Ea

Study of the Factors Affecting the Career Choices of Chemistry Graduates

A report from Ea

28 February 2000

Introduction

1. Background

Research undertaken by the Royal Society of Chemistry (RSC) has shown that:

- equal numbers of men and women consider a career in chemistry
- but men and women make different career choices:
  - more men than women consider or undertake post-doctoral research in higher education
  - women are more likely than men to take up positions outside higher education; for example, in analytical chemistry or in training and education
- within higher education:
  - a higher proportion of women study chemistry at first degree level than either physics or engineering
  - chemistry is less successful than either subject at subsequently drawing women into an academic career.

2. This Study

Against this background, the RSC resolved to commission a study to assess the factors affecting the differing career choices of men and women graduates in chemistry. Following competitive bidding, Ea was commissioned:

- initially to undertake the focus groups
- subsequently, to write a comprehensive report combining the results of the focus groups with further analysis of the quantitative work already undertaken by RSC.

Our report is in four sections:

1. **Women in Research** briefly considers the overall position of women in science, engineering and technology.
2. **Women in Chemistry** presents the results of further analysis by Ea of the RSC's quantitative work on the position of men and women chemistry graduates.
3. **Chemistry Careers in Higher Education** reports on the outcomes of the focus group research.
4. **Conclusions and Recommendations** draws conclusions from the two pieces of work.

3. Acknowledgements

We are grateful to:

- the chemistry graduates who took part in discussion groups
- the academic staff who helped organise the groups
- the chemistry graduates who were unable to attend discussion groups, but took part in telephone interviews
- staff at the RSC, particularly Sean McWhinnie.

This report was written by:

- Trudy Coe, who conducted the majority of the field work
- Andy Boddington, who carried out data analysis.

Judith Kirkham organised and recruited for the groups and, transcribed the recordings.

Women in Research

4. Women Researchers

Women are less well represented among students and staff in higher education than men. Below, we:

- consider the policy environment for women in science
- analyse HESA data for three years: 1994/95–1996/97.

For further details of the data used, see Annex 1.

The Policy Environment

5. "Realising our Potential"

The 1993 Government White Paper *Realising our Potential* stimulated policy interest in the position of women in science, engineering and technology (SET).[1] This report concluded that women were the UK's single most under-valued, and consequently under-used, human resource. In March 1993, the Chancellor of the Duchy of Lancaster established a Committee on Women in Science Engineering and Technology:

To advise … on ways in which the potential, skills and expertise of women can best be secured for national advantage and for the benefit of science, engineering and technology.

The report of the Committee[2] concluded that there were still obstacles that deterred women both from studying SET and from realising their full career potential. Nevertheless, there was:

A rising tide of awareness that the loss of ability and skills caused by gender bias is neither acceptable nor in the public interest.

The report made a number of practical recommendations, including the establishment of a Development Unit for Women within the Office of Science and Technology.

6. Evidence of Discrimination

Interest in the position of women in SET sharpened in 1997, with the publication of a Swedish study.[3] This found that women had to be 2.5 times more productive than men in order to get the same peer review rating. Following this, the Wellcome Trust reviewed its own decision-making processes[4] and found no immediate evidence that women are discriminated against. The Trust did find, however, that women are applying for research funds in much lower numbers than would be expected from their representation in higher education. It has since commissioned a study to investigate the factors behind these lower application rates.

7. Recent Developments

A number of public and private initiatives have been launched to reflect continuing concern about women's lack of progress in SET positions:

- **Go for IT.** In November 1998, the government launched the "Go for IT" campaign to encourage more girls to go for careers in science, engineering and technology.
- **Athena.** The Athena project was launched on 23 February 1999 to improve access, participation and promotion of women in science, engineering and technology in higher education institutions. Its ultimate objective is to achieve the same proportion of women in academic appointments in science as are

recruited as undergraduates. A more realistic nearer term goal is a 10% improvement over current rates by 2003.

- **Register.** The launch of the Women in Higher Education Register to collect, analyse and disseminate information on women in higher education, and to provide data, analysis and IT support for the Athena project.

Higher Education Students

8. Undergraduates and Postgraduates

The proportion of female undergraduate students in all subjects rose to over 50% in 1996. However:

- less than half of postgraduates are female (42%)
- even fewer physical sciences postgraduates are female (36%).

Figure 1 shows the change over ten years:

- there has been a 9% increase in female undergraduates
- and an 11% increase in female postgraduates.

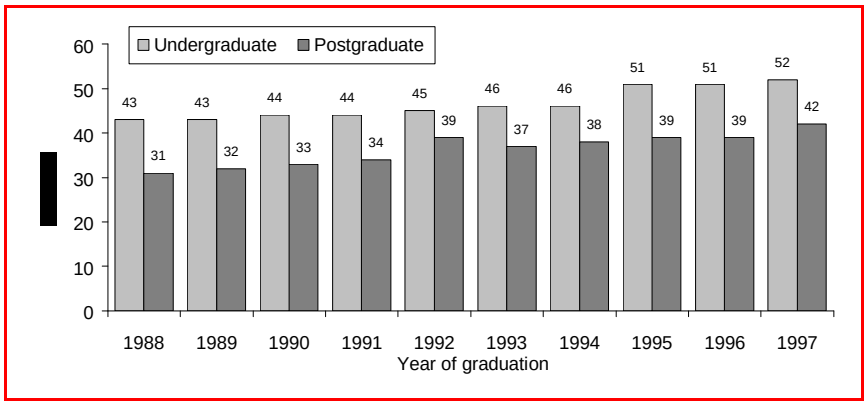


Figure 1. Percentage female students

Higher Education Staff

9. Horizontal Segregation

In contrast to students, there is a strong gender imbalance amongst staff in higher education institutions. In 1996/97:

- HEIs employed 41,520 women in academic roles and 85,048 men (33%F/67%M)
- women predominated in 416 cost centres compared to 1823 where men predominated (19%F/81%M; for further details, see page 41)
- smaller cost centres had a higher proportion of women:
  - predominately male cost centres (<40%F) are 3% larger than the average for the subject[5]
  - broadly balanced cost centres (40–59%F) are 6% smaller than average
  - predominately female cost centres (>60%F) are 12% smaller than average
- 100% female cost centres were smaller than 100% male cost centres:
  - the 28 cost centres employing all female academic staff had an average size of 2.3 staff
  - the 153 cost centres employing all male staff had an average size of 8 staff.

Figure 2 shows data for academic cost centres with more than ten staff (see page 43 for further details):

- there are 51 departments with more than 10 staff that exclusively employ men
- there is just one exclusively female department.

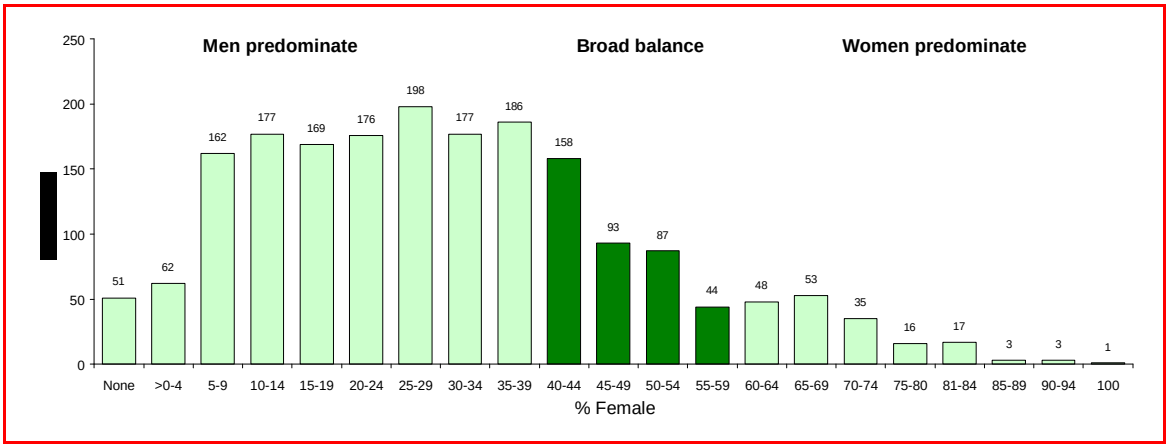


Figure 2. Gender balance in academic cost centres
(all subjects with more than 10 staff; 1916 cost centres)

10. Horizontal Segregation by Sector

A higher proportion of women are employed in the former polytechnics and colleges sector:

- former polytechnics and colleges: 37% female
- established universities: 31% female.

In part, the different subject mixes taught and researched in the two sectors explain this. However, there remain some differences by cost centre (page 44).

11. Vertical Segregation by Grade

Across all institutions, the percentage of women falls dramatically in the higher grades (Figure 3).

Grade	% Female Staff		
	All Institutions	Established Universities	Former Polytechnics and Colleges
Professor	9	8	15
Senior Lecturer	20	18	24
Lecturer	37	32	40
Researcher	39	39	41
Other staff	41	44	39
All	33	31	37

Figure 3. Percentage female staff by grade

Institutions in the former polytechnics and colleges sector have a higher proportion of women, including at senior grades. This difference is partly explained by the different subject mix between these institutions and the established universities.

12. Vertical Segregation by Cost Centre

In all cost centres, there are fewer female staff at the higher grades. There is, however, considerable variation by subject. Figure 4 shows the difference in percentage of female staff between:

- senior staff: professors and senior lecturers
- junior staff: lecturers and researchers.

The analysis shows that different subjects have provided different opportunities for promotion of women to higher grades:

- in agriculture, the proportion of senior female staff is 88% lower than the proportion of junior staff
- chemistry is second worst at 87%
- for nursing the difference is just 9%.

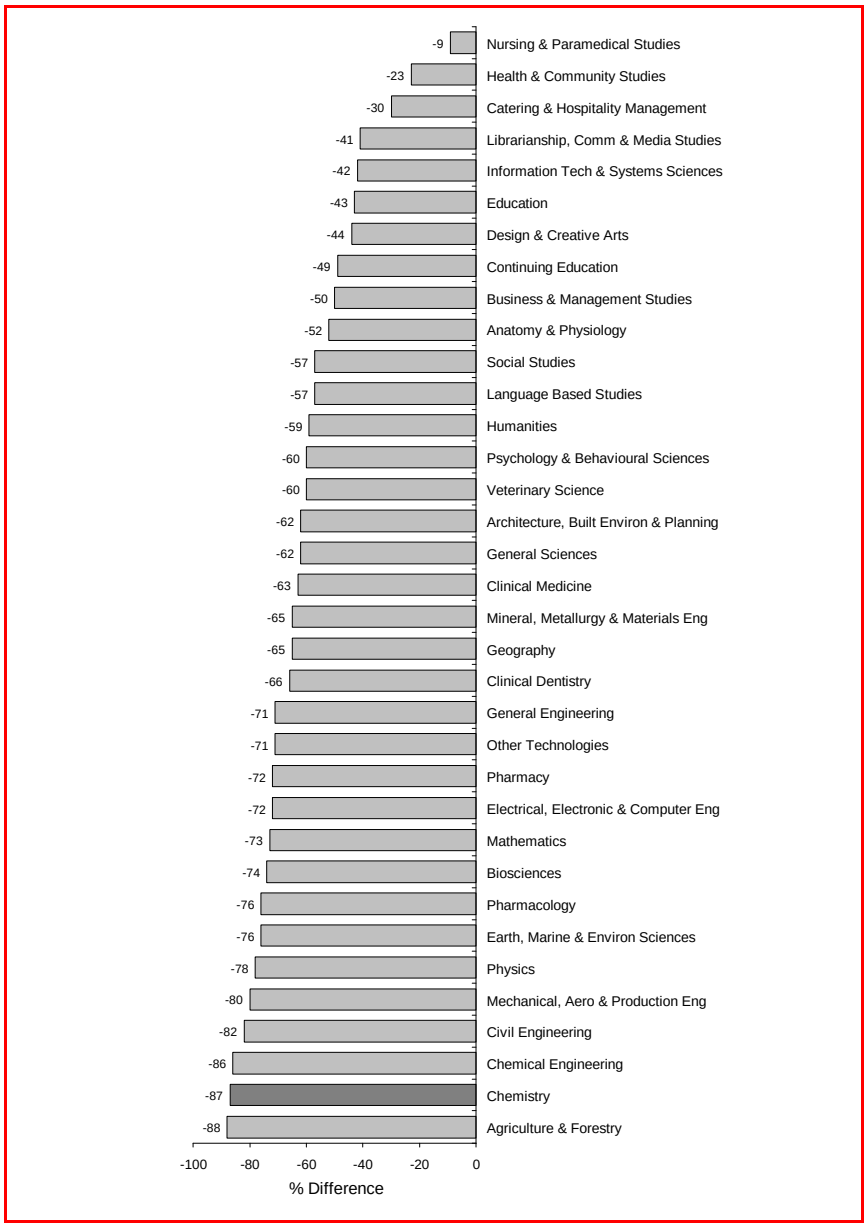


Figure 4. Difference in female senior and junior staff[6]

13. Funding and Security

Male academics are more likely to be solely funded by their higher education institution while women more often draw part or all of their income from external sources (Figure 5).

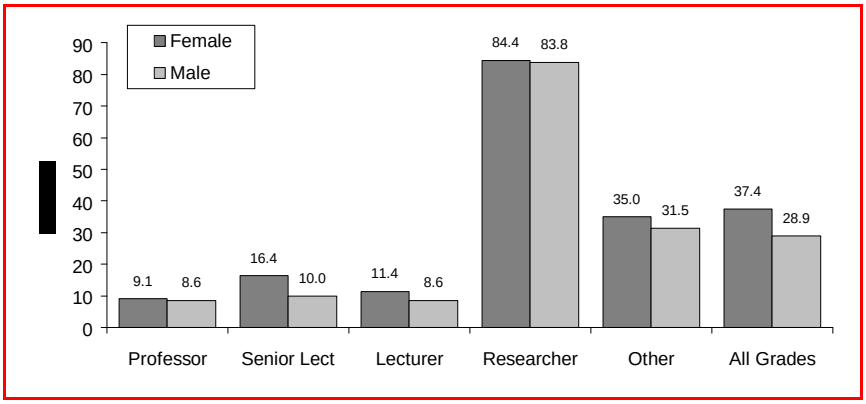


Figure 5. Percentage of academic staff partly or wholly funded by external sources

More than twice as many women as men work part time (Figure 6).

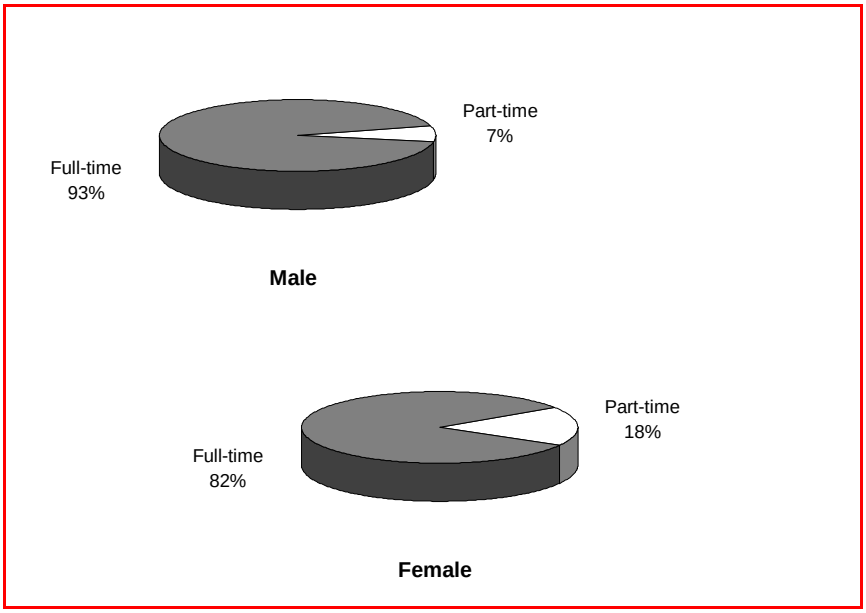


Figure 6. Full and part time staff

Data from a survey of interdisciplinary research suggests that women are more likely to be on short-term contracts than men:[7]

- 29% of women were on short-term contracts
- compared to 12% of men.

The survey also showed that, compared to men, women more often work as lone scholars rather than in teams (Figure 7).

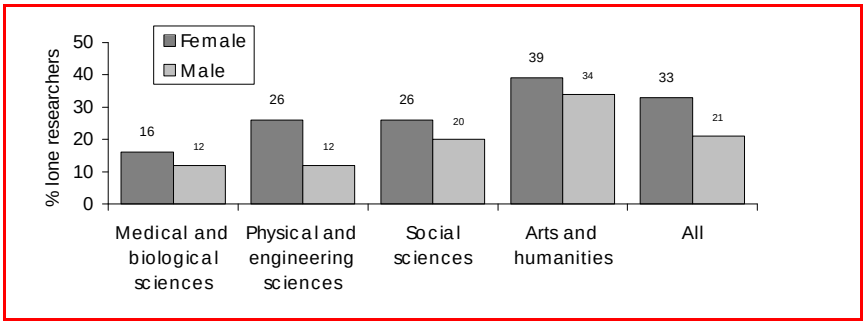


Figure 7. Percentage of lone researchers

14. Age and Status

Female staff are, on average, younger than male staff at the same grade, except for researchers (Figure 8). Overall:

- female staff average 39 years of age
- male staff 42 years.

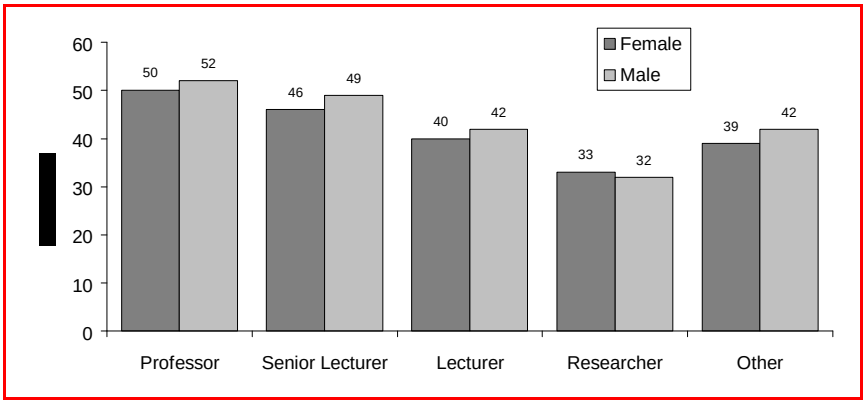


Figure 8. Age of staff by grade: all subjects

Data from the interdisciplinary research survey shows that:

- 12% of heads of departments are female.

15. Change

There was a small improvement in the proportion of women from 1994 to 1996 (Figure 9):

- 1994/95: 28%
- 1995/96: 29%
- 1996/97: 30%.

If this trend continues, women will make up 50% of academic staff in approximately AD2020. The rise in professorships for women has been slower and, unless the trend accelerates, it will take a further century to reach parity in around AD2120.

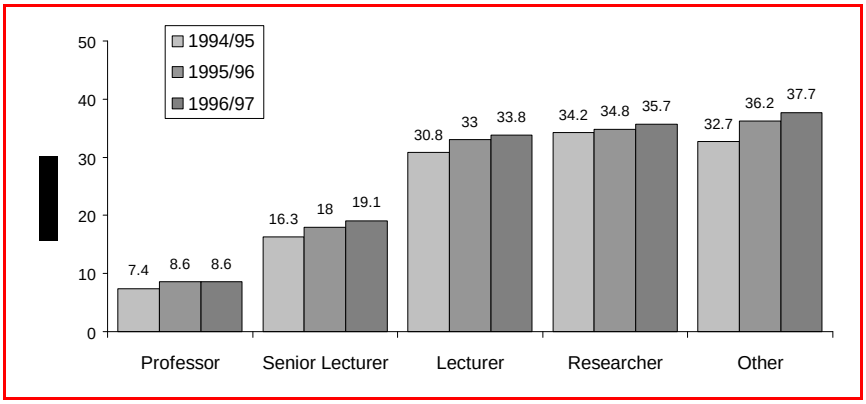


Figure 9. Percentage female staff by grade: all subjects

Women in Chemistry

16. Women Chemists

Women are less well represented in chemistry students and staff than in other subjects. Below, we analyse HESA data for the three years 1994/95–1996/67.[8]

Chemistry Students

17. Undergraduates and Postgraduates

The proportion of female undergraduate students in all subjects rose to over 50% in 1996, but remains at 37% for chemistry. At current rates, it will be about AD2028 before undergraduate numbers equalise in chemistry. Less than half of postgraduates are female, though the trend towards parity is stronger (Figure 10):

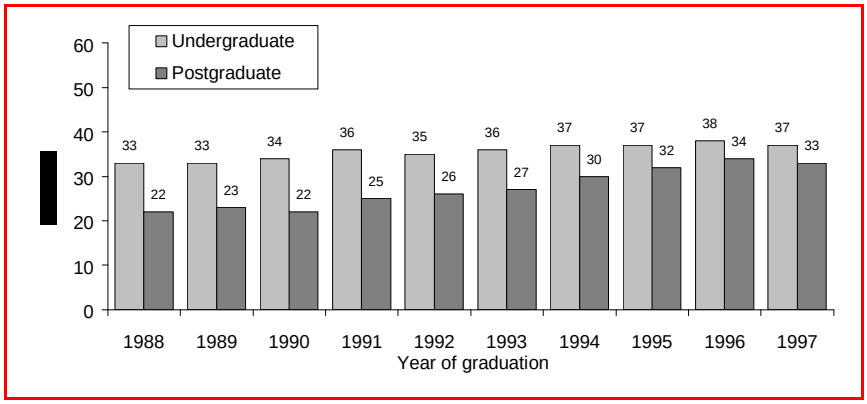


Figure 10. Percentage female students

Chemistry Staff

18. Horizontal Segregation

The gender imbalance in chemistry is worse than that for higher education institutions as a whole. In 1996/97:

- HEIs employed 3705 staff in chemistry of whom 587 are women (16% compared to 33% in all subjects)
- 3315 staff were employed in established universities and 390 in the former polytechnics and colleges sector
- men predominated in all chemistry cost centres but one (Figure 11).[9]

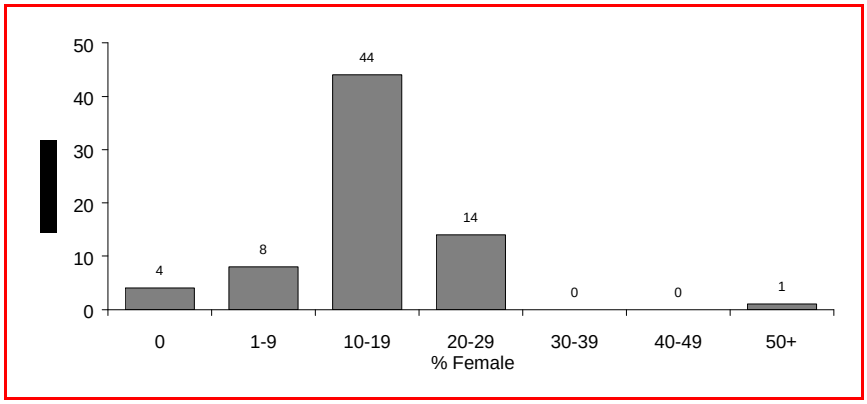


Figure 11. Percentage female staff in chemistry cost centres

There is no correlation between the percentage of female staff and size of department for chemistry. There is also no difference in the proportion of female staff between the established universities, and the former polytechnics and colleges sector.

19. Vertical Segregation by Grade

In common with other subjects, the percentage of women falls dramatically in the higher grades:

Grade	% Female Staff		
	All Institutions	Established Universities	Former Polytechnics and Colleges
Professor	<1	<1	0
Senior Lecturer	4	4	6
Lecturer	13	12	16
Researcher	22	22	32
Other staff	25	27	22
All	16	16	16

Figure 12. Percentage female staff by grade

Figure 13 shows how female representation declines in higher grade posts and reveals that the situation in chemistry is rather worse than in other subjects.

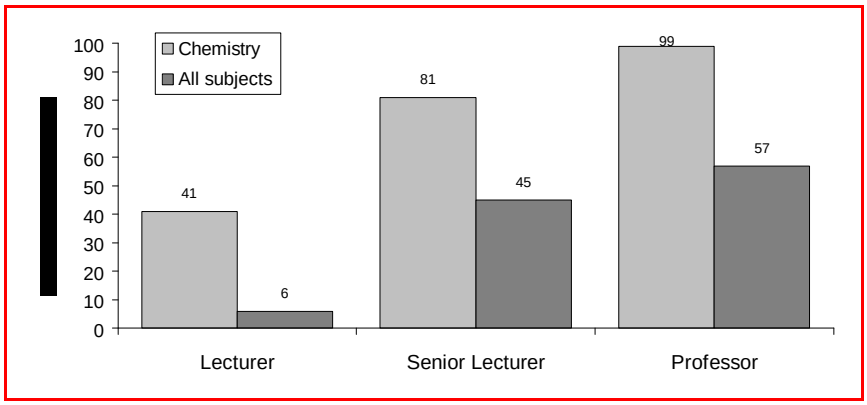


Figure 13. Percentage reduction of female staff between grades

Figure 13 should be read as follows. For chemistry, 22% of researchers are female. Taking this as a base figure, the representation of women is:

- 41% worse at lecturer level than it was at researcher level
- 81% worse at senior lecturer than researcher level
- 99% worse at professorial than senior lecturer level.

For data for individual subjects, see page 44.

20. Vertical Segregation by Cost Centre

Figure 14 illustrates all subjects, ranked by the proportion of women they employ at each grade. Again, it shows that chemistry fares worse than most other subjects in this respect. Only civil engineering, with no female professors, has offered worse promotion prospects than chemistry.

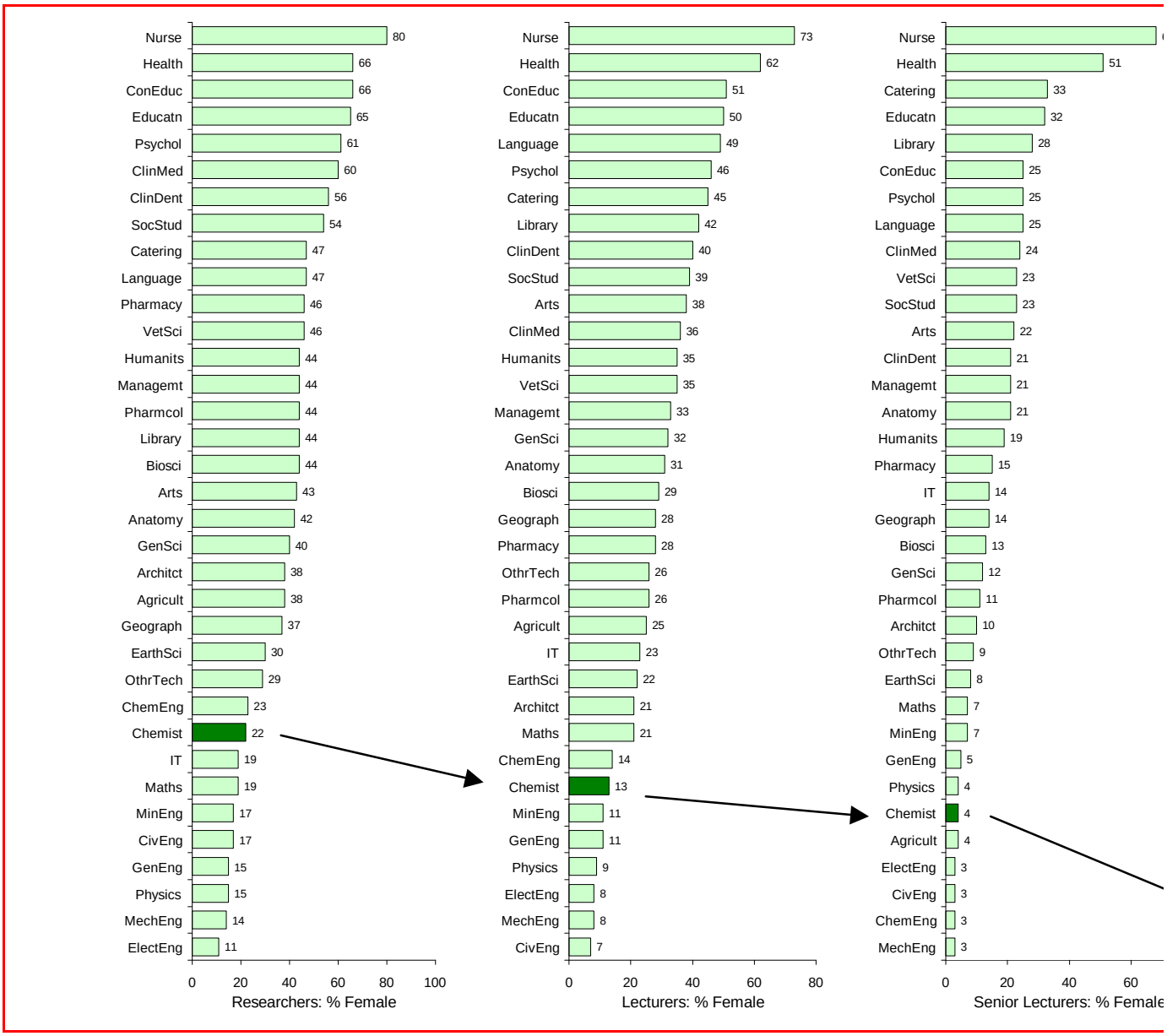


Figure 14. Percentage female staff at each grade

21. Staff: Funding

A higher proportion of women chemists than men were funded from sources outside their higher education institution (Figure 15).

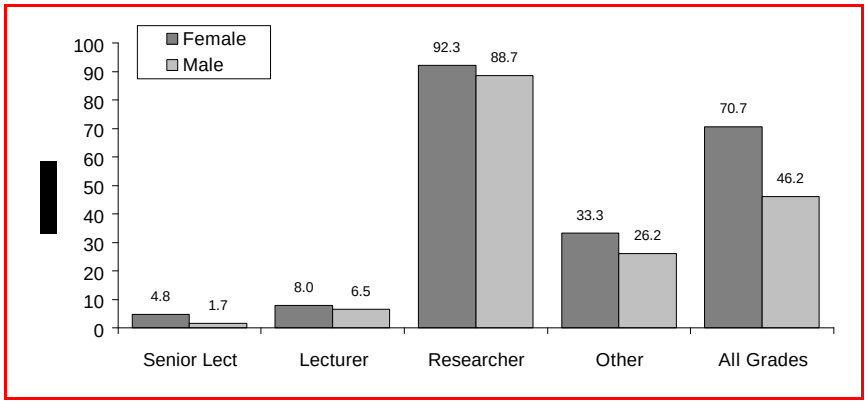


Figure 15. Percentage of chemistry staff partly or wholly funded by external sources

This suggests that women may hold posts that are, on average, less secure and perhaps shorter-term than those held by men.[10]

22. RAE Rating

Women chemists are fairly evenly distributed by RAE rating, though there is a concentration of researchers and other staff in departments rated 1 (Figure 16; see page 46 for further details):

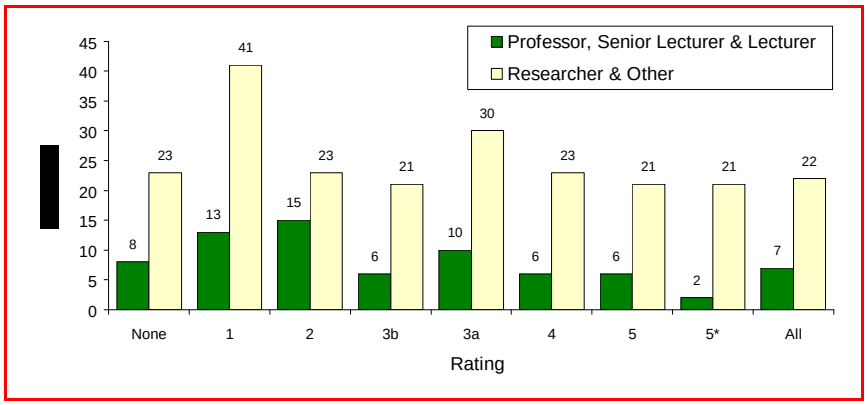


Figure 16 Percentage female staff by grade, gender and 1996 RAE rating

23. Age and Status

As in other subjects, female staff were on average younger than their male counterparts. Chemistry staff were also younger than staff in other subjects:

- women: averaged 32 years (compared to 39 for all subjects)
- men: averaged 39 years (compared to 42 for all subjects).

There are important differences by grade (Figure 17):

- senior lecturers: 46% of women are under 45 years compared to 24% of men
- lecturers: 37% of women are under 30 years compared to 19% of men
- researchers: 19% of women are under 25 years compared to 13% of men.

These data may suggest that a higher proportion of women is now beginning to filter through to higher posts.

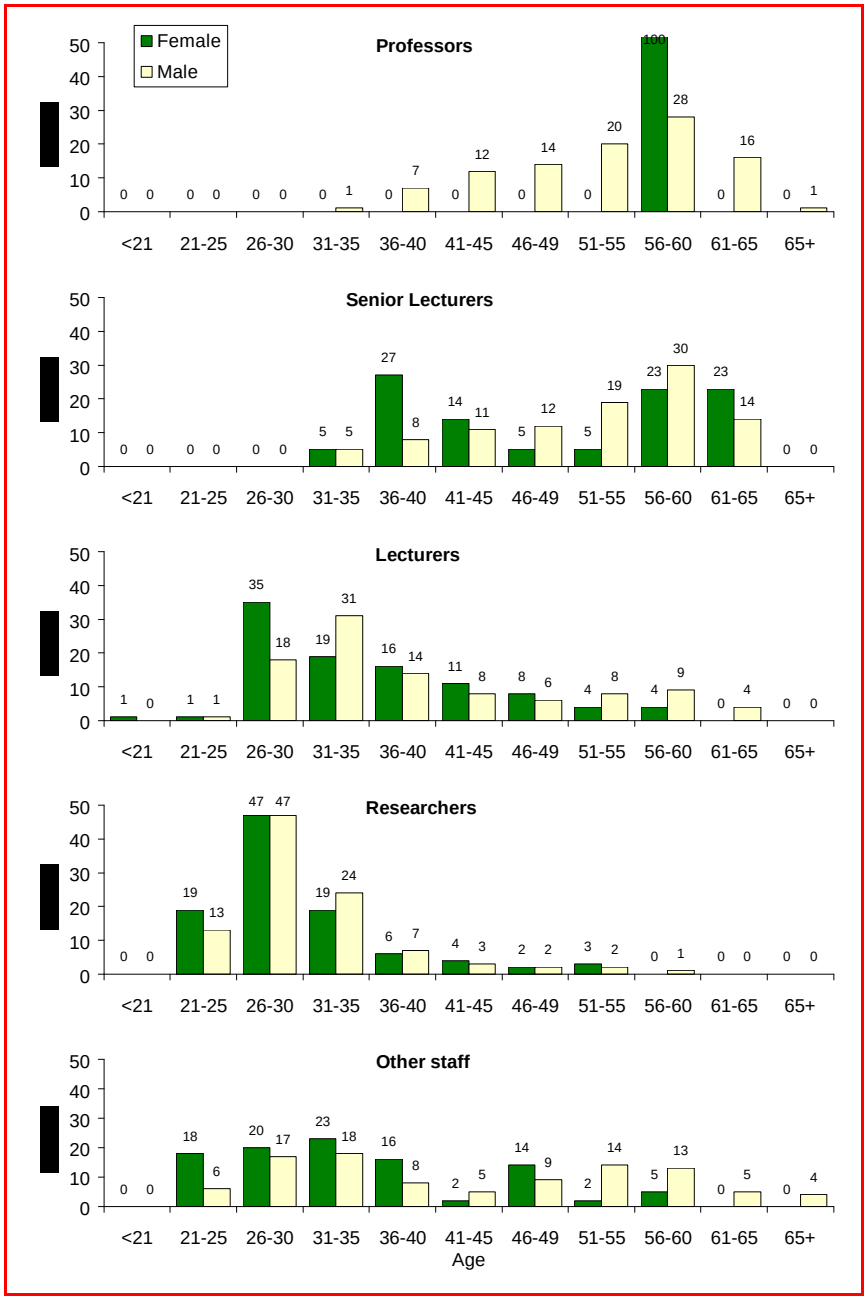


Figure 17. Age of chemistry staff by grade

24. Change

During the period 1994 to 1995, there has been only a small improvement in the proportion of female chemists. The number of full-time chemistry staff has risen by 173, 72 of whom are female (42%; Figure 18):

	Male	Female	All	%Female
1994/95	2844	451	3295	13.7
1995/96	3082	537	3619	14.8
1996/97	2945	523	3468	15.1
Change 94–96	+101	+72	+173	1.4

Figure 18. Change in Chemistry Staff by Gender

The majority of the new female staff, however, are researchers (57; 72%) and the proportion of female staff has only notably risen amongst "other" staff (Figure 19).

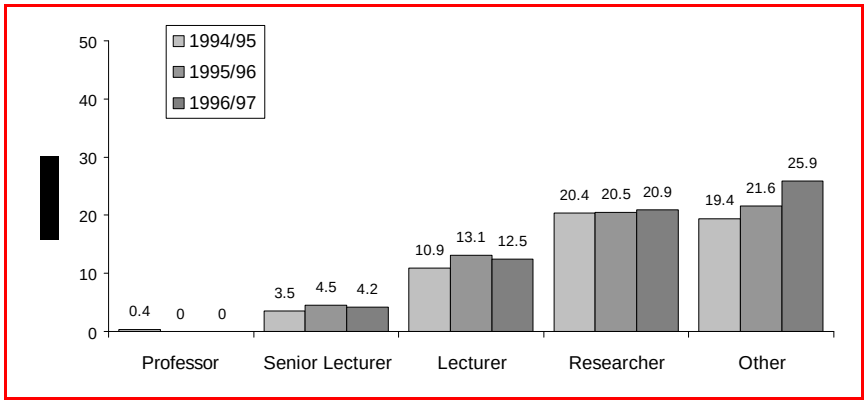


Figure 19. Percentage female staff by grade: all subjects

Over the three years there has been:

- a notable increase in the number of professors, with 46 new posts all filled by men (16% increase)
- a drop in male senior lecturers (70 posts, 13% decrease)
- a drop in male lecturers (40 posts, 6% decrease)
- 7 new female lecturers and 1 new senior lecturer.

This picture, if confirmed by 1997/98 data, suggests a squeeze on middle ranking posts. There is a danger that this will further inhibit the progress of women by reducing opportunities for promotion.

Chemistry Careers in Higher Education

25. The Discussion Groups

We hosted six discussion groups. Their purpose was:

To assess the factors affecting career choices for typical chemistry graduates in HEIs.

The aim was to develop an understanding of why women and men are making different career choices – in particular, why women are leaving academia in such large numbers. Following discussions with RSC staff, we decided that the purpose would best be met by convening the following groups:

- four groups in higher education:
  - in two separate locations
  - one male and one female group in each location
  - participants to be drawn from final year post-graduates, post-docs and recently appointed lecturers
- two groups of graduates working outside higher education:
  - in a single location
  - one male and one female group.

We recruited the groups on the lines of gender to ensure that participants had the confidence to speak, free of any gender issues that might arise. Details of the recruitment methodology are at Annex A. Throughout the text we reproduce participants' comments anonymously giving a broad designation for the speaker. Where necessary, comments have been edited for brevity.

Motivations for Studying Chemistry

26. Differing Motivations

There were strong differences between the motivations of men and women for choosing chemistry:

- women were more likely to stress its initial appeal to the emotions and imagination
- men were more likely to stress its relevance to the real world.

Both groups stressed the importance of teachers' inspirational ability. The samples are too small to draw out any differences in motivation between those still working in higher education and those who have chosen to leave. But this point would merit further research:

Is there any correlation between a student's reasons for selecting chemistry and their eventual career path?

Our groups included examples of:

- those inspired by the subject from toddlers from both inside and outside higher education
- those who had just drifted into it as teenagers.

Below we summarise the views of discussion group participants under four headings:

- the appeal to the emotions
- real world relevance
- the importance of teachers
- the attraction of a PhD.

27. The Appeal to the Emotions for Women

Five women cited emotional reasons for being attracted to chemistry:

I have a clear memory of reading a coffee table book that had liquid crystals in it. That really captured my imagination. *[Woman working in research in industry]*

Pretty colours! *[Woman post-doc]*

The other experiences of women were diverse and included:

Subject strength (2 women)

It was what you were good at when you were at school. *[Woman working in research in industry]*

Job opportunities (3)

I was better at languages but the jobs in languages didn't appeal. It seemed to have more opportunities for me that I would enjoy. *[Woman working in research in industry]*

Just drifting (2)

I just drifted into it. I don't feel there was any active choice on my part, I was just being very lazy ... I chose science A levels because they seemed sensible. *(Woman working in research in industry]*

Exceptions

There were also examples at each end of the spectrum of:

- women who had been pushed into science, because of the lack of girls:

  I kind of got pushed into science, at the time schools were really pushing you into science *[Young post-doc, Midlands]*

- those who had been discouraged from doing science:

  It was very difficult to do sciences at 14, 15, women weren't encouraged to do sciences. I don't think I ever had a particular aptitude for science, but at that stage, I was really kicking against the system. *[Older post-doc, Midlands]*

28. Real World Relevance for Men

Men were more likely to cite the practical, systematic nature of chemistry (5 men):

It was the one subject where everything seemed to fit into place. *[Chemist in government department]*

Chemistry was one of the few subjects that answered questions. *[Chemist in industry]*

For me it was the periodic table, it was real world but systematic. *[Academic, London]*

My experience of physics lecturers was that they gave you a series of mathematical models that were so remote from reality that one simply couldn't believe them. Chemistry was practical, related to the real world. *[Academic, London]*

Other reasons included:

Being good at the subject/finding it easy (4)

Chemistry seemed an easy choice. *[Scientist, government establishment]*

I did chemistry because I thought "I can do it." *(Industrialist]*

Making and finding out about things (2)

I like making things, pottering about in the lab, creativity. *[Academic, London]*

I was inquisitive, wanted to make things interesting, find things no-one else had. *[Academic, London]*

Traditional inspiration (2)

I think I was inspired when I was a toddler almost, because I used to go up to London virtually every weekend to the Science Museum and stuff like that and I just got into physics and chemistry really early. *[EPSRC Fellow, Midlands]*

[I was turned on] by my first chemistry set. *[Research chemist, industry]*

Just drifting (3)

I'd like to say it was because there was one defining moment, but there wasn't. I just meandered through and I've been very lucky in that I've found something I like and pretty much straight away, but I can't claim it was through any planning. *(Academic, Midlands)*

Perhaps you just end up falling into it.

29. The Importance of Teachers

Equal numbers of men and women cited the importance of inspirational teachers (5 each):

It was the science teacher at school – she was a chemist by degree and really enthusiastic, she instilled that in us. *[Woman working in industry as consultant]*

My teacher really sold it to me. *[Chemist in government department]*

With an enthusiastic teacher, you just catch the buzz. *[Scientist in industry]*

I don't think I ever thought career. It just never came to me like that. The teacher was just more human than anyone else. *[Chemist in industry]*

30. The Attraction of a PhD

The reasons for taking a PhD were common across the groups and split into three broad categories:

Deliberate pursuit of a career (6)

If you aspire to any level of promotion in industry or if you want an academic career, then a PhD isn't an accessory it's obligatory. *[Male post-doc London]*

The big chemistry recruiters like ICI, Astra Zeneca won't look at you unless you've got a PhD or if you haven't you won't advance. *[Male chemist, large pharmaceutical company]*

Awareness that it would be difficult to get a job without a PhD (3)

You're not seriously employable after your first degree in any position of responsibility. *[Male academic, London]*

When I finished my first degree, a PhD was the easy option. The jobs market was not that buoyant. So, I thought three years and then the job market might be better. *(Woman in industry)*

Just drifting

After doing my degree, I didn't feel I was grown up enough to get a job in industry. I thought I'd stay in universities for a few more years. *(Woman in industry)*

Reasons for Leaving Higher Education

31. The Nature of Chemistry

Those who had left immediately after their PhD, without considering an academic career, gave four main reasons. These were common to both men and women and relate to the nature of higher education.

Lack of passion/interest

If you want to go into academia in any subject, you have to have a real passion for what you're doing. I don't necessarily have that. *[Female final year post-grad, Midlands]*

My interest wasn't sufficiently strong enough to keep me in academe, so I thought I may as well cut my losses after PhD, don't put it off any longer and do a post-doc and potentially be more specialised and less employable. *[Male chemist, industry]*

It was too difficult

I was put off academia by the constant round of trying to get money to do the work and the confidence to be able to teach as well. *[Male chemist, industry]*

I'm not mentally suited to that type of environment. I saw some extremely good post-docs when I was doing my PhD who ended up their contracts and couldn't find work. And I wasn't as good as they were and that frightened me. *[Male scientist, government establishment]*

It was too all consuming

In academia, a lot of my friends who are very good chemists just eat, sleep and drink it … I just don't have that level of interest. *[Male chemist, industry]*

You have all these people that are really turned on by science and I thought "I'll do the best I can." But it's their life almost and I thought "Get the hell out the lab." *[Industrial researcher]*

It was too narrow

When I was an undergraduate, I actually quite liked the idea of being an academic and one of the things I loved about chemistry was that it was such a broad subject. There were so many interesting things to do and then you walk into a PhD and you find yourself locked in a tiny area and suddenly all the things you found fascinating you haven't really got time to pursue them … and you realise then if you carry on you're just going to be working in smaller and smaller areas, and do less and less and less of all the other stuff and all the things you loved will be disappearing. *[Female Final year post-grad, Midlands]*

We don't have any specific experts in one particular field, which if one of the reasons I love working in that company because you can be working on anything in any area and in any subject … in academia you don't have that broadness. *[Male researcher working in industry]*

32. Dual Career Couples

There was some anecdotal evidence in our groups that women were more likely than men to give up their career to follow a spouse. Two women cited their partner as a reason for leaving academia:

By the time I'd finished my PhD, I'd met my husband, he'd got a [promotion], neither [of us] wanted to move as it was an ideal house, so I targeted the local companies. *[Section manager, industry]*

Myself and my partner had never lived in the same place for seven years. So when I finished my post-doc, we sat down and said "one of us has to make a decision." I was out of a job first ... I decided to move back to London and apply for local jobs only."

This correlates with the results of a recent US study,[11] which found that women physicists face special obstacles in their career progression because they are much more likely than male physicists to be married to a physicist or other scientists: nearly 45% married female physicists have physicist spouses compared to only 6% of males.

Chemistry as a Subject

33. Chemistry is Good

There was little difference in the views of the good and bad points of chemistry as a subject between those inside or outside academia or between men and women. Its attractions were:

Getting results (3)

It's like baking a cake and you get a light sponge. [Female researcher in industry]

It's really nice to go back [to the lab] and show that you can make it work and can scale it up]. [Researcher in industry]

Sometimes the light bulb goes on in your head and you think "I actually understand this and know what's happening." [Researcher in industry]

Solving problems

Non-mathematical problem solving. [Young woman lecturer, London]

You know there's going to be an answer somewhere, you always feel you can get somewhere. [Final year post-grad, London]

Order and logic

How things were put together, order and tidiness. [Final year PhD]

I like the order and the neatness. [Final year PhD, London]

Creativity

Chemistry is somewhere between creativity and accuracy. I love the creative aspect of science altogether but there's more of a quantitative feel to science than some of the life sciences. [Male post-doc, Midlands]

We're the only people who actually make new things. [Male academic, Midlands)

34. Chemistry's Poor Image

The main concern of both men and women was the poor image of chemistry:

It puts a lot of people off you. If you say you're doing chemistry, they think you're polluting the world. [Male post-doc, Midlands]

If ... you say you're an astrophysicist, people will be like, "Wow, that's really good" but if you say you're a physical chemist, I'm an organic chemist, they'll be: "that's not very interesting." (Female post-doc]

There is no perceived benefit from what a chemist does. [Male lecturer, Midlands]

35. The Effect on Men's Job Prospects

However, men were more pessimistic than women about the effect this had on their employment chances:

With a physics PhD … many employers, OK, they might think you're a bit of a nerd, they at least think you're smart and you know a lot of mathematics and that opens lots of doors. But if you're a chemist, even a physical chemist, you don't really have that cred, you're still like a nerdy scientist ... so it's not really clear to people what your core skills are. *[Male post-doc, Midlands]*

The perception is that physicists are bright and chemists aren't. *[Male post-doc, Midlands]*

This guy said: "are you one of those computational guys or are you a pot boiler" and that summed it up – you were slightly intellectual if you were into theory or you were a pot boiler. *[Male lecturer, Midlands]*

36. The Prospects for Women

By contrast, women generally thought chemistry post-graduates were highly regarded by employers. They felt the skills they had acquired during their PHD were in demand and could be applied in a variety of settings.

I'm using my PhD as a stepping stone because I've got all these skills, all these boxes on application forms and assessment centres, all the things they want you to tick, team building, time management, all that kind of stuff. *[Female final year PhD, about to go into marketing management for a large retailer]*

Their male colleagues tended to agree:

Jobs outside are more attractive to women – and they are better equipped to do them. More likely to see the external value of the skills they have acquired during a PhD; and better able to market those skills.

A lot of the jobs you can do with chemistry, outside chemistry are more management jobs ... require skills that a lot of young men haven't got but a lot of young women have in terms of personal skills, communication. *[Male chemist in industry]*

This chimes with the views of an earlier study which looked at the attitudes to research careers in science of women undergraduates in physics and biochemistry. It found that women were more inclined than men to see a science degree as general training for life (72% against 55%).

Higher Education Chemistry: The Good

37. The Attractions of Academic Freedom

At its best, it's a fantastic job. It's exciting, challenging, you get to work with smart people, pleasure to work with, but it doesn't get to its best as often as you'd like. *[Male academic, London]*

Again, women and men were broadly in agreement about the positive aspects of working in chemistry in higher education. Key among these was "academic freedom" – however much this was seen as being under threat:

That overall control over what you actually do and how you manage your time. *[Male lecturer, Midlands]*

What you still have in an academic environment is intellectual freedom even if you don't have real time freedom any more. *[Male post-doc, Midlands]*

You don't have freedom to do what you want to do, you have freedom to do what you can afford to do. *[Academic, London]*

Managing your time, being responsible for what you do. *[Female final year PhD, London]*

Most academics are very good at twisting ... you get the cash and then you do whatever the heck you want with it. *[Young male lecturer, Midlands]*

I think it's amazing that someone pays me to do whatever the hell I want. *[Male post-doc]*

38. Other Benefits

The other positive benefits were seen as:

Flexibility

The benefits are great, it's not as strict a regime. *[Female, final year PHD]*

Variety

I like multi-tasking ... working in higher education means that applying my chemistry takes a lot of different routes and some of those I might not like and find tedious ... but I can productively switch off from them for two hours. *[Female post-doc]*

Making a personal impact or contribution

I always thought that if I went into a company I would be just, not quite a pair of hands ... but if I managed to make any huge or great discoveries, then it's essentially under the umbrella of the company, whereas hopefully in academia, I'll be able to make some impact. *[Young female lecturer, London]*

There's always a chance you might discover something really big or at least make a significant contribution and you know you're going to get the credit for that, and in industry you never know that. *[Male post-doc Midlands]*

Achieving results

My PhD, I'd been working for three years, my whole time was devoted to this thing and all of a sudden, it works and ... you get a real high off that. *[Male lecturer]*

The one area of difference appears to be in the area of public recognition. Three men stressed the importance of getting their name in print – none of the women mentioned this. However, this may be a function of the more junior profile of the women and more work needs to be done in this area:

Publication is a big drug as well, the whole buzz of seeing your name in print ... I have a paper at the moment that's been cited 45 times in the last 2 years and that's a big buzz for me. People are reading this, they understand it, they want it, they refer to my work. That particular piece of work is making an impression on people all round the world, that's very gratifying. *[Young lecturer, Midlands]*

Seeing my name on the paper, its one of the great feelings. You can open up a journal and there's your work and it's alongside the great names of your profession and it's a good feeling. *[Male post-doc, Midlands]*

Your next worry is, we've got to publish this before someone else does this ... the main thing is the personal satisfaction knowing that I didn't know that before and now everyone knows this and you go into the chemistry library and just a couple of pages are taken up by your work. *(Male lecturer, Midlands)*

Higher Education Chemistry: The Bad

39. The Chemistry Environment in HE

While men and women generally agreed about the advantages of working in higher education, there were differences of view about the drawbacks. Both men and women had concerns about:

- the long hours culture
- pay
- the career structure in academia.

In addition, women had major concerns not shared by men:

- the poor working conditions in laboratories:
  - health and safety
  - lack of equipment
  - lack of technical support
- too much emphasis on results rather than process
- isolation and segregation.

We first consider the issues common to men and women, before considering women's concerns

40. The 24 Hour Culture

Both women and men saw the long hours culture required by chemistry as a major issue:

You have to be the sort of person that is willing to sacrifice everything just for that [job satisfaction]. *[Male lecturer]*

I have no real social life. It all dropped off at the expense of chemistry ... Your hobby becomes drinking with chemists. *[Single female lecturer]*

I gave up many, many hobbies to do what I do. I just stopped things and made a lot of sacrifices and I'm fortunate that my wife is a chemistry PhD and she understands that I have to do what I have to do and that's it. *[Young male lecturer, Midlands]*

I was extremely surprised that as a female with a child I was appointed because it is very, very unusual. Normally the typical image of an academic is they are, male or female, it doesn't really matter, but they are single minded, they don't have any distractions. *[Married female lecturer]*

You're running basically three full time jobs: you're expected to be full time teacher, which is incredibly time consuming ... basically during term time, 90% of your time is taken up teaching ... then you're full time fund raiser, because if you don't get cash in ... you might as well pack it in ... and you've got to be full time researcher as well and you've got to teach your research students. And at any one time your head of department will tell you that any one of those is the most important thing and you're expected to do them 100% ... There seems to be this constant pressure you have to be excellent at everything. *[Young male lecturer, Midlands]*

Some participants also felt that, while there was a genuine need to work such long hours, a culture had also developed where you had to be seen to be working to be taken seriously in academia:

Even people who appear to have it all fall on their lap don't get the respect of academia ... people who don't do the hours and are not seen to be working every hour of every day. *[Young male lecturer, Midlands]*

41. Is it Worse in Chemistry than Elsewhere?

Both male and female participants agreed that the position was worse in laboratory-based subjects in general:

It's when you get to do lab work there's a real crunch. [Male post-doc, Midlands]

However, they felt the pressures were even greater in chemistry, in particular organic chemistry, because of:

- the unusually competitive culture
- the culture of independence, including pressure to produce results
- the expense of doing chemistry.

Organic chemists have a hard time because there are no prizes for second in organic chemistry. (Woman academic, Midlands)

From day one you are independent and you are expected to produce lists of your publications every six months and its so pathetic ... whereas in other sciences ... there's a very structured academic layer ... you do get much more support in other departments. [Male lecturer]

Chemistry is very expensive. First of all you have to pay for salaries of research students, without research students you're going nowhere, without post-docs you're going nowhere, without chemistry equipment you're going nowhere, so its very, very expensive, so you have to spend a lot of time raising cash, then you have to spend a lot of time making sure that the people you've got are actually doing the work. [Male lecturer, the Midlands]

42. The Pressure Points

Among those who had experienced it, there was general agreement that appointment to first lectureship was a particularly difficult time:

It's the first time you haven't been under your supervisor's wing, you're standing on your own two feet, you feel very exposed, you're wondering whether your ideas are going to work, you're wondering whether you're going to get funding, you're wondering whether your approval sheets on your lecture courses will come back right. [Male lecturer]

There's a massive increase in stress levels when you finish your post-doc, an absolutely massive increase in stress levels. (EPSRC Fellow, Midlands)

However, one female respondent felt that women were particularly vulnerable to pressure at the post-doc stage:

Post-doc is a very vulnerable time for women in particular ... a lot of women question themselves and whether they're cut out. They lack confidence and a belief in their ability to have new ideas of their own ... Men don't. It's not about having a family. It's more about questioning your ability. [Female lecturer]

43. Pay

Low pay is common across academia and was almost taken for granted by participants:

We're not stupid, if we were in it for the money, we'd have gone somewhere else a long time ago. [Young male lecturer, Midlands]

It was seen as important in the context of this study in three ways:

- there is a much greater differential in chemistry between academic salaries and those outside

- the contact time in laboratory based work, particularly chemistry and especially organic chemistry, is greater than in other disciplines, meaning that women with children will almost certainly need full time child care – which they can barely afford
- there is still an attitude among senior staff in established chemistry departments that any discretionary pay awards should go to male rather than female staff.

44. Higher Pay in Industry

The concern among the more established participants was that people were not just leaving academia but leaving chemistry, because of the premium placed by the City and other professions on the skills acquired by chemistry graduates and post-graduates:

The difference between being an industrial chemist and an academic chemist pales into insignificance [against] the difference between being a chemist and not being a chemist. *[Junior lecturer, London]*

You have to remember that the City is desperate for scientists, you can leave at the end of a post-doc and still walk into a job in the City, if you want it … £40k a year.

I know a final year student who has left to get a job in the City without any experience whatsoever and his starting salary is more than mine. How do you say to that person "No, you're good, you're near the top of our list in the year, you should be a chemist." He would laugh at me quite frankly. *[Junior lecturer, London]*

45. The Impact on PhD Applications

The four junior lecturers responsible for recruiting all agreed this was affecting applications for PhD places and that the position was worst in organic chemistry:

This year, we suddenly found it massively harder to get PhD students, compared with previous years ... there are places going begging, it's quite unprecedented. *[Junior lecturer, London]*

The quality of our PhD students for a number of years has not been as high as it should be. Everyone's pretending that everyone's as good as they were but it's just not true, and we ought to admit it to ourselves that we're starting to produce a second rate calibre of researchers. *[Junior lecturer, London]*

I'm not saying that good people don't come into [organic chemistry] ... I'm saying that the percentage is becoming less and less. In recent rounds of interviews, we've struggled to find good people. *(Lecturer, Midlands)*

I don't think that's true in inorganic – there's no option to go into industry. *(Lecturer, Midlands)*

There's a funnelling off at all levels. A lot of people that would have been good chemists that never actually apply to university. Ones that go there, a lot of our best students, think: "this is silly, I might be able to pass the exams very well, but you can't eat very well on just the ability to pass exams." And if they don't see it then, they see it at post-graduate level … and by the time you get through to the more senior, more permanent positions, we've already siphoned off a large proportion of people that would have been competitive for the job. *[Junior lecturer, London]*

A number of the participants in London suggested that students were now much more worldly and therefore more aware of the low salaries in chemistry at the point they made their decisions about undergraduate courses:

They know how much or how little they're likely to be paid at age 17 ... it seems to be a lot more emphasis on final remuneration earlier on and I suspect that because they know it's not well paid, we will never see a reasonable fraction of people who could potentially be very good scientists. [Academic, London]

46. Childcare

Most women who work view arranging and funding childcare as their responsibility. For young female academics, the issue of low salaries is therefore even more acute:

When I had my second child, I earned £10 a week after paying the childcare. And that's when salary becomes very important. And that has crossed my mind on a number of occasions: "Oh God, maybe I should have gone into industry." (Junior Lecturer, London)

Here, as a post-doc, you can decide to have a child and you want it to go to the university, but the chances are that the nursery fees will not be subsidised, because of the demands of undergraduates and it will cost half your salary. So, at the age when, in your late twenties, it's not unusual to want to have a family, you pay £400 a month in childcare fees. [Post-doc, Midlands]

47. Career Structure

Men's concerns were largely about short-term contracts and the length of time it takes to get an academic job. A number of the male post-docs were very concerned about their ability to secure a full-time post; and whether it would be detrimental to their chances if they were to spend more than five or six years on short term contracts:

I know many people who were my contemporaries who were post-docs for four or five years, who got close to giving up on academic jobs. It takes so long to beat your head against this wall. [Male lecturer]

I have a sense of frustration. I've been a post-doc for nearly nine years ... 20 or 30 applications I've made.

The women in our groups were less concerned by this issue – perhaps because many have already left by this stage. Their career concerns related to the hierarchy within chemistry and the lack of a career structure for those not on the professorial track:

The infrastructure of chemistry where you need so much manpower to get experiments done means that there is a bit of a culture of lab monkeys ... it does mean there's a very rigid tier structure between the person who leads the research and you need people in the lab to do the experiments. [Post-doc, Midlands]

If you enjoy doing experiments and you want to stay in the lab as a chemist and enjoy the hands-on collection of data, then there doesn't seem to be any way of actually progressing a career. [Post-doc, Midlands]

Some areas require washing up and you're never going to get a senior person who wants to progress up the career ladder going into the laboratory and washing their glassware. [Post-doc, Midlands]

Higher Education Chemistry: The Ugly

48. Health and Safety: Female Attitudes

Women were hugely concerned about the neglect of health and safety issues in chemistry in higher education. They were worried about the short and long term consequences of this:

They're stuck in the 1950s, very poor ventilation or anything to prevent you being inundated by the chemical ... very cramped conditions, the environment was very bad. You've always got this worry that what you're using could be very bad for you in the future. [Female industry researcher]

You had someone in my group working with cadmium who wasn't the tidiest of people so we were on edge the entire time. [Female school teacher]

Health and safety measures are not really followed or you don't really take them seriously. [Female final year PhD student, London]

It's something that bothers me. You know the regulations, you know what you have to do. But sometimes as careful as you can be, other people can be less careful than you. It bothers me what the long-term damage [to me] is. [Female final year PhD, London]

49. Health and Safety in Pregnancy

This was seen as partly a funding issue: one of the female lecturers had applied for post-doctoral cover to carry out her demonstrations while she was pregnant. She was told no funding was available and continued to do demonstrations herself rather than let students down. No-one at any point expressed concern about her welfare:

Academia is not concerned about image or liability in the same way as companies are: the only issue for them is a financial one.

By contrast, one of our telephone interviewees became pregnant while working for a large pharmaceutical company and found that the occupational health specialists were more concerned than she was. They immediately pulled her away from the bench and gave her supervisory work:

It's done much more properly and is more supportive.

50. Health and Safety: Male Attitudes

Men agreed that health and safety was an issue in academia – but not one that deterred them. They were much more cavalier:

Chemists in general tend to be extremely lax about safety issues. I was, I still am. [Male chemist, government research establishment]

Health and safety issues in academia seem almost non-existent. (Man in industry)

I used to do a COSSH assessment once a year, sign it, put it in my drawer, and forget all about it. (Man in industry)

Most chemists who had worked in industry felt that conditions were better there, although there was still an element of paying lip service to health and safety issues:

Basically, we know when people are coming to check. (Man in industry)

If anything, men working in industry were more concerned by the bureaucratic constraints imposed by health and safety regulations than by the underlying safety issues:

I was in America a few years ago and I got more accomplished in a month than I had done in the previous year. I didn't do one single bit of paperwork. [Male chemist, government research establishment]

51. Lack of Equipment

Only women raised the issue of poorly equipped laboratories. It is not clear why men did not see this as an area of concern:

If you take away the big bits of equipment, my school is better equipped and laid out than my university ... you are expecting people who are going to be the scientists of the future to work under sometimes terrible conditions. *[School teacher, independent school]*

We give equipment that's twenty years old away to universities. They pick it up and go: "yes that's modern!" They absolutely adore it. *[Industrial researcher]*

It almost put me off wanting a job in industry because I thought, naively, that I knew it would be different, but if I had to go on struggling like this, if you had never been out in industry as an undergraduate you've got no perception of what it's like because the labs are so outdated in universities. *(Academic, Midlands)*

52. Lack of Support

Again, women were more frustrated than men by the lack of technical support:

It took me all morning to find some test tubes. It was so frustrating getting it to work and finding someone to help. I had to traipse round the building three times to find someone who had operated this machine who could give some level of support. *[Industry researcher]*

Industrial labs have everything where you want it. You're not spending days looking for things and it has got support if you need. *[School teacher]*

Men were more likely, however, than women to complain about the lack of administrative support:

They take people like us who are highly trained and qualified and they have them typing in by hand students names onto lists. *[Male post-doc, Midlands]*

53. The Emphasis on Results

Women felt that there was too much emphasis in chemistry on achieving the result at the expense of the route toward it. By contrast, men seemed to relish the battle for publication:

At chemistry [conferences], it's very much on the results and people put their hands up saying "Oh, yes there's this paper by such and such this year and it has this type of result and that type of result" and I was shocked the first time I went to a physics conference because they put their hands up, saying, well, how much did that cost and how many watts did you get out ...

There's a big lack of emphasis in chemistry as well on the achievements of equipment building.

Chemists don't sing and songs and dances about their novel techniques or experiments: there's this peer group idea that you have to get the results and show this wonderful piece of science.

This was seen as a particular issue in organic chemistry, with the suggestion that there is less emphasis on results, i.e. publications, in physical chemistry.

54. The Loneliness of Chemistry

Women perceived academic chemistry as isolating and were concerned about:

- horizontal segregation between disciplines
- vertical segregation between grades.

These were not purely social issues: participants felt that the segregation was detrimental to the development of interdisciplinary working and led to worse teaching. The position was seen as worse in large, long established departments.

Horizontal segregation

When I was an undergrad towards the end, especially I could really see the connections building up between inorganic, organic, physical. Then you come and do your PhD, you're isolated in a tiny section, you never even see, we never even talk to the inorganic chemists. [Final year PhD, Midlands, about to leave]

Traditionally our managers have grown up with a system where there were three divisions. It takes a very brave individual to make the innovative leap to break that down and the difficulty they perceive in doing that, even if you could talk them into it intellectually ... is that in funding terms they don't benefit. [Post-doc, Midlands]

Physicists can teach quantum mechanics or they can teach particle physics, or they can teach a really broad range ... whereas in chemistry you find that people are lecturing and teaching, and being directed to that channel of their research. (Academic, Midlands)

I don't get to meet people working in organic chemistry and I would like to talk to them about polymers but I don't meet those people on a level where I can talk about research. (Academic, Midlands)

You have to show a great deal of initiative and show more aggression than I'd personally be happy demonstrating on most occasions in order to pass across those barriers. (Academic, Midlands)

Vertical segregation

If you're a post-doc or a post-grad you cannot have tea with the staff members. We fall between the cracks. (Academic, Midlands)

The Barriers to Women

55. The Male/Female Divide

Both men and women commented on the barriers they perceived to women in chemistry in academia. There is a risk of caricature in the results:

- men tended to blame women's attitudes
- women tended to blame male attitudes.

However, both groups agreed that the physical demands of chemistry; and the culture created by these demands had led to a working environment where it was more difficult for women to succeed than men:

- the culture was a peculiarly macho one
- the all-consuming nature of chemistry had created an expectation that it was impossible for a woman to combine a fast-track career with having a family.

56. Men Blaming Women

A number of men felt that women were temperamentally and psychologically unsuited to the demands of chemistry.

Most women I knew in the PhD group, if it didn't work, it was more personal, quite unstable on some days! [Male chemist in industry]

Its this fear of failure. I knew a lot of women chemists, during their project, if it didn't work, they were in tears and never wanted to do it again. [Male chemist in industry]

The hard sciences tend to be adversarial, you're right or wrong, not opinion, psychologically men are more adept at making those right-wrong decisions.

57. Women Blaming Men

The issue of whether sexism, whether overt or covert, was present in chemistry departments divided the women very strongly. Younger participants were more likely to feel that it did not exist, that if it did, they were unaware of it, or even that women themselves created any problems of attitude. Older participants were more likely to be able to cite specific instances:

- they have more experience within more departments
- there were some indications that, as women progressed, they became more threatening and were therefore more likely to encounter overt sexism.

Some of the younger participants had not encountered sexism:

There isn't sexism in this department. (Academic, Midlands)

Others suggested that women themselves might even create any problems in attitude. This view was supported by Val Randle in the Nature debates: "the "glass ceiling perpetuates a notion which persuades women to expect to be unfairly treated." Comments from our female groups included:

I haven't come across it, I'll probably get lynched for saying this, but I think people see sexism where they want to. (Academic, Midlands)

I do think that if you want to assume that people are discriminating against you, you will see it, whereas if you just have the attitude, no it's not happening and just sail through, then it doesn't affect you. (Academic, Midlands)

I have thought about it recently, because I'm applying for jobs. I'm a woman and I look young for my age. Also, I have blond hair!. I may not get taken as seriously as men. [Post-doc, London]

I've never noticed that people take me less seriously. Almost I expect them to. (Final year PhD, London)

58. Turning Gender to Advantage

Some of the younger participants even felt there was some advantage to being a woman at the PhD stage:

They remember you better. (Junior Lecturer, London)

Quite high ranking people [in industry], they find it easier to talk, they're less intimidated, which you can turn to your advantage ... you move on to: "What are you going to do?" and then I kind of say: "Got a job for me?" [Final year PhD, moving to industry]

However, they felt that advantage was lost in post-doc positions:

You might have a way in more easily, but then at the moment you have to be compared with male competitors, you might be slightly disadvantaged. (Final year PhD, London].

59. Older Women and Sexism

The more senior participants were adamant than sexism was prevalent:

Undoubted sexism that occurs in a science department. [Post-doc, Midlands]

Some project students were in the lab and they were asked what they wanted to do when they leave here. And they said "Oh we want to go and do PhDs." And the person turned round and said "Well, you're females, you don't want to go and do a PhD, women should go into industry at graduate level, they've got crèches, they've got BUPA, you're wasting your time." [Junior lecturer]

They saw it both at post-doctorate level and on first lecturer appointment:

It was when I was going for jobs at the post-doc level that I remember a couple of very clear occasions ... the head of department, I remember him saying to me: "Are you really sure you can cope with being an academic and a mother?" I went to Personnel and Personnel just squashed it. [Junior lecturer, London]

It's the first time I've really come across sexism at this [junior lecturer] level. I think in many ways I was perhaps protected as a post-doc, because you're not the person in charge of the group ... Some of the comments I've had from colleagues they wouldn't dare make if they were a company. (Junior lecturer, London)

60. Machismo

Men saw the atmosphere in chemistry departments as adversarial and speculated that many women would be uncomfortable with it:

If you talk to graduating PhD students, it's clear that, not just whether they're going to go on or not, but their view of what science is, is actually quite different. A lot of the women see it as unnecessarily adversarial and combative and too much boys playing with boys ... they're a bit sick of that atmosphere, not the science. [Male academic, London]

There's a machismo found in chemistry departments and research groups and its really off-putting, I think its that simple. [Male academic, London]

In organic chemistry, someone very synthetic, very focused, that's maybe slightly aggressive but is very confident ... the sort of person they're looking for or who they think is what they want, a lot of women don't fit into that mould.

In a number of big groups ... they're almost all male and when the new female PhD students come in they last a while and then they give up ... The group functions as a big macho whole with lots of macho individuals in it at the bench, they don't overtly discriminate against the women, but they provide an atmosphere that is uncomfortable. [Male academic London]

61. Career or Family?

Participants were virtually unanimous in believing that it was impossible for a woman to advance in chemistry and have a family: the options were seen as mutually exclusive. Even single females were seen as disadvantaged because so many men in chemistry relied on having a supportive spouse:

Very few lecturers that I know that are female have families whereas all the male academics are married and have families ... I've suffered that problem all the way through ... I was in a research

group where I was one of the youngest and most … had families, wives at home who brought their dinners in so they could work all hours of the day, whereas I had to go home, cook dinner, do that. [Single female post-doc]

Attitudes aside, participants agreed that it is physically more difficult in the sciences to combine career and family. The nature of work in the humanities was seen as more amenable to flexible or part-time input, including from home – and easier to cope with while you're pregnant:

In humanities, the kind of work is different. Most of the women can just bring back home books to read … while we have to stand up and do experiments … I think it's actually true when they say: "are you sure you can cope with a baby?" [Final year PhD]

These difficulties are seen as even greater in chemistry, in particular in organic chemistry, because of its expense and its competitive culture. Both men and women felt that it would be impossible even to contemplate part-time working, or taking time out:

It's a lot of hours at the bench to produce a result and you can't afford to just work half time, it would just take too long to get anywhere. [Male post-doc, Midlands]

The obvious thing is if a woman wanted to take time out to have kids it's pretty difficult ... one of my senior colleagues did say to me "six months out of chemistry and you might as well pack up, because you've lost the plot." [Male post-doc]

One participant suggested that, because promotion criteria are opaque, men are more likely to receive discretionary pay awards in some departments because of lingering traditional attitudes:

I know male colleagues who have gone in to see the head of department thumped on the desk because they're aggressive characters and said: "I want to have an extra point's rise" … and they've been given an extra point's rise for a couple of years, because they're supporting a family, whereas, if I went in there, they'd say: "don't be silly, you've got a husband." [Young female lecturer, London]

62. Children or Professorship?

As a result, none of the women felt it was possible to combine children and a professorship:

I don't think you get both. I'd love both one day, but I don't think you can get both. [Female post-doc]

If I was to have children, I would go for a very different set of responsibilities. Bow out of doing a lot of chemistry. Two tracks in chemistry: readership for those with children, professor for those without. With children, need to reduce number of responsibilities and lower speed at which you do everything. Problem is that everything is accelerating. [Notes from telephone interview, female lecturer]

There was one lone example of a woman who had hitherto overcome these difficulties:

Even in organic chemistry, there is so much written stuff you have to do. I post-doc'd with a young child and I was at the bench all the time and I learned to be incredibly efficient, but you really have to develop those skills that you work very intensively, and have a supporting spouse. But I think it can be off-putting before you go through the experience, because I remember when I came back I thought "My God, I'm not going to cope," you have those sorts of fears, but when you start doing it, of course its manageable … I was

lecturing up to a week before my youngest son was born. The stomach in [the lab] was a bit of a problem ... and afterwards it's not easy, but you can do it. You just have to be organised and you have to be determined to carry on and you have to have a good child care system. [Young lecturer, 2 young children]

63. The Future

Two of the female post-docs and two male lecturers envisaged themselves as professors in ten years time. However, they were unanimous in wanting a personal chair. The women saw a head of department post as too much part of the system and therefore inherently a male preserve:

Getting a personal chair is something that could be awarded to you on the grounds of applying for promotion and doing good science and working for it and achieving it yourself, whereas getting a chair or head of section is something ... achieved by playing the political game, slapping the right backs and playing golf with the right people.

The men simply saw it as an undesirable job:

I've got no ambitions to be head of department, as far as I can see, it's a crap job. A personal chair is about the best you can aspire to be in chemistry at the moment.

Conclusions

64. Debating the Problem

The issue of women in science has attracted huge interest in recent months. Much of that interest has focused on debating the problem, rather than on identifying solutions. Below we set out our conclusions from our research.

Conclusions from HEI Data

65. Data on Women in Chemistry

Our study of quantitative data draws frank conclusions about:

- the representation of women in higher education chemistry
- retention of women and their promotion prospects
- trends in these numbers.

66. Representation

Women are poorly represented in higher education research in general but the situation in chemistry is amongst the worst. For students:

- 52% of undergraduates in 1997 were women but only 37% of undergraduates in chemistry were female
- 42% of postgraduates were women, but just 33% of postgraduates in chemistry were female.

The position for higher education staff is worse than for students:

- 33% of higher education staff are female but only 16% of staff in chemistry are female.

Our analysis of the data on women in higher education as a whole provides some indications why chemistry may be worse at retaining women than other subjects. In general, women are more likely to be:

- found in smaller departments
- employed in newer universities
- work alone rather than in teams
- work part-time and on short-term contracts.

The structure and demands of chemistry leads to a concentration of jobs into large teams and large departments, in the established universities. Part-time working is also rare.

67. Retention

Although chemistry is less good at attracting women initially than other subjects, our analysis shows that the key issue is one of retention. There is a sharp fall off in numbers as women move through chemistry in academia, from 33% of post-graduates to less than 1% at professorial level. Only civil engineering offers worse promotion prospects overall for women; and only agriculture has a greater differential between the number of junior women staff and senior women staff.

68. Trends

Based on the quantitative data alone, the prospects for improvement are not good. The best estimate is that, at the current rate of improvement, it will take until around:

- AD2070 for women to reach parity with men in chemistry
- AD2035 to reach the 33% representation achieved in higher education as a whole.

The picture is unlikely to improve for some time. While over 40% of chemistry appointments in the last three years have been female, almost all these have been to researcher posts. Our data suggest a squeeze on the number of middle ranking posts in chemistry. If this trend is confirmed, it will further reduce the promotion opportunities for women. It may prove particularly difficult for women to reach professorial grade due to the recent appointment of 46 new professors, all male. These promotions led to a reduction in staff at senior lecturer grade, which may delay introduction of senior female role models and changes to the 'male' culture of many chemistry departments.

Conclusions from the Focus Groups

69. Opinions about Women in Chemistry

The quantitative data alone do not provide a full understanding of why the decline in the numbers of women in chemistry is so steep from post-graduate level onwards. This was the aim of the qualitative work. We have drawn tentative conclusions but due to the small numbers involved in the groups, our findings can only be indicative. Rather than reaching definitive conclusions, we see our work as setting out a research agenda for the RSC, highlighting those issues which merit further investigation. We identify the following barriers to the promotion of women in chemistry:

- attitudinal
- structural
- cultural
- environmental.

70. Attitudinal Barriers

Both male and female attitudes appear to militate against the progress of women in chemistry:

- **Men:**
  - see chemistry as a hard-edged discipline not emotionally suited to women
  - have lingering traditional attitudes about the role and contribution of women, particularly of those with children.
- **Women:**
  - have doubts about their own ability, particularly at the post-doc stage
  - have an expectation that they will be treated differently or unfairly, which the small number of potential role models continually reinforces.

71. Structural Barriers

There are three main structural barriers:

- **Promotion.** Chemistry has a bottom-heavy structure. It requires large numbers of PhDs and post-docs to perform laboratory work, but there are few opportunities further up the pyramid. Promotion opportunities may have been restricted by the recent squeeze on middle ranking posts. This translates into massive competition for lectureships and professorships.

Industry, by contrast, has a flatter structure with larger numbers of posts at junior and middle management level – even if there are still few women in very senior positions.

- **Isolation.** The different branches of chemistry are physically separate, often in different buildings: there is little opportunity to develop interdisciplinary ideas, yet we know that women are more likely to favour interdisciplinary working. Also:
  - long contact hours mean little opportunity to socialise, except with other chemists
  - socialising is mainly dominated by male activities, because there have traditionally been so few women.
- **Size of Department.** The nature of chemistry, organic chemistry in particular, requires large departments with large teams working full time. Women by contrast, tend to prefer to work in smaller units and elsewhere in academia are more likely to be found as lone workers or in part-time posts.

72. Cultural Barriers

Chemistry appears to have an exceptionally competitive culture that is inimical to women's way of working:

- there is an emphasis on results, at the expense of process
- that leads to "macho" attitudes where everyone is fighting to get a result out first.

There were suggestions that women, by contrast, are more interested in exploring how to reach a solution and in learning from the process, rather than in arriving at a result and rushing to publish. At the same time, women suggested that some chemistry departments function largely as a male club, with promotion depending more on an individual's fit with the current culture, than on transparent assessment criteria.

73. Environmental Barriers

Many women simply do not like working in university chemistry laboratories! They have stronger concerns about health and safety than the men who most often run and research in their laboratories. By contrast with industry, they find university laboratories frustrating, unsafe, poorly equipped and lacking in basic technical support. This creates particular barriers for women in organic chemistry where the culture and nature of the work demand long hours in a working environment which women do not find congenial.

74. Are These Factors Specific to Chemistry?

There are negative things about higher education that deter both men and women: pay, long hours and lack of career structure for those that are not high-fliers. These issues are compounded for women in the laboratory-based sciences:

- long hours at the bench make it more difficult to find time for a family
- the work is more difficult to do on a flexible or part-time basis, or at home
- longer hours translates into a requirement for more childcare – which low pay makes unaffordable.

These generic difficulties are greater in chemistry because of:

- an aggressive and competitive culture, which places emphasis on securing results and demands even greater contact time

- the isolation of chemistry and the loneliness of women working in a predominantly male culture, conditioned by male values.

75. The Impact of the Barriers

From our work, we clearly cannot measure how much greater these cultural, attitudinal and structural barriers are in chemistry than in other disciplines. What does seem clear, however, is that:

- the working environment in chemistry puts off large numbers of women, while
- its structure creates barriers to their promotion.

If women are not enjoying the core of a chemistry job, they are much less likely to be willing to battle against the other constraints. As Joanna Wilson noted in the Nature debates:[12]

If they love learning about their chosen field, they'll be willing to endure the struggles to keep working in it.

Our tentative conclusion is that women do not love working in chemistry enough to put up with the other drawbacks of a job in academia, or persevere in overcoming the difficulties of working in a traditionally male culture. At the same time, our work suggests that women may be better than men at:

- acquiring transferable skills during their PhD
- recognising the value of those skills; and
- selling those skills to potential employers outside academia.

They are therefore better placed than men to take up employment opportunities outside higher education.

76. Questioning University Culture

If the position of women is to be improved, the culture of universities and chemistry departments needs to change. This should be a bottom-up process, building on existing examples of good practice from institutions and individual departments. Critically, it must cover:

- **cultural issues,** that is ways of working; as well as
- **procedural issues,** rules for working.

In Figure 20, we question some of the cultural aspects of common university procedures:

Procedure	Culture
Career	
Most institutions have open advertisements for appointments.	How often are selection criteria opaque, or even token? Do appointment processes emphasise 'fitting in' with the existing, largely male, culture?
Most institutions have regular appraisal of all staff using stated procedures.	The criteria for measuring success need to be interpreted. Does this lead to emphasis on certain ways of working, long hours and, again, fitting in?
Not all promotions are advertised. Many 'personal' promotions, including chairs, are by application.	Promotion feeds on appraisal. Does it have the same dangers of being culturally biased against women? How often do men still think, "what if she gets pregnant?" even if they usually dare not state it?[13]
Some institutions have staff mentoring schemes but it is not clear how often these apply to, or are taken up by, chemistry departments.	Are mentoring and shadowing held back by a lack of senior female role models in chemistry? Do male role models work as effectively? How many male chemists have had equal opportunities training?
Job Design	
The predominant mode of employment is full-time posts and part-time posts tend to be short-term.	To what extent is structure of jobs determined by tradition rather than the needs of research and teaching in chemistry? Can posts be split or partly worked from home?
Working Conditions	
Health and safety issues are critical and all institutions have policies.	How widespread is the problem of male researchers seeing regulations as an annoyance? How commonly do they develop a bravado about ignoring them? How frequently do women continue in laboratories while pregnant?[14]
Working Culture	
There are no regulations on culture, appropriately so but ...	Can chemists find ways of minimising the 'machismo' atmosphere of laboratories? How widespread is the practice of restricting staff room and other facilities to permanent staff?[15]
Family Support	
University provision of child care facilities is often very poor. Few institutions support paternal leave.	Are institutions and departments prepared to actively manage career breaks, including providing resources to keep professional networking intact? Do institutions target child support at men as well as women?

Figure 20. Procedures and Culture

Annex 1: Methodology

Data Analysis

77. Analysis

Our analysis is based on data from the Higher Education Statistics Agency (HESA):

- staff records for 1994/95, 1995/96, 1996/97[16]
- student records for 1988–1997.[17]

HESA collects data for 35 cost centres, including chemistry. In some cases, cost centres equate to departments but often they cover staff in several departments. Our analysis does not take account of lag and cohort effects. For example, the proportion of female professors is partly a reflection of circumstances some years ago. Regrettably, we have insufficient time series data to model these effects.

Focus Groups

78. Location

For pragmatic reasons, we held the non-higher education groups at the RSC premises. For universities, we downloaded the details of all UK chemistry departments from their web pages and selected candidate departments that were:

- research active (3a, 4, 5 or 5*)
- had high enough numbers of post-graduates and women post-doctorates to guarantee satisfactory attendance.

We then selected one university in London and one in the Midlands representing these criteria.

79. Recruitment

For the non-higher education groups, the RSC provided us with names and contact details for male and female RSC members with post-doctorates living within travel distance of central London. For the university groups:

- the Midlands university appointed co-ordinators for the male and female groups who recruited participants directly
- for the London group, we approached potential participants by email.

We used a neutral form of words in recruitment, to attract participants who represented a spectrum of views, rather than those holding strong views on gender. We recruited 42 participants in total:

- Women with PhDs working outside HE, 9:
  - 4 employed by traditional large chemical and pharmaceutical companies
  - 4 working for smaller science based companies
  - 1 secondary school teacher
- Men with PhDs working outside HE, 9:
  - 2 employed by large companies, 1 chemicals based
  - 3 in government funded laboratories
  - 3 in small science based companies
  - 1 in a learned society

- Women in higher education, 11:
  - 1 lecturer
  - 1 research officer
  - 5 post-docs
  - 4 final year PhD students
- Men in higher education, 13:
  - 5 lecturers
  - 7 post-docs
  - 1 final year PhD.

Of the four women who gave telephone interviews, two were junior lecturers, two worked in large chemical and pharmaceutical based companies. We had few difficulties recruiting, except to the female group in London. This reflects the low numbers of women in research active departments in London and the additional time pressures on women in London.

80. The Groups

Each group was moderated by an Ea director and tape recorded and transcribed. Discussion at the group was based on a topic guide, covering the following broad areas:

- why participants were initially attracted to chemistry
- the good and bad points about chemistry in general
- the good and bad points about chemistry in higher education
- the changes participants would make to chemistry in higher education
- where they anticipated being in ten years' time.

We also facilitated free discussion to allow each group to follow through issues they had identified, rather than those the RSC and we wanted to pursue. Throughout discussion, we aimed to draw out:

- differences between men and women; we did so obliquely and only asked directly about women's concerns in a few instances where the groups did not surface issues themselves
- differences between issues particular to chemistry, and those generic to higher education research
- distinctions between different branches of chemistry.

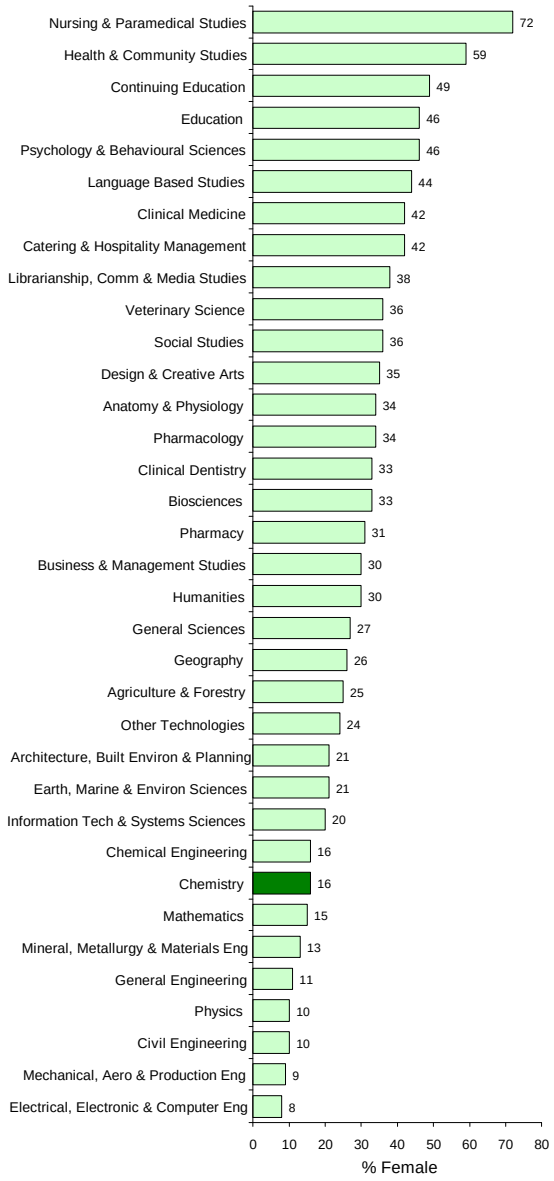
After the groups, we held four semi-structured telephone interviews with women who were unable to attend but wanted to give views.

Annex 2: Gender Statistics

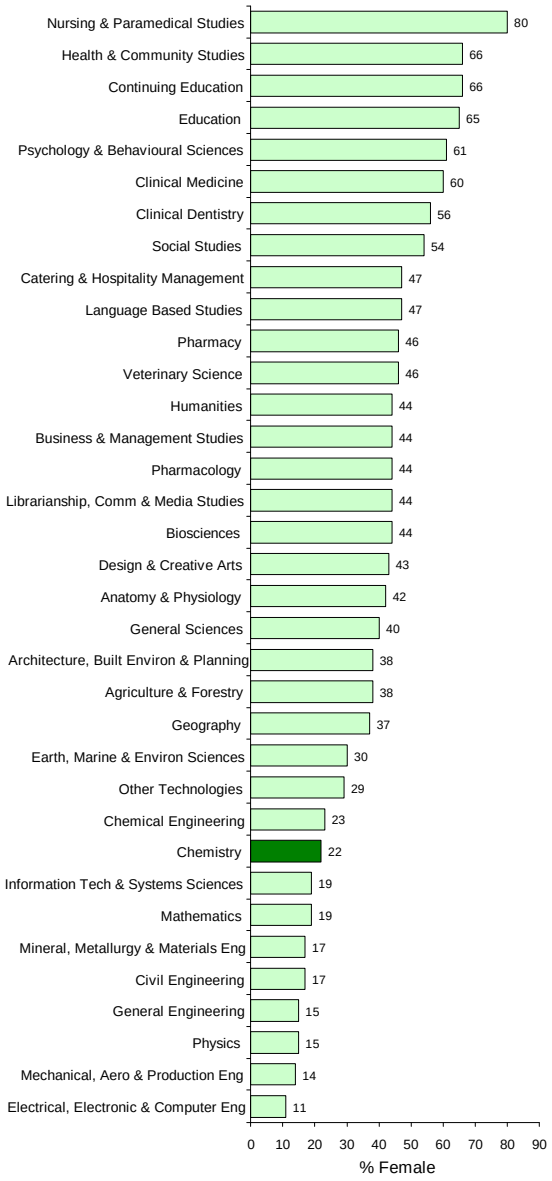
Gender Balance by Cost Centre

Cost Centre	0-39% Female men predominate	40-59% Female broadly neutral	60-100% Female women predominate	% cost centres broadly neutral
Education	31	63	14	58
Psychology and Behavioural Sciences	31	46	13	51
Clinical Medicine	20	22	1	51
Catering and Hospitality Management	11	12	4	44
Language Based Studies	41	44	24	40
Health and Community Studies	12	33	39	39
Continuing Education	20	22	19	36
Social Studies	71	38	5	33
General Sciences	12	7	3	32
Design and Creative Arts	87	36	3	29
Humanities	79	27	4	25
Librarianship, Communication and Media Studies	23	9	8	23
Veterinary Science	7	2	0	22
All	**1640**	**491**	**188**	**21**
Pharmacy	15	4	0	21
Biosciences	75	17	5	18
Clinical Dentistry	14	3	0	18
Agriculture and Forestry	18	4	0	18
Pharmacology	14	3	1	17
Other Technologies	32	6	1	15
Business and Management Studies	100	17	3	14
Anatomy and Physiology	22	4	7	12
Geography	63	6	3	8
Mathematics	88	7	2	7
Earth, Marine and Environmental Sciences	71	5	1	6
Information Technology and Systems Sciences	105	5	3	4
Nursing and Paramedical Studies	2	2	76	3
General Engineering	30	1	1	3
Architecture, Built Environment and Planning	67	2	0	3
Physics	60	1	0	2
Civil Engineering	56	1	0	2
Chemistry	**70**	**1**	**0**	**1**
Chemical Engineering	23	0	0	0
Mineral, Metallurgy and Materials Engineering	28	0	0	0
Electrical, Electronic and Computer Engineering	80	0	0	0
Mechanical, Aero and Production Engineering	72	0	0	0

Concentration of Female Staff by Cost Centre: All staff and Researchers

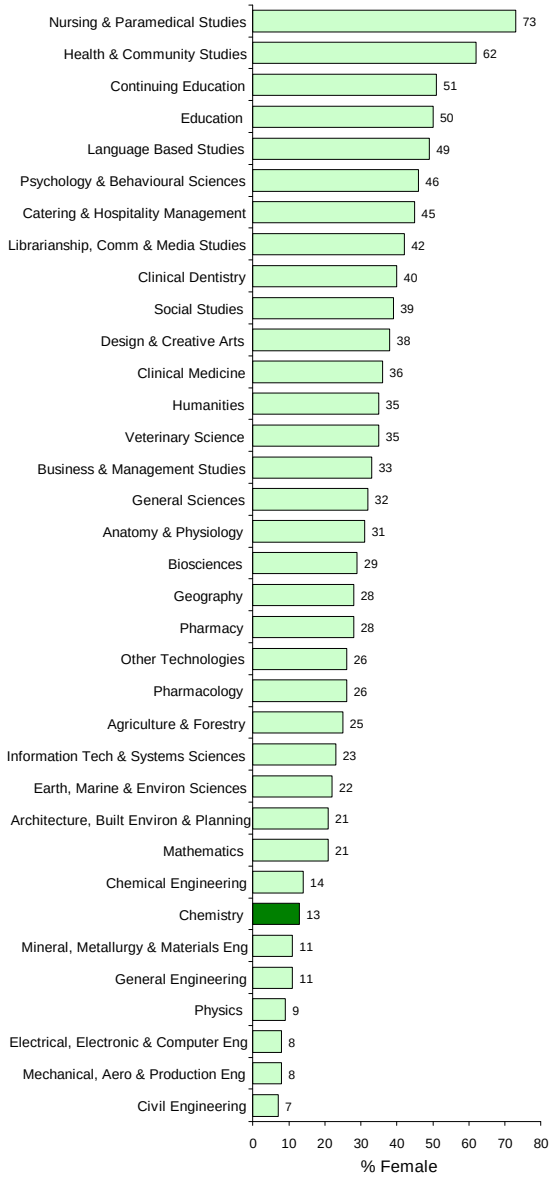


% of all academic staff

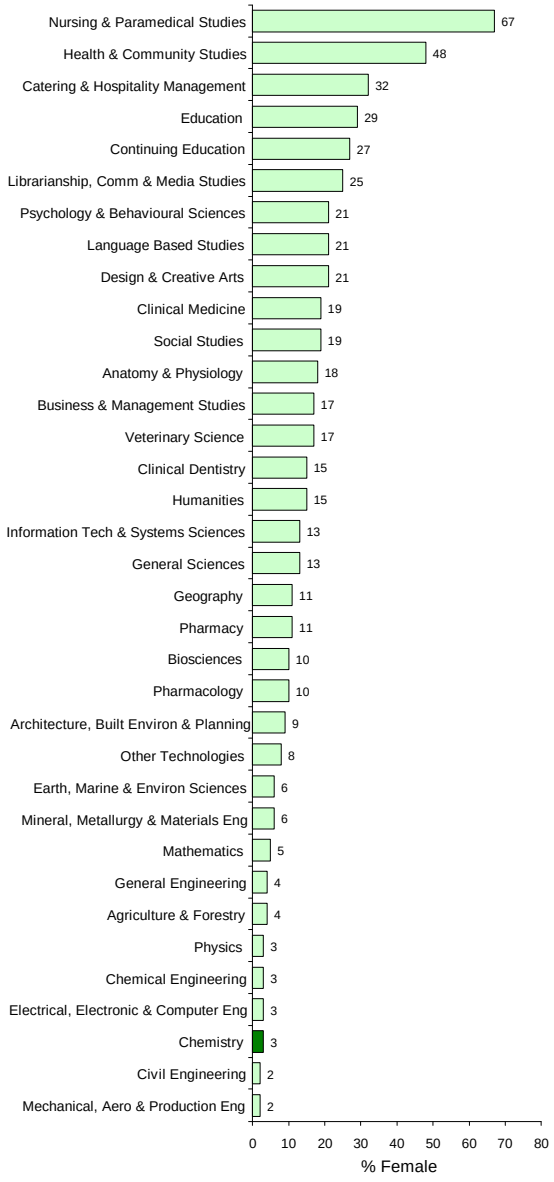


% of Researchers

Concentration of Female Staff by Cost Centre: Lecturers and Professors & Senior Lecturers



% of Lecturers



% of Professors and Senior Lecturers

All Male Cost Centres

Subject	Cost centres all male	Average staff
Physics	3	20
Earth, marine & environmental science	4	16
General, mineral and civil engineering	6	25
Electrical & electronic engineering	12	20
Mechanical, aero & production engineering	11	20
Other technologies	1	22
Architecture, built environment & planning	6	13
Mathematics	6	17
Information technology & system sciences	2	21

The one all female department is health and community studies.

Differences in Proportion of Female Employees by Cost Centre and Institution History

Cost centre	Former university sector		Former polytechnic & colleges sector		Difference	Class
	%F	Average size	%F	Average size		
Anatomy and Physiology	32	58	59	13	-27	A
Language Based Studies	40	80	57	31	-17	
Humanities	25	66	38	33	-13	
Mathematics	12	46	24	18	-12	
Continuing Education	47	13	59	5	-12	
Catering and Hospitality Management	34	20	43	31	-9	
Information Technology & Systems Sciences	16	41	24	41	-8	
Social Studies	33	125	41	47	-8	
Business and Management Studies	26	57	33	85	-7	
Geography	24	32	30	15	-6	
Design and Creative Arts	31	25	36	65	-5	B
Librarianship, Communication & Media Studies	35	16	40	16	-5	
Education	44	64	48	53	-4	
Psychology and Behavioural Sciences	45	48	49	23	-4	
Other Technologies	22	27	25	24	-3	
Earth, Marine and Environmental Sciences	20	48	22	23	-2	
Electrical, Electronic & Computer Engineering	8	69	9	36	-1	
General Engineering	11	99	11	45	0	
Chemistry	16	66	16	18	0	
Agriculture and Forestry	25	79	25	86	0	
Biosciences	33	141	33	34	0	
Health and Community Studies	59	25	59	30	0	
Mechanical, Aero and Production Engineering	9	73	8	36	1	
Physics	10	70	9	13	1	
Civil Engineering	10	44	9	20	1	
Mineral, Metallurgy and Materials Engineering	13	53	12	12	1	
Architecture, Built Environment and Planning	22	44	21	43	1	
Clinical Medicine	42	422	41	9	1	
Nursing and Paramedical Studies	73	79	72	85	1	
Chemical Engineering	17	42	7	14	10	C
Pharmacy	33	47	23	27	10	
General Sciences	47	6	26	36	21	
Veterinary Science	36	100	13	8	23	
Clinical Dentistry	33	54	None	0	None	
Pharmacology	34	35	None	0	None	
All	**31**	**72**	**37**	**41**	**-6**	

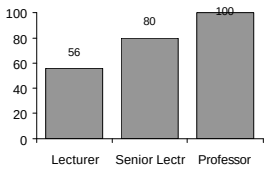
The table shows the % of women employed in the former polytechnics and colleges sector and the established university sector by cost centre. Average size is the mean staff numbers for the cost centre by sector. The classes are:

- **A:** former polytechnics employ a higher proportion of women
- **B:** employment is broadly equal in the two sectors
- **C:** former universities employ a higher proportion of women.

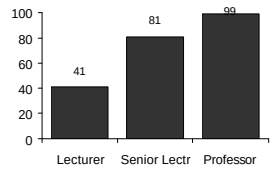
Percentage Reduction of Female Staff Between Grades (opposite)

For chemistry, for example, 22% of researchers are female. Taking this as a base figure, the representation of women is:

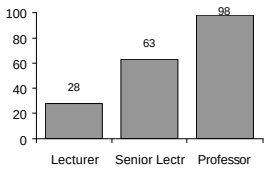
- 41% worse at lecturer level than it was at researcher level
- 68% worse at senior lecturer than researcher level
- 93% worse at professorial than senior lecturer level.



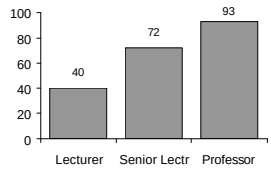
Civil Engineering



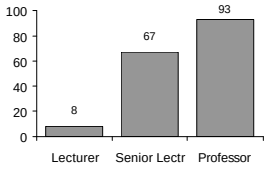
Chemistry



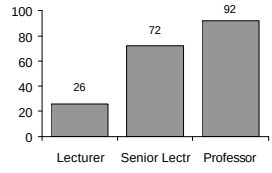
Clinical Dentistry



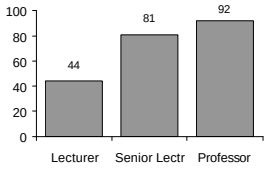
Physics



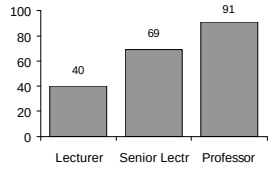
Other Technologies



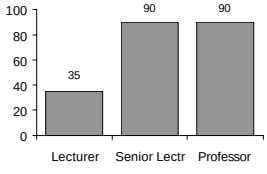
Earth, Marine & Environmental Sciences



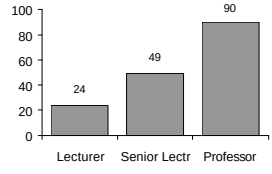
Mechanical, Aero & Production Eng



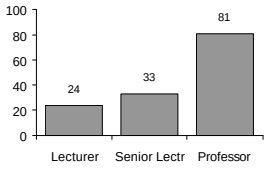
Pharmacy



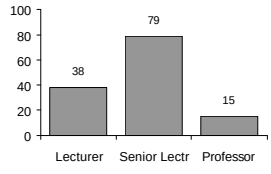
Agriculture & Forestry



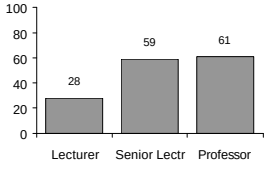
Veterinary Science



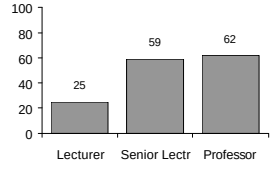
Chemical Engineering



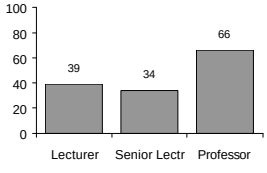
General Engineering



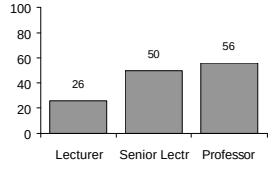
Electrical, Electronic & Comp Eng



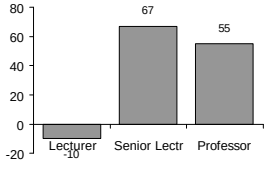
Biosciences



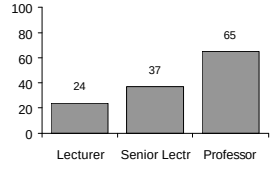
Clinical Medicine



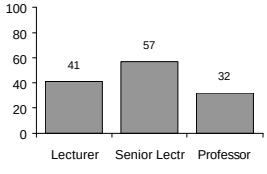
Geography



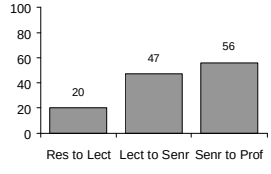
Mathematics



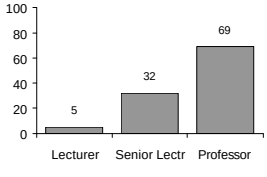
Business & Management Studies



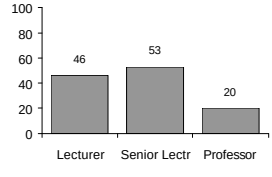
Pharmacology



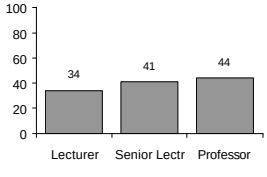
Humanities



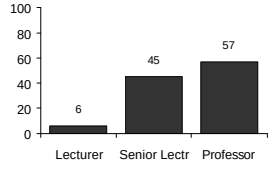
Librarian, Communic & Media Studies



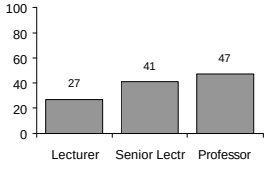
Architecture, Built Env & Planning



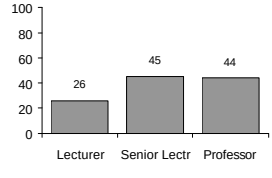
Mineral, Metallurgy & Materials Eng



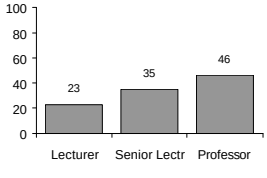
All Subjects



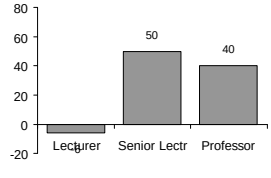
Social Studies



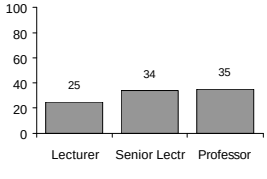
Psychology & Behavioural Sciences



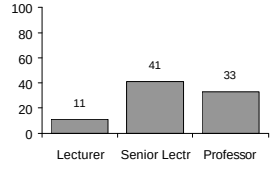
Education



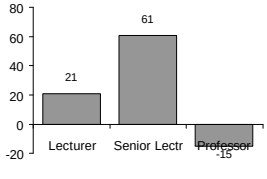
Language Based Studies



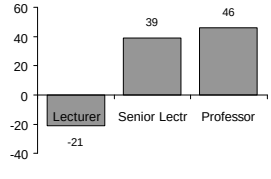
Anatomy & Physiology



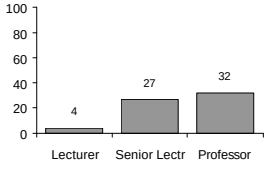
Design & Creative Arts



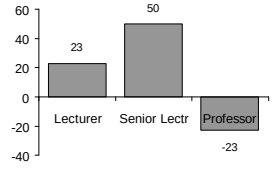
General Sciences



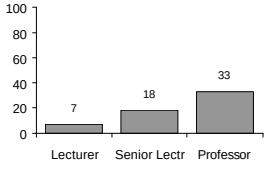
Information Tech & Systems Sciences



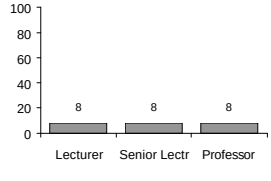
Catering & Hospitality Management



Continuing Education



Health & Community Studies



Nursing & Paramedical Studies

Percentage Female Staff by Grade, Gender and 1996 RAE Rating

Rating / Category	1996 RAE Rating None	1	2	3b	3a	4	5	5*	All
Professor & Senior Lecturer	3	3	8	3	3	2	3	0	**4**
Lecturer	12	17	19	10	21	13	11	3	**13**
Researcher	20	43	24	20	32	23	20	21	**22**
Other staff	24	33	13	37	20	31	25	0	**25**
All staff	**15**	**17**	**18**	**13**	**20**	**16**	**15**	**17**	**16**
Professor, Senior Lecturer & Lecturer	8	13	15	6	10	6	6	2	**7**
Researcher & Other	23	41	23	21	30	23	21	21	**22**

Change in Male and Female Staff Numbers (1994–1996)

	Professors			Senior Lecturers			Lecturers			Researchers			Other staff		
	M	F	%F	M	F	%F	M	F	%F	M	F	%F	M	F	%F
1994/95	280	1	0.4	544	20	3.5	651	80	10.9	1253	322	20.4	116	28	19.4
1995/96	314	0	0.0	510	24	4.5	662	100	13.1	1476	380	20.5	120	33	21.6
1996/97	326	0	0.0	474	21	4.2	611	87	12.5	1431	379	20.9	103	36	25.9
Increase (N)	46	-1	-0.4	-70	1	0.7	-40	7	1.5	178	57	0.5	-13	8	6.5
Increase (%)	16.4	-100		-12.9	5.0		-6.1	8.8		14.2	17.7		-11.2	28.6	

Notes

1 *Realising our Potential – A Strategy for Science, Engineering and Technology*, Cm 2250, HMSO.

2 *The Rising Tide, A Report on Women in Science Engineering and Technology*, HMSO, 1994.

3 Wenners C and Wold A, 'Nepotism and Sexism in Peer Review', *Nature*, **387**, 341-343.

4 *Women and Peer Review: An Audit of the Wellcome Trust's decision making process*. PRISM, Wellcome Trust.

5 This analysis takes account of the variation in size of cost centres by subject. Data are for cost centres with ten or more staff.

6 This graph standardises the proportion of women at junior (lecturer and researcher level). This is taken to be 100%. The percentage of female staff at senior level is then calculated against this.

7 From *Interdisciplinary Research and the RAE*, RAE 1/99, Higher Education Funding Councils 1999.

8 For further details of the data used, see Annex 1.

9 This 'department' was 4 academics allocated to London Senate House Institutes.

10 Data for part-time working is not currently available at cost centre level.

11 http://www.physics.wm.edu/dualcareer.html

12 http://helix.nature.com/debates

13 See the comment on page 30.

14 See page 26.

15 This restriction creates male dominated staff rooms, sometimes exclusively male.

16 Data for 1997/98 have only recently become available.

17 Including data from the former Universities Statistical Record.