



## Meta-analysis of gender and science research

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## 1. Introduction

The UK research on gender-related issues in science over the last 30 years has been focused on a small range of core topics, and in particular, “Stereotypes and identity”, which has produced the largest number of references; followed by “Horizontal segregation” and “Vertical segregation”, and thirdly, “Science as labour activity”. This reflects the political and policy focus of the government’s agenda in the UK during the corresponding years, which was to improve the education system and address equality issues for women, and in particular the gender pay gap. A very important role in this was played by the Women and Equality Unit, a government department, established in 1997. The Unit has been absorbed in 2007 into a new equality body, the Government Equalities Office. Prior to this, the Rising Tide report, published in 1993,

presented 14 recommendations following an evaluation of the situation of women in SET in the UK. Subsequently the Promoting SET for Women Unit (PWSET) was set up in 1994 in the Office of Science & Technology. One of the main organisations to be funded as a result of recommendations from reports evaluating the needs of women in SET and was to support and promote women in SET has been the UK Resource Centre for Women in SET (UKRC) in 2004. The UKRC provides a central point of information and advice for industry, academia, professional institutes, education and research councils and for women entering, returning and progressing in SET careers.

Across the accumulated collection of research references, there is a very strong influence of feminist epistemology on the methodological approaches used in research studies, and in particular the theory of difference: namely, women and men are different and there is a need to explicate these differences to design policies that can address the disadvantages experienced by women. The topic of 'occupational segregation' and 'identity' issues have been analysed very much from this perspective. Another common theme in the accumulated references is academic performance of children of school age, comparing boys to girls, in relation to a range of factors and relationships in order to establish where gendering occurs and influences academic underachievement of girls/boys, and influences young people's career choices. Earlier studies were preoccupied with the underperformance of girls but more recently examination results have shown that girls have been outperforming boys and the focus of attention has now switched to boys and to discussion if the educational policies that worked for girls will work for boys too.

Another frequent topic for research involves analysis of the relationship between women's improved and increased educational attainment and qualifications and the persistent inequalities in the workplace and society. More women attend university than ever before and more of them enter the labour market with good qualifications. This has resulted in some improvement in the profile of the job roles held by women observed over time but explanation of why this advance appears to be limited to lower ranks of management and decision-making levels is missing. Related to this have been numerous studies looking at examination performance, attitudes towards subjects and exams, and comparing the levels of degree awards achieved by men and women, and across different subjects.

The feminist perspective has met with some criticism more recently, which pointed out possible methodological weaknesses of excessive importance given to gender-related explanations and avoiding the more complex aspect of the problem studied. An example of this is disaffection among boys and girls with the process of science education. Whilst the problem exists, gender-related explanation is insufficient to explain it. Accurate representation and analysis of problems is necessary if policies are to deliver the impact needed. Weaknesses in the way gender is theorised and the impact of this on policies has been recognised but only in a small number of papers. Well-intended policies, such as the EU policy on science labour mobility, disadvantages women, whose mobility is all too often restricted by family responsibilities. In dual career partnerships, mobility opportunities have been largely taken advantage of by men. In these situations women scientists 'exit' their own careers, or continue but, in general, their careers will 'trail' those of their partner.

A big gap in the accumulated body of research relates to examinations of the gender dimension in the context of science excellence. This could be potentially explained by the structure of the research funding in the UK, which divides major science fields between different research councils. Consequently, getting funding for interdisciplinary studies is difficult, unless the councils themselves identify the need for such research as a priority.

## **2. Analysis by topics**

### **2.1. Horizontal and vertical segregation**

#### ***Research questions***

- Differences between male and female practitioners across a range of occupational fields and sectors, from HE to dentistry
- Relationship between occupational segregation and occupational inequality. Do conditions of the labour market need to be taken into account when explaining dynamics of this relationship.
- Universities as employers, their cultures and the patterns of women's employment
- Patterns of representation of women in different fields – employment status, type of contract, career structure, research and teaching, grant applications
- Changes in occupational structures as reflections of social change
- Does 'gendered nature' of subject choices in the educational system accounts for the persistence of gender segregation in the technical professions
- Can critical mass of women entering masculine employment areas bring change in work cultures or not
- Are career choices gendered
- When does gender segregation "starts"

#### ***Research approaches***

Educational segregation persists in technical areas and occupational segregation persists across a wide range of employment sectors. There is a complex relationship between cultures and women's agency, and focus has shifted recently to understanding the attitudes of young people towards science and engineering, and the role school plays in the reproduction of gender stereotypes. Studies are mainly qualitative studies, based on interviews and observation, and surveys looking at

- Statistical comparisons of data on women's status in different sectors
- Women's work life stories with regard to choices and career opportunities
- Statistical studies combined with interviews and questionnaire methods targeting HE institutions, companies, and sectors
- Exploration of a wide range of factors, professional circumstances, and employment sector to identify where gender has impact
- Effectiveness of Equal Opportunities policies

#### ***Findings***

- Age, length of time since qualification and the acquisition of additional qualifications where consistently found to differentiate the status of dental practitioners
- Conditions of the labour market need to be taken into account when explaining the dynamics of the relationship between occupational segregation and occupational inequality – they are not the same
- More women enter HE and in academic careers succeed up to lecturer level but advancement stalls when women reach senior positions – women's promotion to senior roles is handicapped by ingrained structural and cultural barriers
- One of the major constraints on women's careers in medicine is that lack of part-time posts
- Across labour force, increase in qualifications level of women over the last 20 years has increased the number of women in managerial and professional roles but they are still underrepresented compared to men – work cultures and gender prejudices are the main cause. Legislation, anticipated skills shortages and changing employment patterns have little impact on the employers' preferred skills formation strategies

- Different perceptions of 'commitment' between men and women impacts on how women and men are evaluated for promotion; efficient management is identified with masculinity, which favours promotion of men
- Women change their behaviour to fit the culture they work in so critical mass of women entering masculine employment areas will not automatically bring change in work cultures, and isolation will persist
- Women tend to deal with barriers in a way which perpetuates existing work cultures
- Knowledge and sex-typed behaviour increases significantly between age 2-3, and so does segregation
- Equal opportunity policies have little impact in academia, which is resistant to change because academic cultures promote professional autonomy, isolationism and lack good management
- Boys are less likely than girls to opt for a job traditionally held by the opposite sex.

### **Gaps**

The analysis is hindered by lack of longitudinal analyses and systematic evaluations and critical reviews of available research. The analysis centres on academia. There are no studies about research in the private sector, with the exception of medicine. A large part of the research effort is aimed at the compilation of data.

## **2.2. Pay and funding**

### **Research questions**

- Impact of feminisation on workforce planning and employment practices – what changes will be needed to accommodate for the fact the majority of employees in medicine and dentistry will be female
- Women's experiences and views of pay and reward system in ICT
- Why despite the increased participation of women in paid employment their position remains a subordinate to men
- Deconstructing women's work to uncover conflicting and often irreconcilable demands and constraint on choices
- Status of women in different fields
- Does access to technologies as tools of prestige and job security impact on the wage premium
- Do gender differences exist in pay and promotions - It can partly be attributed to outside offers, men receive more and are more likely to take them/ask for more money not too where women have a sense of loyalty

### **Research approaches**

Differences in the pay between men and women have been analysed widely by many different stakeholders involved in policy area. The major contributing factor appears to be the fact that there are so many women who are working part-time or whose career patterns have been interrupted. Still, there remains an unexplained proportion of the pay gap of around 20% but there is great reluctance to label this as potentially caused through discriminatory practices. The research concerned itself primarily with accumulating data. There are no empirical studies that tested the relationships identified as contributing to the pay inequality situation. During the last few years the importance of this issue in equality policies has diminished overtaken by more general equality concerns such as eliminating violence against women and child poverty.

### **Findings**

- Impact of sex discrimination – the present state of knowledge is unsatisfactory due to methodological weaknesses in the approach to the evaluation of discrimination. Much greater attention should be placed on hiring/promotion decisions

- Equal opportunities when integrated into good management practice can provide tangible effects on better staff retentions and operational efficiency
- Countries with higher levels of educational segregation by gender have higher levels of occupational segregation
- Full-time working women are as likely as men to be promoted but tend to gain at the bottom end of the wage scale in these promotions
- There is no across-board benefit from the use of computers in terms of work status or prestige
- Gender differences in pay and promotions can be partly attributed to outside offers, men receive more and are more likely to take them/ask for more money too, whilst women have a sense of loyalty that influences their attitudes to pay and promotion.

### **Gaps**

Gender pay gap and gender discrimination has been at the focus of government policy making and the problem has been analysed extensively in the UK, though not directly within science and engineering fields. There are no studies that analyse inequality in the access to funding and resources.

## **2.3. Stereotypes and identity**

### **Research questions**

- Leadership and other organisational factors that shape managerial workplace identities
- Gender differences in performance in public examinations – how hidden information relating to the style of examination and coursework contributes to gender differences in performance
- How female ICT professionals view ICT future and their place within it
- What are the sources of the masculine identity of science
- Is there systematic variation in the review practice and what implications are there in regards to the choice of peer review panels
- How a scientific field and engineering, and in particular, its work practices, cultures and identities may be 'gendered' to explain why women are underrepresented
- How gender, ethnicity and socio-economic group interact and together impact on the under achievements of boys and girls
- How are the practices, cultures and identities of engineering more appealing, supportive and comfortable for men than women

### **Research approaches**

- In general, conceptual contributions about epistemology of science prevail, and to a lesser extent, studies dealing with the critical revision of teaching practices and teaching material in school. However, there are also more empirical studies that attempt to explain why boys and girls embark on different educational paths, with girls being a minority in technical studies
- The neutrality of science and scientific activity is questioned, highlighting the power relations of 'the masculine' over 'the feminine'
- The influence of the feminist critique was to illuminate the study of science as a social institution governed by gender relationships
- The consequences of 'the masculine' and 'the feminine' behaviours have been explored in particular in education and medicine.
- Public disengagement with science has been of some concern but only a few studies looked at this in any depth and the absence of attention to gender effects is striking, give that at the same time many studies have been concerned with the attitudes to science among school students and comparing differences between boys and girls.

### Cognitive ability

- In this area the research was focused on the relationships between approaches to learning, age, gender prior academic achievement and subsequent academic achievement and progression
- Sex differences and career choice – digit ratio, as an indicator of visual spatial abilities: consistent with female norm was found among male and female Science faculty and the ratio consistent with male norm among Social Science Faculty.

### The social construction of science

In this area the research analysed

- Relationships between science and science knowledge and social, political and cultural factors – they are inseparable according to feminist epistemology: knowledge conceived in terms of practice becomes normative and socially constituted
- The concepts of human capital and social capital as explanations of gender effects in economic growth
- Links between gender, ethnicity and socio-economic group
- The concept of 'gendering' in the context of scientific field and engineering, its work practices, cultures and identities
- The concepts of patriarchy, difference, equality to power relations in science
- Attitudes: towards specific subjects, each other, careers, work cultures, etc
- The concept of community of practice.

### The social construction of identity

In this area, the research was focused on

- The impact of HE structural reforms and policy change
- The role technology on conceptions of gender identity
- Relationship between feminisation/masculinisation of teaching
- Assessment methods in education and promotion
- Culture and structures in education and employment
- Career experiences
- Attitudes to men and women

### **Findings**

- Gender identity in cyberspace – gender fluidity can be observed as gender identity can be concealed by a non-gender email account. When female gender identity is made clear e.g. in advertising, dominant discourses of masculinity and femininity are reproduced
- Comfort level and maths background have positive impact, and attribution of luck a negative impact in predicting success in computer science – no significant gender differences were found in these three factors
- Schools could play transformative role in forming gender identities
- Gender stereotypes are deeply entrenched and start very early
- Women tend to be found in groups less likely to be considered for promotion
- Deviation from a group's collective gender orientation and accepted behaviours is likely to be met with unfavourable perceptions by group members and impact person-group fit, person-organization fit, perceived stress, self-efficacy and perceived stress.
- Career choices affected by interplay of self confidence in science, occupational images of scientists, relationship with significant adults, perception of school science
- Role of professional societies and careers of female academics – universities support the hierarchies of professional societies and this disadvantages women
- Physics is popular in Scottish schools but decline or repair in attitudes is observed for girls and boys at different stages of education and in response to different courses. The structure and nature of science course in the early secondary school is of particular importance to the attitudes of girls

- Structural reforms in education system have made institutions more structured, with management being more important than the disciplines, too much managerial control affecting scholarship

### **Gaps**

No direct publications have been identified about the impact of sex and gender on the cognitive and intellectual abilities of men and women as a possible explanation to observed gender inequalities. A critical review of all the accumulated data and methodologies is also missing.

## **2.4. Science as a labour activity**

### **Research questions**

- Employers attitudes and work practices in relation to flexible work and in the context of IT as an area that fails to attract women
- Structure and dynamics of women's careers
- Variations in academic attainment in relation to gender, age and subjects
- Impact of women's and gender studies on women's place in education and science
- How educational experiences contribute to career progress
- Changes in career choices of graduates against time
- The role of emotion and agency in career choices
- Impact of career interventions in organisations
- Gendering of skills in ICT work
- Gender and stress and commitment at work

### **Research approaches**

Documenting women's careers in different fields and sectors and barriers to advancement of every-day and well-known women in science, especially in the fields of engineering and health sciences, showing the relation between the professional and the private spheres and identifying which elements have driven the success in the scientific career. Literature about gender discrimination in the academia is based on interviews and statistical comparisons. It analyses women's scientific activity in the framework of a social patriarchal structure, focusing on issues such as the gender division of work, the domination of 'the masculine' over 'the feminine' or the use of dichotomies such as 'public/private' or 'natural/social'. Empirical studies focus on the analysis of women's perceptions of the barriers and difficulties they face when trying to achieve academic success.

### **Findings**

- Women progressing well in HE to lecturer grade, but their careers stall beyond that level because they have less developed research profile. Processes for promotion to some senior roles are not always transparent. Women more than men are reluctant to put themselves forward for advancement and they value work life balance
- Mobility and excellence in scientific labour market is seen at EU level as essential for promoting scientific growth but these ERA policies disadvantage women with family or caring commitments who less able to take advantage of the opportunities
- Impact of Mobility on career decisions and the progression of the 'trailing partner' in dual career couples, usually woman scientist – women then to 'exit', there is persistence of trailing regardless the level of skills of female partner
- The structure and dynamics of women's careers can be explained through 3 dimensions: cultural, structural and action, which determine options for change and play a role in women's choice
- Academic attainment – women tend to get better degrees than men but this does not apply to all ages or in all subjects: variations in teaching and assessment practice as well as characteristics of the students themselves played contributed to these variations

- Changes in career choices of medical graduates against time – bimodal career patterns persist, very few men continue to choose obstetrics and gynaecology despite better training opportunities, women tend to be in higher numbers in other areas, in particular general practice
- Women and men experience same levels of stress and commitment in relation to their jobs but men are more troubled by pay and benefits, and women report health issues

### **Gaps**

There are very limited number of empirical studies looking into organization of scientific work and the uses of time as factors of scientific knowledge-making and evaluation of performance.

## **2.5. Scientific excellence**

### **Research questions**

- Institutional variations in gender differences in achievement
- How female and male students approach studying
- Why women managers are perceived as 'less committed'
- Does computer science curriculum contributes to the exclusion of women from the higher levels of computing
- Impact of neo-liberalism on higher education and research
- Relationships between biological and social science in explaining, legitimising and naturalising social inequalities
- Gender bias in the refereeing process
- The life science research process
- Academic assessment methods
- Sex differences and career choice
- Commercialisation of university research and women as entrepreneurs

### **Research approaches**

Bibliometric studies compare scientific productivity of male and female researchers, taking into account scientific field and professional category. A few studies attempt to develop new methods or critique existing methodologies. For example, multilevel modelling has been used to study institutional variations in the gender differences in achievement and their interpretation. Relationships between biological and social science theories have been questioned as tools for explaining, legitimising and naturalising social inequalities.

### **Findings**

- Female students' approaches to study are more desirable than those of male students when the gendered nature of their discipline accords with the gendered quality of the learning environment.
- More males use 'commitment' to mean task delivery, being proactive, being innovative, adding value. Women use the term to convey the meaning of involvement, being people-concerned, and availability. These differences have impact on consideration for promotion.
- Computer science curriculum places inappropriate emphasis on 'hard' areas such as mathematical formalism, which contributes to the exclusion of women from the higher levels of computing
- Trend towards neo-liberalism contributes to alienation of researchers from the product of their labour
- A cross-journal study suggests that peer reviews are not sexist, but differences in gender acceptance rates across journals gives grounds for concern.
- The research process in life science - from study design and selecting a species and its husbandry, through the experiment, analysis, peer review, and publications – is rarely subject to question about sex or gender differences in mainstream life sciences

research. There is evidence, though that sex and gender are determinants of many outcomes in life science research. Gender dimension should be embedded into basic scientific research.

- Using digit ratio, as an indicator of visual spatial abilities, to compare male and female academics in Science and Social Science faculties. Digit ratio consistent with female norm was found among male and female Science faculty and the ratio consistent with male norm among Social Science Faculty.
- Women academics are underrepresented and their talents as entrepreneurs are under-utilised in the commercialisation of university research and women as entrepreneurs.

### **Gaps**

Outside a few review studies in life science, there are no studies that question research excellence model or how we measure excellence. Empirical comparisons of scientific productivity of men and women in the same professional category and scientific specialty are absent. The barriers blocking women's access into the academic elite have been analyzed in some cases. There is a small but insufficient representation of studies that consider more specific aspects such as the formal and informal criteria of evaluation, the procedures of establishing the peer evaluation panels or the methods of selecting candidates at different levels, such as the awarding of pre- and post-doctoral grants, the hiring of university teaching staff or the promotion of the university teaching staff. There are no studies about scientific excellence in the research that takes place in the private sector.

## **2.6 Gender in research contents**

### **Research questions**

There are hardly any studies concerning themselves directly with the impact of gender on research process and its outcomes. The best work comes from life sciences where gender plays a role across a wide range of factors. This research demonstrates the need for similar investigations in relation to other fields.

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### **Research approaches**

The issue of gender in research process and content has been largely overlooked. The idea that science is gender-neutral and science-knowledge making is gender neutral has not been challenged outside clinical research. This may be due to the very entrenched disciplinary divisions in the UK science structure. The investigations in clinical research came from inside the field and not from social sciences.

### **Findings**

- gender dimension should be embedded into basic research in life sciences

### **Gaps**

The whole area of how gender influences science knowledge-making and its transfer into community of users. Studies of gendered innovations in specific scientific fields in the USA demonstrate positive benefits in terms of invigorating theories and methodological advances, as well as attracting more women to these fields. Furthermore, some studies available elsewhere (L'Oreal's study of its research labs and London Business School study of international knowledge teams) show that gender balance impacts positively on productivity.

## **2.7 Policies towards gender equality in science**

### ***Research questions***

- How both the principles and practices of equal opportunities between women and men were interpreted in a sample of 213 SOCRATES projects
- Digital divide and progress towards information society
- Women as ICT users and influences on ICT development
- Equality legislation and its impact on gender behaviour
- The raising level of female employment raises interest in policies towards resolution of the employment/caring issues
- Policies on child care stable permanent positions and women's careers
- Women scientists in 'New Europe' and the ERA objective of building the scientific resources of Europe.

### ***Research approaches***

Gender equality policies relating to employment have been strongly promoted in the UK, together with policies on diversity and inclusion. There is no consistent line of research about the evaluation of gender equality policies in the field of science. There are no studies looking at the translation of policies into effective intervention measures. Old cultures persist in universities despite commitments to gender equality.

### ***Findings***

- Inclusion and exclusion are not mirror images of each other, to achieve inclusion it is not enough to curb exclusion mechanisms, but to enhance positive measures of inclusion
- More women ICT users is insufficient to increase women's influence on IT development – more women need to be recruited into ICT professions
- Equality legislation has had little impact on gender behaviour within the work situation of female academics
- The raising level of female employment raises interest in policies towards resolution of the employment/caring issues but these policies contradict competitive labour market demands.
- French women scientists make 15% of professors, they benefit from good child care system and stable permanent positions in academia
- There is little evidence of gender equality for women scientists in the 'New Europe' and this threatens to undermine the ERA objective of building the scientific resources of Europe.
- In CEEC-10 the number of women scientists appears to be a positive sign for ERA in its bid to increase capacity, but the conditions under which they are working are likely to undermine that capacity.

### ***Gaps***

Critical overview and assessment of policies towards gender equality in science and science education is missing.

## **3. Conclusions**

Studies have been concentrated on the compilation of sex-disaggregated data and to provide descriptive evidence about the persistence of inequalities across different areas of science education and science employment.

Critical reviews and analyses of the accumulated evidence are rare and this introduces risk into policy design, if gender-relevance is either overstated or understated in relation to all other

explanatory factors. For example, the current preoccupation with boys' underachievement is motivated by the belief that understanding what happened to girls and the improvement in their academic performance is a policy model that can be now applied to boys. It is not clear, however, that this is the case.

The deeply entrenched disciplinary divisions, and the structure of research funding along disciplinary divisions in the UK form a barrier to the development of cross- and multi disciplinary investigations. The need to prioritise such research would have to come from within the existing structures. It would be very difficult to persuade research policy makers that such research is needed. Whilst feminist epistemologies have made an important contribution to raising the importance of understanding gender issues in relation to science, the deeply ingrained belief in science and engineering cultures that science is gender-neutral prevents women scientists to challenge the status quo. It is much easier for decision makers in science to see gender inequalities as problems solvable through employment and diversity policies.

The transmission of gender stereotypes in early socialisation processes and their influence on the choice of educational paths has been given much attention recently, because it is believed that the under-representation problem in science can be resolved by getting more girls to study science subjects, and thus increase the capacity of the pipeline at the entry level, which eventually will improve situation at senior career levels as well.

The main deficit of gender and science research in the UK lies in the lack of attention to the role of gender in scientific knowledge making and the way science research is communicated and commercialised. There is also lack of critical overviews of the accumulated research and critical assessment of the accumulated body of evidence.

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