women scientists and technologists were more likely than women working in health and teaching professions to defer child-bearing or to remain childless (Blackwell, 2001). Blackwell's analyses show that women in science and technology occupations who became mothers were very likely to leave employment altogether, unlike those in health occupations. Four-fifths of women in health occupations were mothers, compared to two-fifths in science and technology. Those who persist in scientific employment appear therefore to show particular demographic characteristics.

Cohort analysis of science graduates from the Longitudinal Study shows considerable attrition from scientific employment. Blackwell (2001) compares proportions of 25-34 year old graduates in science and technology occupations in 1981 who were in the same occupational groupings in 1991. Attrition was 49% for women and 32% for men, considerably higher than for those graduating in health-related subjects, at 13% and 8% respectively. Furthermore, very recent findings from the UK Labour Force Survey confirm that women science and engineering graduates are less likely to return to work after starting a family than women with other high level qualifications and that a large proportion of qualified women scientists remain out of the labour force (Department for Trade and Industry, 2002). One consequence of this has been the setting up of a DTI committee of enquiry, led by neurologist and president of the Royal

Institution, Baroness Susan Greenfield. The committee will report to the Minister, Patricia Hewitt, in the summer of 2002.

Advancement in Scientific Employment

In relation to advancement (and here I am referring to academic employment, mainly because there is a marked lack of data on scientific employment in the business sector) it is clear that in many industrialised countries, different advancement rates of women and men have resulted in vertical sex segregation in academic scientific employment (Glover, 2000). All sciences show a similar pattern of women being under-represented in high level positions and over-represented in researcher positions, which in the UK are typically short-term and relatively poorly-paid (House of Lords, 1995). The available data allow for disaggregation by discipline and they show that even in those sciences where women's overall representation is high, such as in the biological sciences, women are poorly represented in the high level positions. There appear to be very similar patterns in all European countries (European Commission, 1999a). This of course raises questions for the 'critical mass' thesis - that reaching a given representation of women will somehow solve the 'women and science problem'.

Data for UK Higher Education in 1997/8 from the Higher Education Statistics Agency show that women account for 21% of personnel employed in the biosciences, yet account for only 7% of professors (Table 4). A similar pattern can be found in engineering where 9% of all personnel are women and 2% of professors are women.

Tables 1 to 4 thus illustrate various aspects of horizontal and vertical segregation in scientific education and employment. The traditional pattern of women's place in scientific education and employment appears to be markedly persistent.

The data are however incomplete and suffer from various problems. For example, numbers are small; there is insufficient distinction between disciplines;

Table 4. Representation of women in university scientific employment, 1997/8, UK

Grade	Physics	Chemistry	Engineering	Biosciences
Professor	1.4%	0.6%	2.0%	6.9%
Reader/Senior Lecturer	4.7%	5.2%	4.4%	13.2%
Lecturer	7.6%	12.2%	10.9%	26.2%
Researcher	15.4%	16.4%	15.8%	38.1%
Overall representation of women	5.9%	8.5%	8.9%	21.0%
Total N (women and men)	1466	1632	8950	3787

Source: Higher Education Statistics Agency, data extracted from http://www.set4women.gov.uk/set4women/stats/05_emp.htm and there is a yawning gap in terms of information about business sector employment.

A Need for New Data

Calls for new data on women and scientific employment have come from many quarters over the past decade or so, mostly from the perspective that policy needs to be underpinned by detailed and reliable data. In 1993, the International Workshop on Women in Science in Brussels called for Eurostat to make available quantitative data which would answer a range of detailed questions on women scientists' employment situation (European Commission, 1993). In 1994, the European Parliament's Scientific and Technological Options Assessment argued for the gathering of quantitative and qualitative data in all European Union countries in order to throw light on women's 'careers, positions and difficulties' in science and technology (STOA, 1994: 2). The Council of Europe's Parliamentary Assembly has also considered the role of women in the field of science and technology and produced particularly detailed comments about the specific data which it felt were lacking (Council of Europe, 1999). It accordingly invited the governments of Council of Europe member states and of the European Union to improve the collection and publication of gendered statistics in both national and harmonised European surveys, relating to both the education and career trajectories of those with science and technology qualifications.

The Council of Europe's assessment pinpointed specific areas where data are lacking: the unsatisfactory nature of many occupational classifications that fail to make sufficient distinctions between scientific disciplines; the difficulties arising from the very small number of women in science and technology statistics, which makes many statistical analyses difficult or impossible; the lack of qualitative data, in particular of a biographical nature, which would shed light on subjective elements of women scientists' experience of science and scientific employment. Furthermore, the Council of Europe called for work-history data, which would enable the linking of key phases in women scientists' careers to aspects of their personal lives, thereby shedding light on the relationship between work and family. Lastly, cross-national longitudinal data were called for, so that different generations and cohorts of men and women scientists and non-scientists could be compared both over time and between countries.

Five years after the Brussels International Workshop, at the 1998 European Commission 'Women and Science' conference in Brussels, concern was expressed about the lack of progress made in gathering data (Osborn, 1999). Similar points were made at the European Commission 'Women and Science: Making change happen' conference in Brussels in April 2000, although the proceedings suggest that there was greater optimism at that meeting that policymakers were taking the issue seriously (European Commission, 2001b).

Eurostat, the European Commission's statistics arm, has noted the lack of gendered indicators which would give a clear and accurate picture of the situation regarding women scientists and their careers (Eurostat, 1999). It sees the collection of such indicators as a precursor to the drawing up of appropriate policies and the monitoring of progress. The National Experts on Science and Technology Indicators (NESTI) group, convened by OECD, pledged to develop its work on women and science statistics (OECD, 1999). UNESCO's Institute for Statistics has declared its openness to cooperate with the Commission in the definition of the required indicators.

At the April 2000 'Women and Science: Making Change Happen' conference, organised by the Women and Science Sector of the European Commission's Research Directorate General, a main aim was to present the European Technology Assessment (ETAN) Report 'Science Policies in the European Union: Promoting Excellence through Mainstreaming Gender Equality'. One of the Report's conclusions was that existing data are 'fragmentary, difficult to collate and non-systematised' (European Commission, 1999a: 71). Accordingly, the report recommends a new Directive requiring employers to keep sex-disaggregated statistics. This would ensure that organisations publish systematic and reliable data for monitoring and evaluating gender equality policies and practice. In addition, it recommended that member states' national statistics offices collect and publish sex-disaggregated data on women and scientific education/employment. Furthermore, it said that national statistics offices and gender equality agencies should work with Eurostat to produce sex-disaggregated data on academic rank, discipline and pay in universities and research institutions, as well as rank and pay in business sector employment. Equality indicators were also needed; these would collect harmonised data on education, employment, training and salaries in the sciences in order to develop and review Europe-wide policies.

In line with its general principles of bringing about equal opportunities for women and men in the field of scientific research, the European Commission has pledged itself to make significant efforts to increase women's participation in European research. In a Communication of 17.02.99, endorsed by a Council resolution on 20.05.99, the scarcity of statistics in the 15 member states on women in scientific employment was recognised. Building better statistical indicators is seen by the Commission as the way to gain a clearer and a more accurate picture of the situation regarding women scientists and their careers (European Commission, 1999c: 8). Particular attention is paid in this Communication to the need to collect data which would show what becomes of women scientists once they move into the labour market. This would imply member states collecting data which would help to show the vertical and horizontal distribution of women in scientific research and the government, academic and business sectors (Research Council of the European Union, 1999). The Council resolution of 20.05.99 furthermore invited the European Commission to produce, on the basis of member states' contributions, comparable data and European indicators in order to assess the situation of women in research, technology and development. Finally, it asked the Commission to deliver a report to the European Parliament and to the European Council on progress made in implementing these measures, among others, after two years (ie by mid-2001).

In response to this invitation, the Women and Science Sector, formerly in Research DG's Human Potential and Mobility Directorate and now the Women and Science Unit, located in the Science and Society Directorate, has developed a two-pronged approach to the issue of increasing the quality and quantity of data on women's scientific education and employment (European Commission, 2001a).

Top Down

One prong is a so-called Top Down approach, where the aim is to ensure strong cooperation between the major institutions, which are involved in the production of statistics at European and international levels. The cooperation aims to avoid overlapping and duplication of activities between Eurostat and OECD. The sort of activities which are carried on here include ongoing work by Eurostat and OECD to revise the Frascati Manual (OECD, 1993) which links to international classifications of both education and occupations, respectively ISCED-97 (UNESCO, 1997) and ISCO-88 (ILO, 1990), together with cooperation between the UNESCO Institute for Statistics and the Women in Science Unit of Research DG. The revision of the Frascati Manual to include a sex variable in the R&D Surveys is particularly important, since the Manual constitutes the agreed ways of collecting such data in all member states. Agreement at this level makes it considerably more likely (but importantly, not guaranteed until a legally binding agreement about the collection of data from EU member states has been achieved) that member states will gather the requested data (see http://www.cordis.lu/improving/women/tdapproach.htm#Frascati).

Bottom Up

The other approach, so-called 'Bottom Up', takes the perspective that efforts can be made at a national level to exploit existing data in terms of their potential to shed further light on women's scientific employment. Two main attempts have been made to exploit the potential of existing data on women's scientific education and employment from both member states and, eventually, associated states. The first sought to map the existence of data on women's scientific education and employment in all member states in terms of the potential of data sets to answer a series of key questions on women and scientific education/employment (Glover & Bebbington, 2000). It concluded that these questions could only be answered in a satisfactory way if new data were gathered, and, failing this, if existing data, such as the R&D Surveys, could be adapted in various ways, such as persuading all member states to include a sex variable in the survey.

The second attempt to exploit existing data is the Commission's project 'Design and Collection of Statistical Indicators on Women in Science'. This involves the establishment of a data base in five broad areas relating to women and scientific education/employment: how many women in different scientific fields; vertical sex segregation; horizontal sex segregation; the pay gap and success rates in research funding. The method used to bring together these national data is pioneering. Each member state and associated country was asked to nominate a person (usually a senior civil servant) and these people make up the so-called 'Helsinki Group'. Subsequently, each country was asked to nominate a statistical expert whose role was to validate the national data. Each country has been asked to set up a national steering group to support its Helsinki Group delegate and its statistical expert. Some valuable data have been brought together from these national teams and one early outcome is the production by Eurostat of publicly available statistics, aimed at a general audience, presenting a small number of tables with a broad focus (Eurostat, 2001). The technical notes and the footnotes play a crucial role in explaining issues/concerns about such issues as harmonisation.

The process of gathering data from many disparate sources has of course involved issues of harmonisation and debate about whether non-harmonised data can be presented in aggregate form. However, as predicted in the Glover and Bebbington study, there are limits to the usefulness of existing data and in its report to the European Parliament and the Council of the European Union (European Commission, 2001a: 9) the Women and Science Unit concludes that existing data do not allow all of these indicators to be developed. This implies therefore that new data will need to be collected. This, of course, is a major conclusion, with far-reaching resource implications. The work produced in the Mapping exercise and the work so far of the Statistical Indicators project, in cooperation with the Helsinki Group, seems to be pointing in the same direction: it is only possible to go so far in terms of using existing data and, sooner or later, the bullet will have to be bitten in terms of gathering new data.

A further indication of progress in terms of increasing our knowledge of the position of women in science is the fact that gender issues are to be taken into account in the Benchmarking Exercise, following robust representation from the Women in Science Unit and the Helsinki Group. The Benchmarking Exercise derives from the Research Council Resolution adopted on June 15 2000, which built on the Lisbon European Council conclusions that a European Research Area policy was needed in order for Europe to compete economically. The Benchmarking Exercise is a key element of this policy. The Commission is asked to work with member states to present statistical indicators and a methodology for developing these indicators in order to 'benchmark' (provide targets for) four main themes: human resources in Research, Technology and Development (RTD), including the attractiveness of science and technology professions; public and private investment in RTD; scientific and technological productivity; the impact of RTD on economic competitiveness and employment. Also mentioned are 'issues essential to the understanding of the functioning of RTD policies, such as the promotion of RTD culture and public understanding of science' (European Commission, 2000a).

The intention is that the Theme 1 indicators (human resources in RTD) will be disaggregated by sex. The Commission's Women in Science Unit has pointed out that gender issues should not be neglected in the other themes, especially the analysis of productivity and competitiveness (European Commission, 2001a). Agreement has been reached with the Benchmarking Task Force that the gendering of Theme 2, 3 and 4 indicators will be considered on an indicator by indicator basis. This is in effect a major triumph, since the intention to disaggregate the indicators by sex was certainly not present in the early discussions on the benchmarking exercise.

Underlying all of this work is a need to convince a range of actors that the women and science issue matters. Several different reasons for the concern about women's patchy representation in scientific education and employment can be identified in the academic and polemical literature. These are: equal opportunities, economic growth, economic returns, the argument that science would be different if the representation of women were higher and the 'science and society' argument. Most of these are well-rehearsed (see Glover, 2000) but the 'science and society' perspective is a relative newcomer in terms of its linkage with the 'women and science' issue

Linking 'Women and Science' to 'Science and Society'

A new perspective has emerged recently from European Commission's Research Directorate General (DG). If women played a more prominent role in a European knowledge based society, the debate on science in society would be deepened. Public awareness of science and society issues would be improved and the links between research policies and 'societal needs' would be strengthened through increased public confidence, says the Draft Resolution of the Council of the European Union (2001). Further evidence of this shift in thinking comes from the recent move of Research DG's Women in Science Unit to a Directorate entitled 'European Research Area: Science and Society'. Thus we see that alongside such traditional 'science and society' issues as risk management, ethics and freedom is now the issue of women in science.

The origins of this change appear to be located in an increased emphasis on the importance of building up a European knowledge-based economy (the so-called European Research Area) to rival that of countries such as the USA. Thus it could be argued that this rationale can be linked to the 'economic growth' perspective, briefly mentioned above. The EU committed itself to building such an economy at the Lisbon European Council of March 2000 and this was made concrete in the European Research Area declaration of 2000, under the auspices of the French Presidency. The afore-mentioned Benchmarking Exercise is crucial to this approach. But accompanying this economic goal is the realisation from the Commission that these objectives will be achieved 'only by an economy geared to innovation and a society fully committed to it' (COM (2000) 567 *Innovation in a knowledge-driven economy* cited in European Commission, 2000b). This implies firstly that the strength of the scientific labour force will be crucial and secondly that citizens *as a whole* (emphasis added) need to support the goal of a knowledge-driven economy. The relationship between science and society is fragile, says the Commission. Advances in knowledge are greeted with scepticism and hostility; society is no longer unquestioningly enthusiastic about the quest for knowledge (European Commission, 2000b: 5). Emerging from this rhetoric is the view that support for the 'scientific venture' underpinning the European Research Area project needs to involve a larger spectrum of society than at present. Dialogue needs to be stepped up and the public's knowledge of science improved.

Where does the 'women and science' question come into this scenario? The Commission says that harmonious and productive relations between science and society are dependent upon an increase in interest in science and research amongst groups which have historically excluded themselves (or been excluded) from the scientific venture: "(This interest) will have to be increased in sections of the population where this interest is less than it was once or is only evident to a limited degree." (European Commission, 2000b: 17).

Three sections of the population are accordingly singled out by the European Commission (2000b). They are young people, older people whose experience needs to be valued and women. Two aspects are focused upon in relation to women which can be described as first, women *in* science and second, women *and* science. In relation to this first aspect, it is acknowledged that women are under-represented both vertically and horizontally in the world of research. But the Commission says that it 'cannot simply boil down to that'. This leads on to the second aspect: 'women *and* science'. Regardless of their position in scientific education and employment, women have more generally been excluded from science and the scientific community. The issue is therefore not just one of increasing the presence of women in the world of science; if new and more positive relationships are to develop between science and society, the research agenda needs to take accounts of the 'specific needs' of women. Informing this is the 1999 Commission Communication that set out three dimensions relating to women and science: 'by, for and about': the need to promote research by women, for women and about women (European Commission, 1999c). This was a phrase used earlier by former French Prime Minister Edith Cresson in her address to the 1998 'Women and Science' conference, organised by the European Commission (European Commission, 1999b), one of a series of major conferences (1993, 1998, 2000, 2001) that have sought to enable the networking of practising women scientists.

Persuading Member States

While a firm legal basis for gathering European statistics remains to be achieved, the major challenge here will be to convince member states, or rather their statisticians that this issue matters. It is unlikely that the arguments briefly listed earlier will have equal weight. National statistical agencies are particularly keen to avoid an extra burden on the business sector by imposing on them additional demands for data collection. For this sector, the 'economic returns' argument, relating to the supply of and demand for labour, would be meaningful and the 'science would be different' argument probably less so. The business community might be convinced that it was worth spending more time on gathering statistics if such data could show that firms are incurring financial losses because they are not retaining particular social groups to whom they have devoted training resources. Furthermore, having found out that some social groups persist in science longer than others, the business community could show further interest in discovering *why* some groups leave – whether for structural reasons (family-unfriendly climate for example) or because they had not achieved advancement. It could be argued that such information would feed directly into profitability, since establishing such reasons can lead to the implementation of policy which could improve valuable employees' retention.

The European Union's general approach to social policy is dualistic, whereby economic growth and progressive social policy go hand in hand (European Commission, 1994). It seems reasonable therefore to conclude that liberal feminist equal opportunities arguments would carry some weight amongst EU member states and the European Commission. But would the business community be as convinced by such arguments? This is possible, if there were sanctions associated with failing to meet targets. The affirmative action policy of the USA has the power to do this, although the reality is that there has not been the political will to enforce it strongly since its inception (Blum, 1991). And what about 'science and society' arguments? It could be that this argument is particularly interesting for the business community. If it could be shown that large sections of the population do not support the 'scientific venture', there is considerably mileage for capitalism in getting these people on board. Research and development requires considerable financial support from public funds and thus the willing support of large numbers of taxpayers, an increasing number of whom are women.

Discussion

I have focused in this paper mainly on the existing quantitative data. Such data, however, realistically only tell us about outcomes, not about process. We know rather little about the role of the institutions of science (by which I mean the formal and informal rules of science) and their power to include or exclude. It is a much more difficult research issue to turn the spotlight on science departments and workplaces - their laboratories and their workshops, their lecture theatres and their canteens. In other words, the explanation for the slow feminization of science may reside in the culture of science. Much more research is needed into the institutions of science in terms of their exclusion and inclusion of particular social groups (ethnic minorities, as well as girls/women). But such research would require the acceptance by those who are members of 'the club' that change needs to come about.

One possibility that a changing climate could come about derives not out of a concern for equal opportunities, or even out of a concern for economic growth or for better relations between science and society, but out of recruitment worries at undergraduate and postgraduate levels in higher education. In May 1998, three out of every five physics department in the UK were reported to be in financial deficit because of low student numbers (Times Higher, 27. 3. 98). The Times Higher reported on 7 September 2001 that there were decreases in student recruitment for 2001/2 in almost all sciences (www.thesis.co.uk). Compared to the previous year, there was a 14 % reduction in recruitment to microbiology, 8% to chemistry and 7% to civil engineering. Low numbers of girls are thus clearly not the only issue; boys seem also increasingly less willing to embark on a scientific career. If this is the case, girls may be increasingly seen by university science departments as a potential pool that needs to be tapped if said departments are to remain open.

None the less, it is unclear at this point that there is a culture of change in the scientific workplace and lecture theatres. Until it is, my conclusion is that an emphasis on campaigning to change women and girls' behaviour (the 'deficit model', see Wajcman, 1991) is unlikely to bring about any real change in the way women and girls appear to react to the prospect of entering science, staying on it and subsequently advancing within it. The institutions of science may well need to change, rather than its potential or actual recruits.

From this point of view, it is understandable that research into the institutions of science is rare, and that the focus up to now has been much more on the gathering of statistical evidence. Research exists on sexism in higher education employment in general (Aisenberg & Harrington, 1988; Husu, 2001; Malina *et al.*, 1999; Morley, 1995; Sondergaard, 1992). Research on the gendered cultures and institutions of specific scientific fields is considerably less prolific, an exception being Traweek's (1992) seminal work on the gendered culture of high energy physics in the US. Anecdotal evidence from women practitioners about the hostility of the institutions of academic physics culture is cited in Glover (2000). Webster's research on the culture of information technology employment reveals that women feel that they are trespassing into an alien territory (Webster, 1996).

Is Encouraging Women to Enter Science a Responsible Approach?

To end on a provocative and possibly pessimistic note, it needs to be recognised that there is also the perspective which does not quite say that this issue does not matter but which queries the assumption that women should enter science. This standpoint, primarily coming from the writing of Cynthia Cockburn, says that women correctly gauge that entry to gender-atypical occupations, such as scientific and technological occupations, has considerable social and personal costs and that women are far-sighted in their avoidance of such occupations (Cockburn, 1987). From this perspective, therefore, women are marginalising themselves, but not necessarily to their disadvantage, rather to their advantage. It strongly asserts that women are not victims, rather they are agents in charge of their own destiny. Their destiny does not necessarily include trying to become qualified in order to earn a living in a hostile climate where they would feel literally out of place.

Amongst other things, what this perspective is doing is to turn the conventional perspective on exclusion on its head, by, in a sense, coming out in favour of self-exclusion. Many discussions of exclusion assume that inclusion is desirable and it follows from this that policy implications involve persuading girls to see the 'scientific light'. The implication of what Cockburn is saying is that inclusion is not necessarily desirable. Further, there is a strong message here for those who are included – members of the scientific 'habitus' – to say that if more women are needed in science, for social, economic or cultural reasons, then the institutions of science need to change. Women should not be pathologised for lacking enthusiasm, qualifications, skills and so on. The institutions of science should, by contrast, be the object of concern and hence enquiry. If this is not done, then from this perspective it could be argued that we are being irresponsible in encouraging girls and women to enter science, since this is a move which could have for them far-reaching personal and social costs.

The challenge will be to convince those who are the 'gatekeepers' of scientific workplaces and places of education that there is an issue here that requires researching, and thus to grant widespread research access to these locations. If this persuasion was successful, a two-pronged approach could develop: the continuation of data gathering in the form of statistics, something which appears to be gathering momentum on the European stage, together with qualitative research into the processes that underlie these statistics.

Notes

1 This article is based on a presentation to the Athena Project conference 'New Research on Women, Science and Higher Education' Royal Institution of Great Britain on 25 September 2001.

2 The Longitudinal Study is a 1% sample of the population of England and Wales. It links census data from 1971 to 1991 (2001 will be added, probably by 2003). For more details see Hattersley and Creeser (1995).

3 The NCDS is a continuing longitudinal study which follows the lives of all those living in Great Britain born in one week in March 1958. To date, six sweeps have taken place. The NCDS is administered by the Centre for Longitudinal Studies, Institute of Education, University of London. Data are available from the UK Data Archive (http://www.data-archive.ac.uk).

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