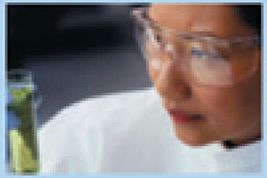
The Right Chemistry: The choice of chemistry courses and careers

A report for the Royal Society of Chemistry



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Executive Summary

Objectives and approach

The main objective of this report is to review the existing literature covering the factors that influence the choices that pupils and students make about studying chemistry and chemical careers. Importantly, material has been selected on the basis of substance and impact. Material simply aimed at influencing choice is intentionally not covered. The aim is to get behind the decision making process and to allow the development of recommendations. Each piece of literature included is abstracted and reviewed for the lessons it can provide about chemical choices. The literature has been divided-up into five chapters:

- Chapter 2, following the introduction, covers public environment of policy, and attitudes towards chemistry and science in general, within which choices about it are made.
- Chapter 3 covers attitudes towards chemistry at school and looks at the impact of gender, teaching, and other factors on choosing chemistry.
- Chapter 4 examines the role of careers advice and its impact on chemistry study and careers choices.
- Chapter 5 looks at the choice to study chemistry at university and how it is taught.
- Chapter 6, the penultimate chapter, examines the sparse literature covering chemical careers and employment.

The lessons that can be drawn from the literature are collated at the beginning of each chapter. These lessons are summarised in the final chapter and a series of recommendations for action by the Royal Society of Chemistry are made.

Attitudes to chemistry

The products of chemistry are widely respected and valued. Chemistry is, therefore, seen as important both by the public and the Government. However, many aspects of chemistry are not presented or perceived as part of chemistry. An example of this is nano-technology, which is perceived as engineering rather than chemistry. Equally, the pharmaceutical products used by medicine are not seen as products of chemistry and chemists. This means that chemistry as a discipline does not benefit as much as it could from the respect given to its products. There are also some residual problems with risk assessment and images of pollution.

Choices at school

The process of subject choice at school is complex and often starts when very young. Gender has been an important, and heavily studied, determinant of the patterns of subject choice. However, compulsory Double Science at GCSE level in England appears to have succeeded in ensuring that equal numbers of boys and girls now study 'A' level chemistry. However, the reasons pupils choose chemistry at 16 are still poorly understood.

Careers advice and choice

Generally, careers advice appears to have very little impact on the subjects studied or careers pursued by school children. These choices are often made surprisingly young, with careers advice only confirming existing choices or prejudices. However, given the changing orientation of the careers service, there is a growing role for subject teachers to perform a careers advice role. Unfortunately, these teachers often feel ill-equipped for this role.

Choice at universities

Undergraduate chemistry is suffering from a relatively recent and sustained drop in numbers. In part, this can be explained by the Government supported growth in the number of medical places that are available. However, undergraduate chemistry only attracts a very small proportion those gaining 'A' level chemistry, and only attracts 42 per cent of females compared to the 51 per cent completing an 'A' level. Despite these problems, little is known about the motivations of those who choose chemistry, or those who reject chemistry, despite being qualified to study the subject.

Recommendations

In the final chapter the report contains a resume of the main points from the preceding chapters, and a series of recommendations. These recommendations are outlined below:

- to build on the positive attitudes to the products of chemistry to develop positive attitudes to chemistry – emphasise that the largest employer of RSC members is the pharmaceutical industry

- reincorporate nano-technology into chemistry as nano-chemistry –- ensure that the exciting developments in this area are seen as chemistry
- pre-empt public misunderstanding of nano-technology — avoid the problems associated with genetically modified crops by starting a properly informed debate about the risks and benefits of nano-technology
- encourage science and chemistry teachers to take up and use appropriate chemistry careers materials — recognise that teachers are potentially the best ambassadors for the subject and support them in providing careers advice to their pupils
- understand the career and study aspirations of 16 to 19 year old chemistry students — a better understanding of the reasons behind studying post-compulsory chemistry should make it easier to encourage a greater proportion of the cohort to study
- engage in the development of new chemistry curriculum specifications — new and more engaging chemistry curricula can both encourage further study and build chemical literacy
- encourage a dialogue between the chemical industry and chemistry teachers to decide the best approach to industrial visits and placements — industrial visits can be highly effective at encouraging choice of chemistry study and careers if they are effectively planned
- lobby for transitional support for chemistry departments suffering from the expansion of medical studentships — recruitment to first degree chemistry courses appears to have suffered as a result of the Government sponsored expansions of medical schools
- understand why chemistry undergraduates choose chemistry — any efforts to expand the number and gender balance of chemistry undergraduates needs to be based on a clearer understanding of what motivates those who choose the subject
- urge universities to co-operatively respond to university funding changes and avoid cannibalising chemistry courses — an overall increase in the number of chemistry students is better for the discipline than individual departments poaching potential students
- university chemistry lecturers to be aware of, and engage in, the debate surrounding 14-19 education changes — changes to the school chemistry curricula will obviously impact on what and how lecturers teach undergraduate chemistry
- release selected highlights of the RSC members remuneration survey to provide inputs to policy debates and careers advice — the remuneration survey, which is currently only available to members, can provide valuable inputs to other RSC objectives.

1. Introduction

1.1 Background

In November 2003, the Institute for Employment Studies (IES) was approached by the Royal Society of Chemistry (RSC) to produce this annotated bibliography covering the factors that influence the choices to study chemistry or pursue a chemical career. This review is based on an earlier review produced by IES for the Engineering Technology Board (ETB). The review for the ETB, entitled 'Ready SET Go: A Review of SET Study and Career Choices', covered the whole of science, engineering and technology. This review contains some material from the earlier review, but given the focus on chemistry, contains a wide range of new material. At the request of the RSC, this review also focuses on chemical education and its impact on choice.

1.2 Annotated bibliography approach

This annotated review is based on a comprehensive search of the academic and policy literatures. The literature was assessed both in terms of its relevance to the topic and in terms of its impact and importance. The emphasis was on recent literature, literature that had a significant evidence base, literature that had been highly cited and had been critical in terms of policy formation or practice. Each item was then read and abstracted to emphasise the aspects relevant to chemistry choices. The intended result is a piece of secondary research that draws together and synthesises previous research to provide an overview.

Given the history and nature of this literature review there is much overlap, both in content and approach, with the previous study for the ETB and therefore thanks are given to them, and those that worked on the original review.

The annotated bibliography, with its abstracts of the selected literature, represents the bulk of this report. Within each section the literature has been arranged in alphabetical order to ease access. In order to help make sense of the literature it has been placed in a series of chapters examining different aspects of the issue. Each chapter starts with a brief review of the type of literature that has been found covering the topic. Where literature in one chapter can also provide information for a topic covered by another chapter this is noted. However, the chapters have been structured in an attempt to reduce unnecessary duplication and should be relatively self-contained. Additionally, each chapter also contains a section covering the key messages and research questions that emerge. The final chapter draws together these key messages and research questions as well as suggesting some courses of action for the RSC. It should be emphasised that careers materials have not been included in this review and that interventions to improve the number of chemists have only been covered where an evaluation of their impact has been found in the literature.

1.3 Chapter structure

Thus, this annotated bibliography consists of seven chapters the first being this **Introduction**.

Chapter 2, **Public environment for chemistry**, covers the general public, policy and careers service environment within which choices about chemistry careers and choices are made. The policy environment affects both the funding and nature of initiatives, but also indirectly has an effect on choice by influencing parents, peers and others. This public environment is also influenced by other sources such as the media and public perceptions and misconceptions.

Chapter 3, **Chemistry in schools**, examines the processes by which chemistry is taught in schools and how this influences choices. Since gender is a critical and much researched determinant of choice in schools, a section of this chapter is devoted to this topic. The chapter also covers the literature on choosing chemistry as a subject of study in schools.

Chapter 4, **Chemistry and careers advice**, examines the impact of careers advice on the choice of chemistry careers or chemistry study. The chapter also examines the impact of other interventions on pupils' choices outside of the classroom.

Chapter 5, **Post-compulsory chemistry**, examines undergraduate and postgraduate chemistry education, including academic careers. The chapter also covers the choices made to study the subject at that level and subsequent career moves.

Chapter 6, **Chemical employment** examines the experience of those in chemical employment, and how this can influence the choices of others in the supply chain. There is a section that specifically examines the experience of female chemists.

Chapter 7, **Conclusions and recommendations**, the final chapter draws together the messages from each of the preceding chapters and develops common themes. On the basis of these messages and themes, a series of suggestions for action by the RSC are developed.

Additionally, there is a bibliographic listing that provides cross-referencing to the sections containing the abstracts.

2. Public Environment for Chemistry

2.1 Scope and range of literature

2.1.1 Headings used

The literature reviewed in this chapter has been divided into three sections:

- **the policy environment** — covers Government policy documents as they affect the pattern of supply or demand for chemists
- **public understanding of science** — covers public attitudes towards science and their understanding of science and, in particular, chemistry
- **the changing careers service** — covers the changing pattern of provision of careers advice in the UK.

2.1.2 Amount and type of literature

The bulk of the literature in this chapter consists of Government documents, including external reviews and evaluations commissioned by the Government. Given that chemistry is rarely singled out in Government policy documents, the key documents relating to science and technology policy have been included.

2.2 Key messages

2.2.1 The policy environment

Chemistry's identity problem

There seems to be a problem with chemistry spinning off whole domains of research and chemical activity into new areas that do not appear to be chemistry (Adam, 2001). For example, nano-technology sounds like an engineering discipline rather than the exciting area of chemistry that it is. This, in turn, suggests that chemistry is not involved in this cutting edge science, and makes chemistry seem old-fashioned and out-of-date.

Government support for science and technology

The importance of science and technology within Government policy making extends beyond the Department for Trade and Industry (DTI), which is officially responsible for science, and is a focus of policy making by the Treasury and the DfES as well as other departments (Roberts, 2002). Overall, it is clear that there is extensive high level commitment for science and technology, which is backed up with funding. Often the resulting policy initiatives will only have a marginal impact on the choice of subjects or careers by individuals. However, the level of Government commitment contributes to a positive environment within which these decisions are made.

Recognition of the importance of gender

There has been a long-term recognition that much could be gained by increasing the numbers of girls and women studying science subjects, including chemistry (Greenfield, 2002). The problem with chemistry is converting the equal gender balance at the 'A' level stage into a better gender balance at degree level and above. Many, sometimes disjointed, initiatives have been undertaken to improve this situation.

2.2.2 Public understanding of science

Chemistry, as part of science and technology generally, is greatly appreciated for the benefits it has brought. However, there is at the same time a widespread apprehension about chemistry, the chemical industry and chemical products (RSC, 2001). In part this apprehension may be driven by ignorance or misunderstanding, however there seems to be a widespread problem with the understanding and apprehension of risk (OST and the Wellcome Trust, 2001a and 2001b).

2.2.3 The changing careers service

The development of Connexions has explicitly focused on young people at risk of social exclusion

The nature of the problem that Connexions was designed to meet was outlined by the Social Exclusion Unit (SEU, 1999), where (in England, and in 1999) nine per cent of 16–18 year olds were not in education, training or work. The strategy to address this problem and the bringing together of a range of experimental initiatives and approaches was announced with the launch of Connexions (Connexions, 2002). This was based on a series of pilots (Dickinson, 2001) and research (Hughes and Morgan, 2000).

Focus on those at risk uses and builds on the personal adviser model of careers advice

The SEU report, with its emphasis on the potentially socially excluded, led to the examination of earlier initiatives under New Start which used personal advisers to work with 16–17 year olds (Barham *et al.*, 2000). The use of one-on-one personal advisers has become a key feature of Connexions.

Implicit in this redirection of the careers service is that those in the academic mainstream, which provides the bulk of those entering higher SET training, will receive less external careers guidance

Careers advice has become a compulsory part of the curriculum and is provided by schools and colleges internally. This different focus of careers advice provision may impact either the quality or nature of the advice given. Apart from an OFSTED review (OFSTED, 2001), this does not appear to have been assessed. This suggests that this might be an area for future investigation. This is potentially a problematic area as there is evidence that those who have received careers advice are more likely to stick with their subjects of choice in post-compulsory education (Kidd, Wardman, 1999). Similarly, there is a growing need for careers advice at a greater range of ages and stages of education as the number and nature of choices becomes more complex, (Roberts, 1997). Despite this, the first OFSTED assessment of the Connexions service suggests that it has restored, and sometimes improved, provision in schools and colleges (OFSTED, 2002).

Another implicit consequence of this redirection of the careers service is that it might lead to an increase in those advised into vocational study and potentially into technician type roles

Given that one of the main 'successful' outcomes for a Personal Adviser intervention is enrolment on vocational courses in FE, it is possible that this might lead to an increase in those studying qualifications that normally lead to technician type employment.

Messages from elsewhere in the UK

In Scotland, a review of the Careers Service known as the 'Duffner Report' (Raffe, 2001), identified a need for change, with greater integration to provide an inclusive all-age provision. This report drew on a range of research into the pattern of provision (*eg* Howieson and Semple 2001a and 2001b). Similarly, a history of self-assessment of the provision of careers education and guidance (CEG) by schools in Scotland (SOEID, 1998) provided a self-reflective background to these developments. The Scottish Executive responded with the launch of Careers Scotland to take forward the recommendations of the Duffner report (ELLD, 2001). Over a similar period the Welsh developed a similar integrated all ages CEG provision (QCAAW, 2001).

2.3 Policy environment literature

Adam D (2001), 'What's in a name?', *Nature*, Vol. 411, pp. 408-409.

Notes a process whereby new and 'interesting' parts of chemistry often end up being called something else, *eg* the early work on DNA was done by chemists, but is now covered by genomics, a part of biology. Another example is seen as work around C60, or buckyballs, which is now seen as applied physics or nano-technology. The author argues that there is a need for chemists to '… assert themselves if they want the results to be branded as chemistry.'

DfES (2002), *14-19: Extending opportunities, raising standards: analysis of responses to the young person's summary of the consultation document,* Department for Education and Skills

This report is based on 4,369 responses to a questionnaire published alongside the young person's version of the green paper '14–19: extending opportunities, raising standards'. Many of the respondents said that they would like to have a wide variety of subject choices on offer. They also welcomed the chance to have more freedom to follow the subjects that interested them. They commented that, at the moment, their choices are very limited, not always only by the subjects that were on offer, but also by the option blocks they were in and timetable clashes.

Most of the respondents said that guidance would still be needed in helping prevent them from making wrong decisions. More advice from teachers would be welcomed, both in making choices at 14, and to help them achieve their educational and career ambitions. The respondents also commented that, at the moment, many students were left unsure what options to take for their chosen career, what was available to them, and what they would like to do as a career or university/college course. The majority of respondents however, were against career advice being started in Year 7. They suggested that this was too early and would be more suitable in Year 8 or Year 9. They also considered that at this age they were just getting used to a new school, so having to think about their futures this early could increase pressure on them.

DTI (2002a), Maximising returns to science, engineering and technology careers, Ref. URN 02/514

Explores the number of people with SET degree level qualifications and identifies how many are in SET and non-SET occupations. It also investigates how those in non-SET occupations could be attracted back into SET occupations and how employers could support such moves. Makes a series of recommendations for government, industry, HE and other organisations, including schemes for returners.

DTI (2002b), *Investing in Innovation: A strategy for science, engineering and technology*, DTI, HM Treasury, DfES

Building on the government's Science White Paper 'Building on Excellence' from 2000, this report reflects the outcomes of the crosscutting review of science spending that was part of the 2002 Spending Review. It outlines how an extra £1.25 billion will be allocated. It specifically contains the government's response to the Roberts' Review, with details of how the government proposes to implement each of the Review's recommendations.

DTI (2003), *A strategy for women in science, engineering and technology*, government response to SET Fair, a report from Baroness Greenfield CBE, Department of Trade and Industry

This report represents the government's response to the Greenfield report on the position of women in SET. There are announced funds of £1.5 million for new initiatives. The bulk of the money (£0.8 million) will go to a new science resource centre which will support, advise and work with SET employers and professional bodies to raise the profile of women in SET. Additionally, the centre will maintain a database of women experts; produce good practice guides; and develop a means of recognising good SET employers. The centre will draw on existing organisations and experience and provide co-ordination to achieve critical mass. There will also be funds for women returners and pump-priming money for innovative pilot schemes.

In addition to the Resource Centre the government will ensure that all government bodies are good SET employers. The government will also set up an independent group to oversee and monitor the implementation process. The Office of Science and Technology's Promoting SET for Women Unit will have a new enhanced role and improved statistical monitoring will be introduced.

Greenfield S (2002), *SET Fair: A report on Women in Science, Engineering and Technology*, DTI

The Greenfield Review on the position of women in UK science engineering and technology makes a series of recommendations for actions and targets over five years. These include:

- a working science centre — a centre to bring together, support and co-ordinate bodies supporting and advising women in SET areas
- funding for returners — revisiting the 'Maximising Returns' recommendations and removing the age constraints on programmes such as modern apprenticeship

- high-flyer development programme — providing funding for 25 to 30 potential high-flying women in SET programmes
- encouraging the part-time and job-sharing incentive programme already set up by the DTI to encourage these practices
- SET women speakers' bursary scheme — providing funding for women SET speakers
- HR good practice guides — creating sector-specific groups to champion HR good practice, equality and diversity through good practice guides and codes of practice
- developing a range of targets for female participation in policy bodies.

Mentions stereotypical careers advice as a factor that puts women off SET subjects at post-compulsory level. SET careers were perceived to lack a link to societal benefits, which are important for women's careers choices.

Hoyles C, Wolf A, Molyneux-Hodgson S, Kent P (2002), *Mathematics Skills in the Workplace*, an Institute of Education report for the STMC

This report finds an increasing number of people involved with mathematics in the workplace at an increasingly sophisticated level. This increase is driven by the greater use of IT in the workplace enabling the use of more sophisticated analytical techniques. Concludes that the country needs to rethink and upgrade the mathematics education for young people and ensure access to lifelong learning in this area.

Roberts G (2002), *SET for Success: The supply of people with science technology, engineering and mathematics skills,* 'The Roberts' Review': HM Treasury, DTI, and DfES

A review involving the Treasury, DTI and DfES set up as part of the 2002 spending review's crosscutting review of science and technology. The review, led by Sir Gareth Roberts examined the supply of and demand for science, engineering and technology skills in the UK. Overall, although numbers of SET graduates were growing, this disguised a fall in graduates from the physical sciences and engineering. There was also some evidence that this pattern, along with stable, if not growing, demand for high-level SET skills, was leading to shortages reflected in rising salaries and problems with academic appointments.

The Review made a series of 36 substantive recommendations that were subsequently accepted by the government. These recommendations covered:

- schools and further education (13 recommendations)

- undergraduate education (six recommendations)
- postgraduate education (four recommendations)
- employment in higher education (five recommendations
- scientists and engineers in R&D (eight recommendations).

The Review recognised the importance of early SET teaching, the curriculum and laboratories for the subsequent interest in SET study and careers. Made a recommendation (2.13) about improving the perception of careers in science and engineering by setting up a small central team of advisers, possibly in Connexions, to support existing advisers, teachers and parents. There was also a recommendation about implementing the Harris Report relating to HE careers advice. The Roberts' Review details how it intends to implement recommendations found in DTI (2002) 'Investing in Innovation'.

Scottish Executive (2001), *A Science Strategy for Scotland: Making it work together*, Scottish Executive

Set five objectives for a science strategy:

- maintain a strong science base fully connected to UK and international activity and funding sources
- increase the effective exploitation of scientific research to grow strong Scottish businesses and provide cutting-edge science to meet the needs of the people of Scotland
- ensure that enough people study science to a standard that will enable the future needs of the country to be met
- promote the awareness, appreciation and understanding of science across society
- ensure the effective use of scientific evidence in policy formulation and resource allocation by government.

The document largely concentrates on developing these objectives, identifying the bodies and approaches that are likely to deliver these objectives.

2.4 Public understanding of science literature

AllChemE (2002), *Science and Society: Challenges and opportunities from a Chemical Sciences perspective*, Alliance for Chemical Sciences and Technologies in Europe (AllChemE)

Collates the major conclusions from a Brussels science and society seminar attended by almost 100 scientists and engineers from all sectors. The participants debated the relationship between science and society and how science can contribute to the knowledge society while at the same time responding to societies concerns about risks. The responses fell into six themes:

- the use of expertise — 'responsible science must be seen to be central to decisions taken by politicians and governments. In order to counter the mistrust of actions taken by decision makers, there needs to be a climate of greater transparency.'
- The European skill pool — if an European Research Area is to be established there needs to be an equivalent Europe wide media push to inspire the best young people to pursue scientific careers.
- General education — there is considerable concern, and a lack of knowledge, as to why the best young people are rejecting science and engineering as a first choice career. The authors focus on the status and lifelong training of science teachers.
- Risk communication — there are problems with the perceptions of risk, partly because the media is not balanced in its communication of risk. Risk assessment needs to be part of the school curriculum and the Internet needs to be used to better explain risks.
- Involving the public — communication of science to the general public should take the form of a dialogue using terms and expressions that are commonly understood. Argues that the European Commission should provide grants for television programmes featuring European science.
- The ethical dimension — suggests that the AllChemE can help the Commission promote awareness of ethical responsibly in the chemical industry.

RSC (2001), 'What does the public think of science and scientists', *Chemical Science Issues*, No. 5

Reviews two surveys. Firstly the 'Science and the public' survey funded by the OST and the Wellcome Trust and reviewed elsewhere in this review. The second survey covered is a Wellcome Trust funded study 'The Role of Scientists in Public Debate' and asked scientists their views on how and who should communicate scientific ideas to the public. The sample consisted of 1,540 research scientists working in Great Britain. Despite contrary evidence, scientists feel that the public does not hold them in great esteem. Scientists feel that the public gets their scientific information mainly from the media and campaigning groups rather than from their preferred source, of fellow scientists. Based on the two surveys it is felt that scientists need to recognise the public holds science and technology in high regard but there are concerns.

Hayes B C, Tariq V N (2000), 'Gender differences in scientific knowledge and attitudes towards science: a comparative study of four Anglo-American nations', *Public Understanding of Science*, Vol. 9, pp. 443–447

Attempts to address the lack of empirical evidence to support the oft-cited assumption that women are anti-scientific because they are less interested and knowledgeable about science. Uses nationally representative Anglo-American data from the 1993 International Social Survey Programme (ISSP) covering the US, the UK, Canada and New Zealand. Shows that, apart from the US, the gender differences, although supporting the hypothesis, can be explained by differences in educational background and religious belief.

Hughes C (2001), 'Shackled to Stereotypes', *Science and Public Affairs*, February, pp. 21–23

This article notes how the Government has been encouraging scientists to be more interactive with the public. It looks at two pieces of research carried out by the Wellcome Trust and OST which mapped public attitudes to science communication activities (see below), and work by MORI, also funded by the Wellcome Trust, to survey scientists' attitudes to their role in science communication. The author notes that scientists have a positive attitude towards communicating research, and its social and ethical implications, to the public; and feel that it is their duty to do so. Yet only half of the scientists surveyed had communicated their research to the public: either through talks to non-scientific audiences, speaking to the media, participating in open days, or publishing in non-specialist media. Also, it is generally older or more senior scientists that engage in scientific communication. This highlights the importance of providing training, fostering self-confidence, and improving the awareness of support services to help scientists communicate their research. The article also notes that scientists have a low opinion of the public's ability to understand science, tend to distrust the media (particularly the popular media which is deemed to be the most effective method of communication with the public), and believe that they (scientists) are viewed negatively by the public.

> *' … while scientists are most likely to view themselves as enquiring, intelligent and methodical, they typically believe that the public sees them as detached, poor at public relations, secretive and uncommunicative.'*

The article concludes that there is a need to improve relations between scientists and the public, and between scientists and the media.

Jones R A (1997), 'The Boffin: A stereotype of scientists in post-war British films (1945–1970)', *Public Understanding of Science*, Vol. 6, pp. 31–48

The article notes that the period between 1945 and 1970 was critical for the public reputation of British science. Feature films of this period are used in this paper as a tool for investigating the public image of the scientist. Three main stereotypes are identified. However, only one of these, 'the boffin', forms the main focus of the paper. Boffins are seen as scientists working with the government, and with the armed forces in wartime. Characterisations of the boffin include: the hero, the outsider, the obsessive, the schoolmaster, the innocent, the villain.

Khan R N (1988), 'Science, scientists and society: Public attitudes towards science and technology', *Impact of Science on Society*, No. 151, pp. 257–271

This report indicates that surveys amongst the general public can give interesting insights into attitudes towards science and technology. By and large, the public puts science and scientists in high esteem. Almost three-quarters of respondents said that science and technology has changed life for the better, and similarly science has done more good than harm. The results also show that the public, on both sides of the Atlantic, gives top priority to medicine, and that physicians are the only professional group, which enjoy higher prestige than members of the scientific community.

Lannes D, Flavoni L, De Meis L (1998), 'The concept of science among children of different ages and cultures', *Biochemical Education*, Vol. 26, pp. 199–204

Schoolchildren's images of 'the scientist' were investigated in Brazil, USA, France, Italy, Chile, Mexico, India and Nigeria. They were asked to draw what they considered to be a scientist. Although the research does not investigate where children obtain these images from, it is asserted that children from a young age (between five and seven) have a good idea of what constitutes scientific activity. It was found that, despite large differences between these nations in relation to science, all the children studied held (and drew) a similar image of scientists. However, children's perceptions were strongly biased toward the male sex. Interestingly, drawings by teachers also suggest a gender bias.

Long M, Steinke J (1996), 'The thrill of everyday science: images of science and scientists on children's educational science programmes in the United States', *Public Understanding of Science*, Vol. 5, pp. 101–119

The US report looks at the effects of media perspectives, and suggests that televised images can influence children's perceptions of science and scientists. The study analyses images of science and scientists in four children's educational science programmes. The images of science as true, fun, and part of everyday life are common for everyone; as were images of scientists as omniscient and elite. However, there was little evidence of the image of science as magical or mysterious, or scientists as evil or violent.

The authors suggest that images may affect individuals' self-efficacy (*ie* belief in oneself), and the image of science as fun may increase positive attitudes to science and consequently encourage take-up of science study and careers. Similarly, linking science to everyday phenomena, such as cooking, may help dispel myths of science as frightening. They feel that representation of women and ethnic minorities is improving but that more work is needed to provide positive role models for diverse groups. However, the authors are concerned that images of science can have negative effects. They note that presenting science as 'truth' can discourage individuals from questioning science and from critical analysis.

Images of science were also found to affect the functioning of the scientific community. They can help with recruitment of scientists, they can provide an image with which the scientific community can identify, and can assist in relations between the scientific community and society.

To conclude, it found that, overall, the TV images are more constructive than detrimental, reinforcing helpful images of science and scientists.

OST and the Wellcome Trust (2001a), *Science and the public: a review of science communication and public attitudes towards science in Britain*, OST and the Wellcome Trust

This is the full report which is summarised in OST and the Wellcome Trust, 2001b. The study was sponsored by the Office of Science and Technology (OST) and the Wellcome Trust and consisted of two main components. The first component is a survey of the various ways in which science and science policy issues are communicated to the public. This aims to map the provision of science communication. The second component was a survey of the attitudes and educational background, as well as employment and leisure activities, of 1,839 people. This focused upon public attitudes towards SET. The report was intended to be a consultation document for the SET community.

The work presented a range of findings including:

- The main issue concerning science communication is how to develop a dialogue between scientists, policy makers and the public over the facts and processes of science (*ie* insights into the methods of scientific discovery). This is borne out of a desire to engage a wider range of people in debate about science policy, and to allow people to develop an awareness of the role of science in everyday life (the scientific literacy debate). Although it is acknowledged in the report that some organisations may have less altruistic reasons for scientific communication activities, and may masquerade public relations as communication. This means that there seems to be no real independent framework within which people can access and critically assess information about science.
- Scientific issues are more usually communicated to the public in terms of facts rather than in terms of the ethical and policy implications of scientific developments.

- There is a reluctance for scientific agencies and organisations to work together to improve scientific communication, or to try and understand the needs of their audiences.
- Three-quarters of those surveyed were amazed by the achievements of science, and can see the benefits of science in terms of making life healthier, easier and more comfortable. Few reported that they were not interested in science or felt scientific achievements were overrated. In general scientists are respected and are seen as making valuable contributions to society. Interestingly, three-quarters of those surveyed felt that science and engineering were good careers and that there would be more opportunities in these areas in the future.
- Also, the majority recognised the need to develop science and technology and to invest in research to enhance competitiveness and advance knowledge. However, there were concerns over the ability of society or the government to control science; and over what goes on behind closed doors in research institutions.
- Six attitudinal clusters towards science are identified, based largely on interest in science and perceptions about the control and regulation of science. The authors suggest that science communication activities can be tailored to meet the needs of these clusters. The clusters are: 'confident believers' who are interested in science for the benefits it brings and feel it can be controlled/influenced; 'technophiles' who were educated in science but were concerned over the control/direction of science; 'supporters' who were amazed by SET and believed it was controlled effectively; 'concerned' who acknowledged that science is an important part of life but were sceptical of those in authority; 'not sure' who have unformed views of science and do not always see the benefits of science; and 'not for me' who were not particularly interested in science but appreciated its benefits for the future and for younger people. The characteristics of individuals who fall into these groups tended to differ by age, gender, socio-economic status, and educational achievement and confidence. The groups also differ in terms of media use.

OST and the Wellcome Trust (2001b), *Science and the public: a review of science communication and public attitudes towards science in Britain*, *Public Understanding of Science*, Vol. 10, pp. 315–330

Provides a summarised form of the full report in (OST, Wellcome, 2001a).

Pardo R, Calvo F (2002), 'Attitudes toward science among the European public: a methodological analysis', *Public Understanding of Science*, Vol. 11, pp. 155–195

The work is set within the scientific literacy debate, which first emerged in the 1980s. It examines the linkage between scientific knowledge and attitudes to science, and criticises these links arguing that they are weak. It notes how much research assumes that positive attitudes to science depend on familiarity with science and, as such, cognitive deficit (*ie* lack of scientific knowledge) is undesirable. However, the authors here argue that many of the papers basing themselves on the 1992 Eurobarometer survey may be methodologically flawed and that more attention should be paid to questionnaire design if this issue (attitudes towards science) is to be addressed.

Pyke N (2003), 'They're watching the detectives', *The Independent* 3rd April

This article comments on the boom in forensic science studies at UK Higher Education institutions which is said to have been influenced by 'the glamorous world of criminal investigation' as shown on television. Staff from various universities and colleges including: Liverpool John Moores University, the University of Teesside in Middlesborough, and Manchester Metropolitan University; have noted that television programmes such as Morse, Silent Witness, and Cracker have strongly encouraged young people to take up the forensics-related courses at their institutions. The numbers of HE places in forensics-related subjects have increased by 55 per cent in the past year, with over 1,000 students taking up the new places. The employment opportunities in forensics and elsewhere after following forensics courses are also discussed.

Shachar O (2000), 'Spotlighting women scientists in the press: tokenism in science journalism', *Public Understanding of Science* Vol. 9, pp. 347–358

The report notes that science and its practitioners (scientists) have been extensively covered in the media, and that research has analysed this coverage. However, it notes that few studies have analysed news coverage of science and scientists in a social context. This project concerns itself with the question of cultural power in the context of gender media presentation. In this study, the concept of social tokenism is used for investigating journalistic discourse. In particular, the treatment of female scientists by science journalists is used as an illustration of tokenistic journalistic routines in the press.

The report notes that tokenism, as a social concept, refers to the process by which a privileged group allows an individual from an excluded group to share its advantages. Tokens are often used as symbols rather than as individuals. The report points to empirical research which has highlighted the effect of tokenistic practices, and these include: stress, social isolation, and gender role encapsulation. This study found the existing approach in science journalism has created a peculiar inclination towards depiction of female scientists, finding that they are portrayed from a personal, individualistic orientation with less of an emphasis on the public, shared role. These women are portrayed as individuals with their unusual interests, but are also scientists, while the male scientists are painted in their professional public position.

2.5 The changing careers service literature

2.5.1 Creation of Connexions

Connexions (2002), *Connexions: the best start in life for every young person,* Connexions

Sets out the Connexions strategy aimed at creating a step-change in participation and attainment through the teenage years. Connexions brings together a number of existing and new initiatives and is designed to co-ordinate a range of national and local policies and services to deliver results for all young people. Locates the work of the Connexions service in the context of a range of policies and initiatives aimed at improving educational and training provision for children and in particular teenagers. The Connexions Service aims to provide a new approach to guiding and supporting young people through their teenage years and their transition to adulthood and working life. Structured with a national cross-departmental, Connexions Service National Unit, Connexions Partnerships at Learning and Skills Council level, and local management committees at the level of local authorities or groupings of local authorities bringing together local partners. It involves eight key principles:

- raising aspirations — setting high expectations of every individual
- meeting individual need — and overcoming barriers to learning
- taking account of the view of young people — individually and collectively, as the new service is developed and as it is operated locally
- inclusion — keeping young people in mainstream education and training, and preventing them moving to the margins of their community
- partnerships — agencies collaborating to achieve more for young people, parents and communities than agencies working in isolation
- community involvement and neighbourhood renewal -- through involvement of community mentors and through personal advisers brokering access to local welfare, health, arts, sport and guidance networks
- extending opportunity and equality of opportunity -- raising participation and achievement levels for all young people,

influencing the availability, suitability and quality of provision and raising awareness of opportunities

- evidence-based practice -- ensuring that new interventions are based on rigorous research and evaluation into 'what works'.

Dickinson P (2001), *Lessons Learned from the Connexions Pilots*, RR308, DfES

Report on the DfEE funded action research undertaking formative evaluation as the Connexions pilots were developing. The pilots proved a useful test bed for many of the concepts and patterns of service delivery adopted by the service. Key lessons from the pilots included:

- 96 per cent of clients found sessions with their personal adviser useful
- 80 per cent mentioned this was because they could discuss their problems with someone who would listen
- 79 per cent said that they were more interested in education as a result of their interviews
- 70 per cent said that they had more confidence about getting a job
- 77 per cent said that the support they had received was better than they had received in the past
- there was much evidence of multi-agency working
- relationships with schools and colleges were positive
- significant numbers of young people were found to require targeted and innovative solutions.

Hughes D, Morgan S (2000), *Research to Inform the Development of the New Connexions Service*, Centre for Guidance Studies, Occasional Paper

The paper presents a brief summary of research findings drawing on UK and international projects related to social exclusion and youth support developments. Draws conclusions about the need to co-ordinate research to avoid duplication, and lists a wide range of areas that require further research. Recognises that most of the research has focused on young people at risk, while Connexions is designed to meet the needs of all young people. A range of methods and perspectives are required including:

- longitudinal ethnographic investigations
- conventional surveys
- evaluation studies
- reflective practitioner research
- young people as researchers.

Recommendations cover research into:

- young people — what they want and need, their perceptions of the service and when and how turning points occur in their lives
- agencies — mapping agencies that work with young people, identifying overlap and good practice and how information and referrals should flow between them
- personal advisers — identifying similarities, differences and strengths of the various models of personal adviser their relationships with clients and the tensions these produce
- support for personal advisers — the strengths and weaknesses of the various forms of training and support for personal advisers
- output measures — development of hard and soft output measures with indicators of distance travelled, as well as measures that take account of the intensity of work.

OFSTED (2002e), 'Connexions partnerships: the first year 2001–2002', Report No. HMI 521

A generally positive assessment of the careers guidance services for the 13–19 age group. Connexions has restored, and sometimes improved, CEG provision in schools and colleges. Most partnerships have made good efforts to involve young people themselves in the development and implementation of the service. The presence of the personal careers adviser was felt to be wholly positive, enabling young people to overcome barriers and become more self-confident. Deficiencies include the fact that sometimes key partners are not well enough represented at board and local management committee level. Also, although Connexions pilots are helping to break down barriers and ease collaborative working, procedures for joint working are still under-developed. Similarly, the quality of guidance is variable, particularly in some areas such as work-based training.

2.5.2 Higher education careers services

DfES (2001), *HE Careers Advisory Services Review: Analysis of responses to the consultation document,* Department for Education and Skills

Over 100 careers advisory services responded to a questionnaire concerning the consultation document of the DfEE. Overall, the vast majority of respondents were in agreement with the proposals. The suggestions for the core services were well received by all the respondents who also agreed that the provision of career guidance was an essential core service. Most respondents said that students should be able to use the careers service for two years after graduating from the institution. Most agreed that even if students withdrew before completing their course they should have some entitlement to using the facilities even if it was for a specific time limit. Many are also of the view that this entitlement should be dependent why they withdraw and how long they have been on the course.

The main concerns that arose were regarding the resources the institution has available to them. Many considered that meeting all the core services and Statements of Entitlement that have been suggested could pose problems if they were not given any additional funding, particularly for the smaller establishments. It was for this reason, along with the fact that the individual institutions are aware of their local labour market and students, that they considered the implication of many of the proposals should be at the discretion of the institutions rather than defined by sector.

Harris M (2000), *Developing Modern Higher Education Careers Services*

Looked at four areas: students' entitlement to career information, advice and guidance; links with employers; the strategic role and position of careers services within HEIs; collaboration with other bodies with a similar purpose.

Makes recommendations to:

- **The HE sector**, formalising the scope of the service to be offered to students, graduates (own and other HEI), employers, improvements to ICT infrastructure, good practice for recruitment and development of CS staff.
- **Institutions**, to ensure objectives set for CS, statements of entitlement for students and employers, availability of careers advice for FE students on accredited courses, conform with Disability Discrimination Act (DDA), adequate funding, systems to ensure objectives are met, identifying of students requiring additional help, labour market information, customer feedback, improvement to academic/CS relationships, regional partnerships where beneficial, ICT investment, review links with employers.
- **Careers services**, use of ICT, Information Advice & Guidance (IAG) partnerships, relationships with Connexions, access to additional expertise for students/graduates with particular barriers to labour market success, review links with employers, professional qualifications.
- **QAA/HEFCE**, the Quality Assurance Agency for HE and the HE Funding Council for England, about to include coverage of their careers services in their reviews of institutions.
- **AGCAS/CSU/Guidance Council**, monitor best practice, take into account the needs of HEIs with disadvantaged students,

changes to CSU website, improvements to service for students/ graduates, quality standards, accreditation.

- **DfEE, Learning & Skills Council,** arrangements for FE students doing accredited courses, need for single agency.

2.5.3 Careers service in Scotland, Wales and NI

ELLD (2001), *Careers Scotland -- The Way Forward: Scottish Executive's Response to the Consultation Process*, Scottish Executive Education and Lifelong Learning Department

The response to a consultation following a report by a committee of inquiry examining Scotland's Careers Service (the Duffner Report (Raffe, 2001)). This report outlines the structures and responsibilities of Careers Scotland that replaced the Careers Service in Scotland. The report accepts the proposal of the Duffner report and aligns Careers Scotland as well as the Education Business Partnerships, Adult Guidance Networks and the Local Learning Partnerships with the two Enterprise Networks. The objective being to bring the activities of all these bodies into line with each other. Outlines the remit of the new body and how questions of impartiality and the vacancy-handling role should be dealt with.

Howieson C, Semple S (2001a), *How would you know? Assessing the Effectiveness of Careers Guidance Services*, CES Briefing No. 22, Centre for Educational Sociology, University of Edinburgh

Draws on a study of the effectiveness of Careers Services in Scotland to consider the issues involved in assessing the quality and effectiveness of careers guidance work. Accepts that assessing the effectiveness of a careers service is difficult and multiple approaches have to be used. Quantitative measures combined with client feedback were most commonly used, although internal review of advisers' professional practice by peers or managers was also used as a form of assessment and training. Reports on two models of assessment both using multiple approaches developed during a four-year longitudinal study.

Howieson C, Semple S (2001b), *Pupil's Experience of the Careers Service*, CES Briefing No. 23, Centre for Educational Sociology, University of Edinburgh

This briefing reports the experiences and views of some younger clients of the careers service (4th and 5th year pupils in Scotland) who were surveyed as part of a larger research project on the effectiveness of the Careers Services. The most common interaction with the careers service was individual interviews with a careers adviser. Most pupils rated their careers interview as useful and though it had occurred at an appropriate time. However, not all those who wanted an interview received one. It was also sometimes not clear why some had received an interview and others had not.

QCAAW (2001), *A Framework for Careers Education and Guidance for 11 to 19 year-olds in Wales*, Qualifications Curriculum and Assessment Authority for Wales

Defines careers education and guidance, and sets out the legal requirements in Wales set in a Welsh context. Clarifies the aims and broad objectives of careers education and guidance in Wales. Identifies learning outcomes at Key Stage 3 and Stage 4 as well as in post-16 education. Careers advice in Wales is provided by Careers Wales, a Welsh all-age careers information, advice & guidance service launched in April 2001. Inspection of CEG at Key Stage 3 and Stage 4, as well as post-16, is provided by Estyn (Her Majesty's Inspectorate for Education and Training in Wales).

Raffe D and others (2001), *Careers Service Review Committee Report (Duffner Report)*, Scottish Executive

Report of a committee chaired by Barbara Duffner that was given the remit:

> *'to examine the role of the Careers Service in Scotland and the scope for change and development of that role in the light of trends and initiatives in education, lifelong learning, and the labour market'.*

Outlines six guiding principals for Careers Scotland, which should be impartial, informed, client-centred, confidential, available to all and coherent. Recommended that Careers Scotland should become an inclusive all-age careers guidance service. That it should move towards a national service with national branding and marketing with a range of services provided nationally.

3. Chemistry in Schools

3.1 Scope and range of literature

3.1.1 Headings used

As with the previous chapter the literature contained in this chapter is divided into three sections:

- **gender and school chemistry** – examines the impact of gender on the choice and study of science in general and chemistry in particular
- **choosing chemistry in schools** – covers the more general literature examining the factors that determine choice of science and chemistry
- **teaching of chemistry** – covers the process of teaching chemistry, the curricula that are used, and its impact on subsequent subject choices.

3.1.2 Amount and type of literature

The literature covering these headings is largely academic. However, it is also very broad and contains many duplications and small-scale studies. This means that the review concentrates on the papers with empirical evidence, based on larger samples, and, where possible, longitudinal approaches. This literature is not limited to the UK, and examples from the US, Canada, Ireland and Australia are included. The majority of this literature focuses on science in general, largely as chemistry is often only studied as a separate subject after GCSEs, except in Scotland.

3.2 Key messages

3.2.1 Gender and school chemistry

Gendered stereotypes develop very early

Children develop ideas about gender roles at a very young age, and parents, teachers, and the media then reinforce these ideas. Research indicates that children, at age eight, hold significantly more stereotyped views regarding who should perform certain jobs than older children at 12 and 16. Generally, boys allocate appropriate genders to occupations to a significantly greater degree than girls do (EOC, 2001a). A French study suggests that both sexes perceive men to be better at science and maths, while women are better at languages (Guimond, Roussel, 2001). Another study indicates that young children are keen to identify themselves as the correct gender and will work hard to ensure they appear publicly as proper boys and girls (EOC, 2001b). Largely, these stereotypes are generated by parental and peer behaviour. Male children are more likely to be exposed to scientific and technical toys and items than girls are (Jones *et al.*, 2000).

However, the gender specific roles are not inevitable (Harding 1992a and 1992b), but a wide range of factors are at work reinforcing the stereotypes (Lupart, Barva, 1998 as well as Roger, Duffield 2000). Unfortunately, some interventions designed to reduce stereotypes can inadvertently reinforce them (SQW, 2002).

3.2.2 Choosing chemistry in schools

Interest in chemistry and science declines rapidly at about 10 years old

Murphy and Beggs (2003) showed a marked drop off in interest in science between the ages of eight to nine and ten to eleven, as gender roles and associated attitudes appear to develop at very young ages (Skelton, Hall, 2001)

Gender is an important influence, but so are teachers, and the perception of chemistry as a hard or polluting subject

Gender is a critical factor in terms of attitudes towards science and chemistry (Osborne *et al.*, 2003). However, gender is one of many factors (Woolnough, 1996 as well as Steinke, 1997). Using painting by children shows that chemistry is often associated with negative images of environmental pollution and animal experimentation (Hilbling, Barke, 2000). Chemistry also suffers because it is considered hard (Harvard, 1996) or dull (Munro, Elsom, 2000). Teachers can make a difference (Matthews, Davies, 1999), but they often lack the information or confidence to give advice (see Reid *et al.* 2003; as well as Jenkin, 2002 in Section 3.5).

Parents and peers have a critical role in determining choice of science subjects

The role of parental encouragement (Ferry *et al.*, 1999) and parenting style (Kerka, 2000) and their relationship to the child's education (Williams *et al.,* 2002) are all important in determining the choice of science subjects. Equally important are the wider family and friends (Semple *et al.*, 2002).

Career goals can be an important influence on choice

Career goals are an important determinant of 'A' level subject, however career goals are often un-realistic and can be considered 'lottery jobs' (Foskett, Hemsley-Brown, 1997).

Chemistry gains and loses as a result of the requirement for chemistry for medical studies

A large proportion of chemistry 'A' level students are initially hoping to study medicine, but rather than change to chemistry in place of medicine they are more likely to study biology (Barker, 2001). See also UCAS (various years) in Section 5.1 which shows that the recent decline in university chemistry entrants has been mirrored by an increase in entrants to medicine.

Numbers attempting Chemistry 'A' levels have recently been declining in absolute and relative numbers

Numbers of pupils in attempting Chemistry 'A' level has been declining since 1995, following a gradual and spasmodic increase in numbers from the 1960s. The recent absolute decline also reflects a greater relative decline in terms of a percentage of all 'A' level entries and as a proportion of the relevant 16 to 19 year old cohort (RSC Education Department, 2003). Apart from the perception of chemistry as hard (Osborne, Collins, 2000) there is very little evidence why this pattern should exist, although it is consistent with the other physical sciences. The positive message, however, is that female pupils now represent more than half of Chemistry 'A' level entrants and especially those achieving higher grades (DfES, 2004).

Relational versus status

Interest in SET is the most important factor influencing both males and females to pursue an educational or occupational career in SET. Although gender is not always found to exert a direct effect on perceived desirability of jobs in science, gender is found to impact on the underlying psychological processes indirectly influencing the development of an interest, or otherwise, in science-related careers.

For example, several studies draw the same conclusion: that women are more likely than men to work in areas that involve contact with people, which seems to indicate that women prefer relational work (O'Driscol, Anderson, 1994). Few differences in work goals are found between sexes, but income and status was found to be more important to men, and careers that involve relationships with people were more important to women (Morgan *et al.*, 2001).

Also, evidence suggests that boys may overestimate the usefulness of science to their anticipated careers, whereas girls underestimate the value of physical sciences to careers such as nursing and catering (Harding, 1992b).

Possible declining impact of gender

Although girls and boys still tend to choose different school subjects to study, when allowed to by the curriculum, recent studies seem to confirm that gender stereotyping in school subjects is weakening (Miller, Budd, 1999). Breakwell and Robertson (2001), who measured children's attitudes in 1987-1988 and 1997-1998, support this.

One of the most encouraging findings points to the influence that teachers can have. Teachers use of practical problems, demonstrations and active learning techniques lead not just to the development of more favourable attitudes towards maths and science but also to pupils being more likely to believe that their performance can be improved through their effort (Miller *et al.*, 2002).

Declining interest in chemistry is an international problem

Chemistry education has similar problems elsewhere, for instance Ireland (Childs, 2002), and similar measures to deal with the problems and negative attitudes towards chemistry (Regan, Childs, 2003).

3.2.3 Teaching of chemistry

The UK is relatively effective at teaching science subjects and appears to be getting better

Before any criticisms of chemistry education in the UK it needs to be acknowledged that on many international comparisons the UK performs well, for instance (Gill *et al. 2002).* Equally, assessment of chemistry and science teaching quality show sustained improvements (OFSTED, 2002a, 2002b, and 2002c).

Chemistry as taught needs to be more relevant to everyday life and provide the basis for chemical literacy

The House of Commons Science and Technology Committee, (2002a and 2002b), catalogues a series of problems with the current practice of science teaching in schools. Despite science being compulsory up to GCSE level, the national curriculum is believed not to provide sufficient underpinning for science 'A' levels in terms of numbers or content (Nicolson, Holman, 2003). Although, much has been achieved compared with the situation before the national curriculum.

At the same time the current curriculum does not provide the necessary basis for chemical literacy (Holman, Hunt, 2002). This is a problem as scientific literacy is seen as increasingly necessary for life in the modern world (Levinson, Turner, 2001). This lack of relevancy is also off-putting for pupils (Osborne, Collins, 2001). As such, the current curriculum is failing to properly prepare pupils for further study or for engagement with the scientific debates of society (Millar, Osborne, 1998).

Currently, a new science GCSE is being piloted that attempts to address these problems (21st Century Science Project Team, 2003; as well as MacKay, 2003). The GCSE science specifications for England are being revised for first teaching in 2006. Similar developments are under way with chemistry 'A' level (Hughes, 2000). Although, any changes to the 'A' level curricula will need to take into account changes to the GCSE curricula and changes to the overall structure of post-16 education.

Research into chemical education is becoming increasingly useful to practitioners

There is an increasing empirical basis for effective chemistry education (Jong *et al.*, 1999; and Kempa, 2002). At the same time this information is also increasingly being disseminated to practitioners (Monk, Osborne, 2000).

Practical work is important for interest and understanding of chemistry

It has been shown that practical chemistry work can enhance the learning experience and make the subject much more appealing (Hofstein, Lunetta, 2003). Despite some popular misconceptions, current Health and Safety regulations are not a rationale for dull practical work or boring demonstrations (RSC, 2002a). However, practical work does require adequate technician support (Royal Society, 2003).

Changing the chemistry curriculum can make it more accessible, more female friendly, and better at developing chemical literacy

The reforms of GCSEs and 'A' levels in England and Wales provides an opportunity for reform of the chemistry curricula. These changes could generate a more accessible and female friendly subject (Hughes, 2000). At the same time the changes could generate greater chemical literacy (Holman, Hunt, 2002; and Levinson, Turner, 2001).

Industrial experience works

A series of interventions culminating in an industrial visit can change attitudes towards chemistry (Parvin, 1999). This is consistent with a wider literature that examines the impact of industrial experience (Boreham, Arthur, 1993 in Section 4.3F). However, the industrial experience needs to be more available, carefully structured and avoid the trap of 'industrial tourism' (Munro, Elsom, 2000; Rolfe, 1999 both in Section 4.4).

Again the problems and suggested solutions are international as well as national

A US report by the National Research Council (1996) argues for scientific literacy and for 'minds on' science as well as 'hands-on' science. Another US survey of science and mathematics teachers (Smith, 2002) found that one-third of chemistry teachers were approaching retirement in the next ten years and needed more professional updating.

3.3 Gender and school chemistry literature

EOC (2001a), *Sex stereotyping: from school to work*, Equal Opportunities Commission

This article details an EOC three-year plan to promote greater gender equality in respect of career choice and opportunity during the transition stage between full-time education and employment. It is felt that children develop ideas about gender roles at a very young age and that these are then often reinforced by parents, teachers and the media. The EOC aims to challenge these ingrained perceptions by:

- collaborating with employers and training organisations in gender-stereotyped fields
- working with Connexions to build equality into their approach
- encouraging the government/QCA to promote equality in relation to work experience and the school curriculum.

According to UK Education and Training Statistics (1999), GCSE subject choice is highly gendered, as is choice of GNVQ, with girls tending to choose hairdressing, and boys choosing mechanics and computing. DfEE 'A' level entry statistics (1999) show the persistence of gendered subject choice, with greater proportions of boys opting for physics and maths, and girls for English and social studies. However, chemistry at 'A' level attracts almost equal numbers of girls as boys. However, there remain gender divisions at HE level with chemistry as well as the other sciences apart from biology. It was noted that, following university, a greater proportion of women with SET degrees entered teaching or 'an occupation where their degree was not directly applicable', where men with the same qualifications were more likely to enter a scientific career, especially as managers. Salary discrepancies between genders are discussed, highlighted by Foundation/ Advanced Modern Apprenticeship statistics.

EOC (2001b) *The development of gender roles in young children: the review of policy and literature*, Equal Opportunities Commission

This report identifies the range of factors and key ideas contributing to how and what young children learn about being a boy or a girl. Sex role theories have been shown to be the most influential in the development of equal opportunities intervention strategies. Strategies based on these theories assume that providing access to non-stereotyped materials and role models, and encouragement to enter opposite sex areas, will enable young children to adopt non-traditional attitudes and behaviour. Gender-relational theories see children as actively involved in developing their own gender identities with their concepts of gender constantly changing, depending on the context. As a consequence, direct intervention in the development of gender identities is recommended by those who adopt the gender relational perspective, in order to help young children understand conventional gender stereotypes.

Studies found that younger children are more likely than older children to view gender stereotypically, but have little understanding of the word 'sexism'. The girls demonstrated more egalitarian views than the boys and the children generally applied the notion of equal opportunities more often to women than men. Parents, local communities, peer groups, early years settings and the mass media are the main sources of information from which children learn about gender. Young children are keen to identify themselves as the correct gender, and work hard to ensure they appear publicly as proper boys and girls.

Recommendations are made for workers in 'early childhood' who should be provided with guidance in exploring their fundamental beliefs about early childhood, and in recognising the effect that their beliefs have on children.

EOC (2002), *Evidence to the House of Commons Science & Technology Committee Inquiry: Science Education 14 – 19*, Equal Opportunities Commission

Provides a useful summary of the issues surrounding gender and science education. Evidence covers:

- the role of the Equal Opportunities Commission
- the gender issue in science
- the current situation

- implications for science education
- the national curriculum entitlement to science
- why girls opt out and what solutions work
- implementing solutions
- in addition there are annexes listing useful material and recent and current initiatives on gender and science.

It argues that the compulsory science component of the national curriculum up to age 16 has generated higher performance and engagement with science amongst girls. However, there is a critical need to better understand why historic patterns of female disengagement re-emerge post-16. It is believed that the early socialisation of boys and girls determines this pattern. Research is cited identifying careers material used in Britain from the 1970s until 1998, that equates males with practical jobs and females with caring jobs. The authors hope that the requirement for Connexions projects to develop an equal opportunities project will lead to more action to encourage non-traditional choices by girls and boys.

Guimond S, Roussel L (2001), 'Bragging About One's School Grades: Gender Stereotyping and Students' Perception of Their Abilities in Science, Mathematics and Language', *Social Psychology of Education*, Vol. 4, No. 3–4 pp. 275–293

This article reports on three French studies designed to examine stereotypes relating to the abilities of men and women, and the implications of these for self-evaluation. All three suggested that women are generally perceived to be better than men at languages, and men better at science and maths. The first study — a large-scale attitude survey (*eg* n = 463), suggested that female psychology students who believe that men are better than women at science, felt significantly less able in science, have lower self-esteem, and report lower school marks than students who do not believe that men are better.

Harding J (1992a) *Breaking the barrier: Girls in science education*, Schools Council publication, Longman Publishing

'Women are under-represented in science.'. The author discusses fallacies and arguments against this. On the basis of scientific studies, the author argues that:

- given appropriate conditions girls achieve in science as well as, if not better than, boys
- research has produced no reliable evidence that girls have less science ability than boys
- when girls see that science addresses their concerns and values, they show just as much interest as boys do

- when girls recognise that the problem relates to areas that are important to them and they are free to include contextual aspects, they are able to produce valuable and realistic solutions to problems
- given time, girls can weigh up aspects of the complex problems they perceive and come to conclusions which they can justify
- girls enjoy enquiry learning, but faced with cognitive styles with which they are not comfortable, girls may retreat into rote learning
- it is arguable that girls are better at routine, repetitive, rather than creative work
- given a congenial, encouraging climate, girls enjoy practical work.

The author then discusses the implications of these arguments and gives options for educational planners and policymakers.

Harding J (1992b), *Breaking the barrier: girls in science education*, UNESCO, Paris

Starts with international comparisons of the level and pattern of female participation in HE science. Then addresses a series of fallacies about females and science. The next section covers what educational planners and policy makers can do to increase female participation. The conclusion suggests three things that need to be done to remove barriers to girls participating in secondary science:

1. make a clear policy commitment to gender inclusive education
2. release resources to implement the policy
3. engage in effective monitoring and evaluation.

Jones G M, Howe A, Rua M J (2000), 'Gender differences in student's experiences, interests, and attitudes toward science and scientists', *Science Education*, Vol. 84, No. 2, pp. 180-192

A US study that surveyed 437 sixth grade students' attitudes and experiences related to science. It found continuing significant gender differences where boys were more likely to have had extracurricular experiences with batteries, electric toys, fuses, microscopes and pulleys. Girls, on the other hand, were more likely to have experienced bread making, knitting, sewing and planting seeds. In terms of future jobs, boys were more interested in jobs that involved controlling people or becoming famous, while girls were more interested in helping other people. More females than males reported science as difficult, while more males than females felt science was dangerous and suitable for boys.

Lupart J, Barva C (1998), 'Promoting female achievement in the sciences: Research and implications', *International Journal for the Advancement of Counselling*, Vol. 20, No. 4, pp. 319–338

This article contains a review of recent research in the area of gender and science, as well as a study of a Canadian scheme for high achievers. According to the review, girls and young women are less likely than their male peers to participate in advanced maths and science studies, are less likely to perceive themselves as capable in these fields, and are less likely to proceed into related careers. Negative parental influence, inappropriate teaching materials and methods, and poor perceptions of self-efficacy are noted as key in affecting this imbalance. According to the high achievers study (n = 576), although no significant difference was observed between males and females in respect of teachers' ratings of ability, females were achieving significantly higher grades in English, French and social studies, and males in physics and computing. Maths scores were similar between the sexes. Implications for careers counselling are discussed. It is noted, *eg* that counsellors must be aware of their own gender prejudices, and of the gender stereotyping implicit in computer-assisted guidance systems.

Miller L, Budd J (1999), 'The Development of Occupational Sex-role Stereotypes, Occupational Preferences and Academic Subject Preferences in Children at Ages 8, 12 and 16', *Educational Psychology*, Vol. 19, No. 1, pp. 17–35

This paper reports data from a questionnaire-based UK study aimed at examining occupational sexual stereotypes and occupational preferences of male and female pupils at three ages. Data were collected from 594 children in total who responded to questions that asked for their views on whether males, females, or both should perform certain occupations and how much they would like to have each of the occupations as their career. The children were also asked to indicate their favourite school subjects.

Analysis indicated that the youngest age group held significantly more stereotyped views regarding who should perform certain jobs then the older children. Generally, boys sex-typed appropriateness of occupations to a significantly greater degree than girls, although this difference was not significant in the youngest age group. Furthermore, analysis of the occupational preference ratings revealed significant differences between male and female subjects for many occupations, with higher ratings generally being awarded to stereotypical gender-appropriate careers. Significant differences between the three age groups are also observed in the preference ratings for many occupations, with a tendency for the majority of occupations to be perceived less favourably with increasing age of respondents. Finally, schools subject preferences are considered. No consistent or stable pattern of preferences emerged for males and females across age groups, confirming recent suggestions that gender stereotyping of school subjects is weakening.

Miller L, Hayward R (draft), *New jobs, old occupational stereotypes: gender and jobs in the new economy*

A study of 508 British school children to measure the extent of occupational sex-role stereotyping and perceived educational segregation of 14–18 year olds. Both boys and girls had significantly strong preferences for different job titles; stereotyped female occupations included occupational therapist and physiotherapist; male occupations included software engineers and computer engineers. Preference ratings for job titles were strongly correlated with the extent to which the job was gender stereotyped and even more so with the extent to which the job was perceived as appropriately gender stereotyped.

Promoting SET for Women Unit (2001), *Get with it!,* Promoting SET for Women Unit

A report describing the main stages of the 'Go for it' posters campaign ran by the Government's Promoting SET for Women Unit. It describes how and why the posters aimed at encouraging girls to take up science were produced. The process started with research with teachers, parents and other members of the SET community to establish the best approach. Three key areas were identified to make science more attractive to girls:

- humanise and personalise science as much as possible
- address issues of confidence
- make material appealing and relevant to target age range.

The report contains a set of good practice guidelines based on this research which expands on how to respond to these three key areas.

Roger A, Duffield J (2000), 'Factors underlying persistent gendered option choices in school science and technology in Scotland', *Gender and Education*, Vol. 12, No. 3, pp. 367–383

The last 15 years have seen a persistent under-representation of girls in school science and technology subjects. The article is divided into three parts. The first part surveys the persistence of girls opting out of science and technology option choices and reviews the influences from a wide range of literature, which affect girls' choices. These influences are: early socialisation, primary teachers as change agents, option choices process, guidance and careers advice, teachers and teaching, and work experience. The second part presents a meta-analysis of initiatives to encourage girls and women into science, engineering and technology courses and careers, drawing upon the survey undertaken as part of the Scottish initiative to encourage women students and staff to enter courses in SET in higher education, and to progress in careers there. The analysis is then used to illuminate various school initiatives and to estimate the likelihood of their success in addressing the underlying influences on girls' choices away from science and technology.

SQW (2002), *Review of Girls-only hands-on experience opportunities in STEM*: A final report to EMTA, EMTA

This report reviews the impact of a wide range of often *ad hoc* and small-scale initiatives. Projects specifically for girls were relatively rare. Found that often the impact of many of the current initiatives was, at best, to reinforce girls' views about their immediate preference or dislike for SET subjects. In part, this is because the projects provided only limited additional information about possible career options, although where this was done it could have some effect on girls. More should be done to align the initiative with the national curriculum, as this would maximise their impact. The WISE vehicle programme appeared to be both liked and disliked by girls, the age of the vehicle is sometimes important here. However, the impact was short-lived and did not generate any lasting changes to attitudes to SET subjects. In some schools the vehicles were not being used as intended and this may have influenced the impact. Few initiatives aimed at increasing girls' interest in ICT were found, although it was felt that many of the approaches used with science could be applied.

3.4 Choosing chemistry in schools literature

Barker V (2001), 'Why do students choose 'A' level chemistry?', *Education in Chemistry*, September 2001

Reports the results of two surveys, one at the start and the other at the end of an 'A' level chemistry study by 356 students at 27 schools. The surveys examined the career choices of these students and the paper uses these choices to try to better understand why they had chosen 'A' level chemistry. Overall, 90 per cent intended to go to Higher Education. At the time of the first survey over a fifth (21.9 per cent) were undecided about their degree subject, 17.7 per cent hoped to study medicine and only 4.2 per cent hoped to study chemistry. By the time of the second survey only 7.3 per cent were undecided about their degree subject, while the proportion intending to study medicine had dropped to 13.2 per cent. However, biology, rather than chemistry, was the main recipient of those making up their mind and rejecting medicine.

The author suggests that relatively little change occurs between the beginning and end of 'A' level study and that encouraging people to study chemistry needs to be undertaken before then. It

Table 3.1: 'A' level chemistry students' further study intentions

	First survey		Second survey	
	(N)	%	(N)	%
Subject undecided	78	21.9	26	7.3
Medicine	63	17.7	47	13.2
Chemistry	15	4.2	28	7.9
Chemistry related	35	9.8	33	9.3
Biology and biology related	22	6.2	40	11.2

Barker V (2001), Why do students choose 'A' level chemistry, Education in Chemistry, September 2001

is also suggested that potential medical students select biology as a more 'obvious' alternative to medicine.

Breakwell GM, Robertson T (2001), 'The gender gap in science attitudes, parental and peer influences: changes between 1987–88 and 1997–98', *Public Understanding of Science*, Vol. 10, pp. 71–82

The study looks at changes during the 1990s in the gender differences in attitudes to science by replicating a study in 1997 that was conducted originally in 1987. Comparison of the data gathered indicated that females still liked science less than males, had a perceived lower performance in science than males, participated in fewer science-related activities outside of the classroom, and had more negative attitudes towards science in general. Also, the results showed that overall (for both males and females) liking of, and performance in, science had declined over the period, although attitudes towards science in general remained constant.

The report indicated that parental influence, particularly mothers' perceived support for science, was important in liking of and attitudes towards science. It also found that mothers' support for science increased over the ten-year period. The authors argue that parents and peers do influence individuals and that the largely negative results in the research were due to external factors:

> *'… positive changes in parental factors were swamped by changes in other areas not measured by this study.'*

The authors conclude that over the ten years from 1987 to 1997 there has been no narrowing of the gender gap in attitudes towards science (see Chapter 3 for more detail).

Childs E (2002), 'Securing the future of chemistry: A case study of developments in chemical education in Ireland', *Chemistry Education*, Vol. 3, No. 3, pp. 361-369

Reports that between 1999 and 2002, science education moved to the top of the Irish Government's agenda. The paper reviews of series of initiatives. In 2000, a new chemistry curriculum was introduced at the Leaving Certificate (LC) level as the previous course had been '*perceived by students and teachers to be long, difficult and too mathematical*.' In 1999, the Irish Government also launched their Physical Science Initiative that involved:

- modernisation of school laboratories
- introduction of new syllabuses in LC Chemistry and Physics
- new syllabuses in LC Biology and LC Physics with Chemistry
- review of the Junior Certificate (JC) Science syllabus
- revision of ordinary level exam papers to make them more accessible
- a major skills upgrading of science teachers using a panel of trainers
- investment in IT for school laboratories
- a Physics Sciences Support Team to provide in-service courses and help to teachers in implementing the new courses.

Farmer H, Wardrop J, Rotella S (1999), 'Antecedent Factors Differentiating Women and Men in Science/Non-science Careers', *Psychology of Women Quarterly*, Vol. 23, pp. 763–780

Factors that differentiate women and men who choose a science career from those who do not were investigated using longitudinal data from 1980 and 1990. The participants were ninth or twelfth graders at six mid-western high schools in 1980. Women in science, compared to women in other careers, were significantly more likely to value maths and science for their future career goals. Whereas men in science, compared to men in other careers, had significantly higher high school grade point averages in natural science and high career aspirations.

The findings indicated that environmental variables, such as the influence of parents, teachers, and counsellors, did not contribute to the fitted models. One of the strongest predictors for young adult women who were participating in science careers was current motivational feelings and commitments, namely, valuing mathematics and science for their career relevance.

Not unexpectedly, both women and men in science careers, compared to those in non-science careers, took more high school science courses because they wanted to. They also aspired to higher prestige careers as young adults, and attributed their maths successes more to their ability. The male model accounted for more than twice the variance accounted for by the female model, and context variables were not predicted for either model. Suggestions for revising the model and improving the assessment of context influences are made. Implications for research and practice include designing and evaluating programmes to increase the number of intellectually able girls valuing maths and science as these relate to their future goals.

Ferry T, Fouad N, Smith P (1999), 'The Role of Family Context in a Social Cognitive Model for Career-Related Choice Behaviour: A Math and Science Perspective', *Journal of Vocational Behaviour*, Vol. 57, No. 3, pp. 348–364

In this quantitative study, the Social Cognitive Career Choice Model (see also Lent *et al.*) is used to analyse data on 791 undergraduate psychology students at two US universities. The effects of family-context variables, such as parental encouragement on learning experiences, interests, and outcomes were examined and found to be significant. In turn, learning experiences were found to have a significant effect on self-efficacy and outcome expectancies.

Foskett NH, Hemsley-Brown JV (1997), *Career Perceptions and Decision Making among Young People in Schools and Colleges*, HEIST

A report covering the Career Perceptions and Decision-Making (CAPDEM) project. The project examined the perceptions and knowledge of specific careers held by pupils aged ten, 15 and 17, and the influence of those perceptions on choices of career and education pathways. The project studied 410 pupils/students in the West Midlands and the South East using focus group interviews and questionnaires. The project focused on nursing and engineering careers (as well as perceptions of careers in general), and how these perceptions influenced decisions at key points in their educational career.

The pupils/students identified three types of potential career:

- lottery jobs — very high-status but with a chance element which make them uncertain, such as acting (aspired to by 28 per cent)
- high-status jobs — professional jobs with high competitive entry criteria such as medicine or law (aspired to by 22 per cent)
- customary jobs — other jobs undertaken by most people (aspired to by 50 per cent).

It was found that decisions about jobs are often made very early on, and therefore by late primary school the majority of pupils have rejected most jobs on the basis of their perceptions. Enjoyment and interest were cited as important choice criteria by 90 per cent.

Perceptions of careers are very individual and are based on images they see for themselves, and images of parents and friends, as well as images derived from the media. Many jobs are invisible and therefore have no associated image, while many images are more determined by associated lifestyles rather than the job itself.

Among the ten to 15 year olds interviewed, perceptions of engineering jobs were dominated by images of dirty and physical work associated with car mechanics. Alternatively, 17 year olds had images of graduate engineering jobs, but these still had a physical as well as intellectual component. However, engineering careers tended to be invisible which emphasises the importance of role models. Exposure to visiting engineers in schools through Business–Enterprise links, however, tended to confirm rather than challenge stereotypes.

The report concludes with a series of recommendations for careers education and guidance as well as policy areas.

Harvard N (1996), 'Student attitudes to studying 'A' level sciences', *Public Understanding of Science,* Vol. 5, pp. 321–330

An older UK qualitative study of 175 sixth form pupils in Gloucestershire. The study looked at the factors which influence subject of study amongst those studying science and those studying non-science subjects. The research found that young people have different attitudes to the different science subjects. Physics elicits the most negative attitudes generally because it is considered to be difficult; whereas biology had the most positive attitudes because it is considered to be interesting. The work indicates that perception of difficulty affects individuals' study choices, but that gender and parental influence does not influence choice. The study also found that science students feel that science study will enhance career prospects, but non-scientists feel that science subjects would limit their future options.

Hilbling C, Barke H D (2000), 'An idea of science: Attitudes towards chemistry and chemical education expressed through artistic paintings', *Chemistry Education*, Vol. 1, No. 3, pp. 365-374

Deals with attitudes towards chemistry and chemical education of pupils with, and without, experience of chemistry lessons. Pupils were asked to draw paintings that reflected their views of chemistry. The paintings were assigned to a number of categories: environmental pollution; animal experiments, laboratories, everyday life, and specialised knowledge. The first two categories were considered negative and the last two were considered to be positive. Boys painted more pictures with negative motifs than girls. Compared with a similar exercise 15 years previously, far fewer negative paintings were produced.

Kerka S (2000), 'Parenting and Career Development', *ERIC Digest*, No. 214

With reference to 'attachment theory' and 'social learning theory', this paper looks at parenting styles, family functioning and parent-child interaction in an attempt to assess their impact on children's career choices and career self-efficacy. Effectively a literature review, the author concludes that there is a link between parenting behaviour, family functioning, and career development. As a consequence, Kerka suggests that careers services should move away from individual to family-level guidance, encourage parental involvement in schools, help families become more proactive (as this encourages children's autonomy and life-shaping abilities), and find ways in which schools can replicate 'helpful types of family functioning'. There are also recommendations for parents.

Matthews B, Davies D (1999), 'Changing children's images of scientists: can teachers make a difference?', *School Science Review*, Vol. 80, No. 293, pp. 79–84

This article details a research study in which 281 pupils aged between five and 13, across four London schools, were asked to draw an imagined pair of scientists. The results include that:

- children form their images of scientists at about the age of six or seven
- the older the child, the more likely he or she was to draw a male scientist
- on the whole, boys tended to draw more male scientists and girls, female scientists
- participants had an overwhelming view of scientists as being 'white'; even though children from ethnic minorities were involved in the study, very few 'black' scientists were drawn
- very few (only five per cent) of the seven to eight age group, when asked where they felt their images of scientists came from, directly referred to teachers or school experiences as being the main influence in their drawings. External influences included (in order, from the most influential) books, TV, comics, museums, and posters
- secondary school pupils, when asked, cited within-school influences as greater than external influences.

The authors criticise the OFSTED framework for enforcing a narrow curriculum that precludes the social issues around science, *eg* equal opportunities; and for focusing too heavily on the academic side of the subject. A possible result of this was the fact that, compared to recent studies, secondary school pupils in this study were drawing *more* stereotypical images. The report also gives recommendations for the classroom.

Miller L, Kellie D, Acutt B (2001), 'Factors influencing the choice of initial qualifications and continuing development in Australia and Britain', *International Journal of Training and Development* Vol. 5, No. 3, pp. 196–222

A study exploring the factors that influence the choice of individuals qualifications at different stages throughout their employment history. A survey was carried out in Australia and Britain to analyse individuals' training and education decisions between school and employment. Few differences were observed, either between the two countries or between the two sexes, particularly at the pre-work stage. The most important factor that influenced decision-making at this stage was parental advice, which was ranked above the influence of friends, teachers or careers advisers. The major finding was that those involved in academic programmes were far more likely than those entering vocational programmes to have cited issues of self-development, demand and achievement, with the latter more likely to cite the influence of a manager or the availability of funding.

Murphy C, Beggs J (2003), 'Children's perceptions of school science', *School Science Review*, Vol. 84, Issue 308, pp. 109-116

An analysis of about 1,000 questionnaires in which 8-11 year old children recorded the science topics they liked, their attitudes to science, and their favourite subject. The questionnaires came from 44 schools across Northern Ireland and had 50.1 per cent female respondents, which closely reflects the sample population. The results indicate that 8-9 year olds were more enthusiastic about science than 10-11 year olds. However, the older children were more confident about their scientific knowledge. Girls seemed to like science more than boys and were more appreciative of links between school science and everyday life. When asked what they liked most about science, the pupils said it was experiments as they were learning while enjoying themselves. This suggests that it might be a lack of experimental work that was putting pupils off science. Another idea put forward is that the preparation for national tests was putting them off science as a different style of teaching was involved. A final explanation put forward involved an inappropriate curriculum. The paper ends with a call to improve children's primary science experience.

Osborne J, Sion S, Collins S (2003), 'Attitudes towards science: a review of the literature and its implications', *International Journal of Science Education*, Vol. 25, No. 9, pp. 1049-1079

Reviews the last 20 years of literature covering science attitudes and their implications. Explores what is meant by attitudes to science and associated measurement issues. Examines the linkage between attitudes towards science and choosing science courses and careers. Based on the literature, it identifies the central importance of gender and the quality of teaching. Issues around motivational impact of teaching may be critical. Concludes that:

> *'It is somewhat surprising that so little work has been done in the context of science classrooms to identify what are the nature and style of teaching and activities that engage students. For lest it be forgotten, attitudes are enduring while knowledge often has an ephemeral quality.'*

Regan E, Childs P (2003), 'An investigation of Irish students' attitudes to chemistry: The promotion of chemistry in schools project', *Chemistry Education*, Vol. 4, No. 1, pp. 45-53

Ireland is also facing a decline in chemistry and physics numbers and has implemented a number of initiatives in response. This paper gives details of one of these initiatives, the 'Promotion of Chemistry in Schools Project'. This project was established to investigate:

- the attitudes and interests of Irish students towards the sciences
- factors which may influence their subject choice at senior cycle
- an intervention strategy which might increase their interest in chemistry.

Stage one of the project involved 8,500 students in 67 intervention schools and ten co-operation schools who were exposed to a 'Chemical Magic Show', designed to promote chemistry. This was followed up by positive reinforcement involving the distribution of 'ChemKidz', a magazine containing chemistry jokes, activities, cartoons, and careers information. The following year saw the distribution of a similar magazine called 'CheMystery'.

The paper is based on an analysis of one of a series of longitudinal questionnaires, this one administered before the Chemical Magic Show to get baseline data on attitudes towards chemistry. The large majority (87.5 per cent) of the students would choose to study chemistry voluntarily and were interested in the subject. The barriers were the perceived difficulty and boring nature of chemistry. Physics was perceived to be less interesting than chemistry.

Semple S, Howieson C, and Paris M (2002), *Young People's Transitions: Careers Support from Family and Friends*, CES Briefing, Centre for Educational Sociology, University of Edinburgh

This briefing was derived from a longer report 'A Longitudinal Study of Young People in Ayrshire', also conducted by CES in 2002. The study followed 36 young people in Scotland over three years as they moved from school into further education, training or work. The work focused on the factors influencing career ideas and compared the influence of formal and informal networks of career support. It found that informal support via parents, families, friends, and neighbours was more influential and had greater impact on career development than formal support provided by careers advisers and guidance teachers. Also, that the informal network changed as young people moved through key stages in their lives, to include subject teachers, fellow FE/HE students, and work colleagues.

> *'Parents and families have a strong influence on most young people's career development, career decision making and transitions. This informal network of careers advice and information has been described as providing the background music against which the information and advice of careers advisers and guidance teachers (the formal network) is heard.'*

The authors indicate that informal networks influence young people in a number of ways either explicitly and planned, or through assumptions and in unplanned ways. Planned interventions include: encouraging and motivating; raising aspirations (sometimes unrealistically); providing practical assistance and contacts (*ie* with costs of study, learning to budget, and information on opportunities and occupations); and involvement in the careers guidance process. Unplanned influence can occur when values, expectations and assumptions about work and education are shared; when impressions are developed from others' experiences (*eg* family and friends'); through media such as TV and newspapers, and through the direct experience of part-time work.

The authors note that the power of informal networks is that they give directive advice/guidance.

> *'Advice from the informal network was valued precisely because it was directive and could give some direction to a young person struggling with career planning. The formal network, on the other hand, often refused to give an opinion, an approach that was sometimes seen as unhelpful by a confused client.'*

However, they note that professional help is needed when individuals are uncertain about their careers, as the informal network is relatively helpless. So they recommend that formal guidance services need to acknowledge not only the importance and influence, but also the limitations, of informal networks of support; and to test implicit assumptions that influence career decisions and present a wider view of the opportunity structure.

Skelton C, Hall E (2001), *The development of Gender Roles in Young Children: A review of policy and literature*, Equal Opportunities Commission

This literature review concerns the development of sex stereotypes in early childhood. This report identifies the major factors and key ideas contributing to how young children learn about being a boy or a girl.

These factors can be summarised as children:

- are actively involved in constructing their gender identities
- learn their information about gender from adults in the family, local community and professional childhood practitioners; their environment; their peers; the media.

Many parents form deep-seated and seemingly unconscious perceptions of their children based on gender. Studies have shown mothers reacting differently according to what they are told of the biological sex of their baby. Young children's knowledge and understanding of acceptable gender behaviours is affected by local cultural constructions of what it means to be a man or a woman, and the gender expectations of their peers. In addition, a continuing source of conventional gender stereotyping is the mass media. Also, some early years' settings, *eg* child carers, have been found to differentiate between boys and girls for management and organisational purposes.

- Working with young children is still primarily viewed as women's work, whether seen from a caring or from an educational perspective.
- The principles and practice of early years' educational work have tended to obscure gender issues. The current expansion of the sector demands a re-evaluation of recruitment, training and development for work with young children.

Sexual role theories have recommended that children are provided with a non-sexist environment, and that it is sufficient to encourage children to take on non-conventional gender behaviours. However, gender relational studies have suggested that children's desire to demonstrate publicly that they are clearly a boy or a girl requires an active intervention on the part of adults to help them understand that a variety of behaviours is acceptable.

Steinke J (1997), 'A portrait of a woman as a scientist: breaking down barriers created by gender-role stereotypes', *Public Understanding of Science*, Vol. 6, pp. 409–428

Educational, attitudinal and social cultural factors create barriers that prevent girls and young women from pursuing opportunities in science. Of these barriers, gender role stereotypes of science have been cited as a significant obstacle. This research analyses a US television series that counters gender role stereotypes of science. The analysis found that images presented in the series challenge previously reported stereotypes of women scientists in the American media by emphasising the expertise of women scientists, showing alternatives for balancing the demands of their professional and personal lives, and providing examples of role models who have succeeded in male-dominated fields. The significance of these results are discussed in the light of gender scheme theories, the need for future research on the effects of women scientist role models on girls, and young women's, interest in science. The study did not research the actual effects of positive images of women scientists on young female viewers.

Williams B, Williams J, Ullman A (2002), *Parental Involvement in Education*, BMRB Social Research/DfES RR332

This UK study was designed to investigate the levels of involvement parents have in their children's education and general school life. It found that around one in three parents felt very involved in their child's school life. Primary school parents are more likely to feel this way than secondary school parents; and mothers are also more likely to say that they are very involved than fathers are. However, around 72 per cent of parents agreed that they wanted more involvement. Barriers to involvement were found to include: competing demands such as work commitments, demands of other children, childcare difficulties, and lack of time generally.

Almost all parents were found to be happy with the school's attitude towards them, and felt welcomed. Parents were found to particularly value face-to-face contact with teachers.

Parents were also largely happy with the quality of written communication coming from schools. However, a significant minority, 27 per cent, felt that general information (as opposed to child-specific information) was spoilt by jargon. Parents who had themselves left school at 16, were the most likely to feel this way. Also many parents were found to be unaware of the various labels given to recent education initiatives. Over one-third (35 per cent) did not recognise the term 'home–school agreement', despite the fact that all of them should have been invited to sign one.

Woolnough B E (1996), 'Changing Pupils' Attitudes to Careers in Science', *Physics Education*, Vol. 31 No. 5 pp. 301–308

What motivates or demotivates pupils to study science and follow careers in SET? This article looks at the opinions of 654 students in six Oxfordshire comprehensives in 1994. They were asked if they would consider a career in SET and what was attractive/ unattractive about these jobs, whether they thought science teaching made them more or less likely to work in SET, and what other influences there were prompting an interest in SET careers.

Woolnough found fewer than half of these pupils were considering a SET career, fewer still among the girls, though there was a hint in the data that focused careers advice may change girls' attitudes temporarily. What turned students on or off were factors relating to science as an area of study, the usefulness of science in the wider world, and vocational factors, *ie* a lack of interest in SET careers may in fact be a positive vote for something else. The influence of school science appears to turn students off careers in SET with every year of study. TV programmes were the most commonly mentioned external factor influencing students towards a career in SET.

The author concludes that there is no one right answer to motivating people to study science, as everyone is different, and that this has implications for the range of methods used to teach SET in schools.

3.5 Teaching of chemistry literature

21st Century Science Project Team (2003), 21st Century Science — a new flexible model for GCSE science, *School Science Review*, Vol. 84, Issue 310, pp. 27-35

Outlines the innovative aspects of the new flexible 21st century Science GCSE. This is designed to have a core component that teaches the basic scientific knowledge that is considered to be vital for scientific literacy. The GCSE also has a range of additional modules that allow a range of subjects to be taught, reflecting a range of interest and ability. At the time of writing the piloting of the curriculum had just started in about 80 schools.

DfES (2004) *GCE/VCE A/AS Examination Results for Young People in England, 2002/03 (Revised),* DfES

This statistical first release from the DfES gives details of the number of males and females aged 16, 17 and 18 obtaining 'A' levels in England at Schools and Colleges. This shows that in 2003/04 the majority of those obtaining Chemistry 'A' levels were female and this was especially the case for those obtaining A grades.

Gill B, Dunn M, Goddard E (2002), *Student Achievement in England: Results in reading mathematical and scientific literacy among 15 year olds from OECD PISA 2000 study*, HMSO

The OECD PISA study used a common series of questions answered by a carefully designed sample of 15 year olds in 28

Table 3.2: Chemistry 'A' level results in 2002/03 by 16, 17 and 18 year olds in all schools and colleges in England

	A Grade	A-E	Total entries
Male	4,115	14,404	15,127
Female	4,940	15,435	15,946
Total	*9,055*	*29,839*	*31,073*
% Female	54.6	51.7	51.3

Source: DfES (2004) GCE/VCE A/AS Examination Results for Young People in England, 2002/03 (Revised) countries. The main focus was on reading literacy, but some of the tests looked at scientific as well as mathematical literacy.

Table 3.3 shows that on average English and UK pupils did well in terms of scientific literacy with only Korea, Japan and Finland scoring better. Interestingly, in some countries, most notably Korea, girls performed significantly worse than boys. However in other countries, most notably New Zealand, the position was reversed with girls performing better than boys were.

Table 3.3: Comparison of mean scores in scientific literacy by country

	Mean score	Standard error	Girls	Boys	Gender difference
Korea	552	2.7	541	561	–19
Japan	550	5.5	554	547	7
Finland	538	2.5	541	534	6
England	533	3.2	533	537	–4
United Kingdom	532	2.7	531	535	–4
Canada	529	1.6	531	529	2
New Zealand	528	2.4	535	523	12
Australia	528	3.5	529	526	3
Austria	519	2.6	514	526	–12
Republic of Ireland	513	3.2	517	511	6
Sweden	512	2.5	513	512	0
Czech Republic	511	2.4	511	512	–1
France	500	3.2	498	504	–6
Norway	500	2.8	505	499	7
United States	499	7.3	502	497	5
Hungary	496	4.2	497	496	2
Iceland	496	2.2	499	495	5
Belgium	496	4.3	498	496	2
Switzerland	496	4.4	493	500	–7
Spain	491	3.0	491	492	–1
Germany	487	2.4	487	489	–3
Poland	483	5.1	480	486	–6
Denmark	481	2.8	476	488	–12
Italy	478	3.1	483	474	9
Greece	461	4.9	464	457	7
Portugal	459	4.0	462	456	6
Luxembourg	443	2.3	448	441	7
Mexico	422	3.2	419	423	–4

Source: Gill et. al., 2002

Hofstein A, Lunetta V (2003), 'The laboratory in science education: Foundations for the twenty-first century', *Science Education*, Vol. 88, No. 1, pp. 28-54

An update of a much cited paper by the same authors from 1982. Reviews what it considers to be the still under-researched topic of the impact of laboratory study on science education. Concludes that:

- school laboratory activities have special potential as media for learning, that can promote important science learning outcomes for students
- teachers need knowledge, skills, and resources that enable them to teach effectively in practical learning environments. They need to be able to enable students to interact *intellectually* as well as *physically*, involving hands-on investigation and minds-on reflection
- students' perceptions and behaviours in the science laboratory are greatly influenced by teachers' expectations and assessment practices, and by the orientation of the associated laboratory guide, worksheets, and electronic media
- teachers need ways to find out what their students are thinking and learning in the science laboratory and classroom.'

Holman J, Hunt A (2002), 'What does it mean to be chemically literate', *Education in Chemistry*, January 2002

Outlines the results of a consultation undertaken as part of a Qualifications and Curriculum Authority's review of the National Curriculum's science GCSE. Based around a model of core science modules which provide the basis for scientific literacy and additional science modules that prepare students for further scientific study. The consultation sought to establish what elements of chemistry every member of the pubic should know, long after they have forgotten the rest of the science they learnt at school.

Hughes G (2000), 'Salters' curriculum projects and gender inclusivity in science', *School Science Review*, Vol. 81, Issue 296, pp. 85-89

There are indications that contextualising chemical knowledge in everyday life and in social issues increases the engagement of girls. This is supported by this study of the Salters' chemistry 'A' level. *'However, not all student respondents appreciated the importance and relevance of applying chemical knowledge to society.'* The author argues that this was because the Salters' course did not contain enough social contextualisation:

> *'The message that all science students need to study the role of science in society requires greater emphasis if Salters' chemistry and similar courses are to prepare future scientists and aim for greater gender inclusivity.'*

Jenkin P (2002), 'The role of science teachers in the drive for scientific literacy', *School Science Review*, Vol. 83, Issue 304, pp. 21-25

The Presidential address of Lord Jenkin of Roding delivered at the annual meeting of the Association of Science Education, Saturday, 5 January 2002. Consists of three parts: the first documents the process by which Lord Jenkin became aware of the importance of scientific literacy; the second part covers the House of Lords Science Select Committee's Science and Society report; the third and final part covers the importance of science teachers in encouraging scientific literacy. The author believes that, since the publication of the Select Committee's report, the issue of scientific literacy amongst the public has risen up the agendas of many bodies and its importance for a modern society recognised. He concludes:

> *'that if the 90 per cent who are not going on to 'A' levels are to be helped to become science-literate, then a fresh approach to the syllabus will be essential, especially in the early years of secondary schooling.'*

Jong O, Schmidt HJ, Burger N, Eybe H (1999), 'Empirical Research into Chemical Education: The motivation, research domains, methods, and infrastructure of a maturing scientific discipline', *University Chemistry Education*, Vol. 3, No. 1, pp 28-30

Outlines the motivations and common methodologies underlying research into chemical education. It also details the growing networks and journals that are associated with science education in general and chemistry education in particular. It concludes with the following statement:

> *'… a key step in the development of effective chemical education research is an increased interchange of ideas and a more active collaboration between researchers, developers and practitioners (the teachers and lecturers) all of whom share the common aim of providing the best possible education in chemistry for the next generation of students.'*

Kempa R (2002), 'Research and Research Utilisation in Chemical Education', *Chemistry Education*, Vol. 3, No. 3, pp. 327-343

Argues that despite a growth in the amount of science education research (including chemical education research), the impact on the practice of science education has been relatively low. Five factors for this are identified:

- the research has concentrated on diagnostic rather than application studies
- a concentration on fashionable areas, such as pupils misconceptions and alternative frameworks

- insufficient elaboration of the research findings in terms of their impact on teaching practice
- unawareness of research findings by science teaching practitioners or a tendency to ignore such research
- an inclination amongst practitioners to depend on 'common sense' and/or 'personal knowledge'.

Given these problems, efforts to enhance the impact of research on chemical education practice will depend on researchers adopting more practice-related areas of research and strategies that improve the responsiveness of practitioners to the research. The author suggests that the development of a partnership between researchers and practitioners where each can inform the practice of the other is probably the best way forward.

Levinson R, Turner S (2001), *Valuable Lessons: Engaging with the Social Context of Science in Schools: Recommendations and Summary of Research Findings*, The Wellcome Trust

This shorter report (28 pages) presents the recommendations and executive summary of the full report published by the Wellcome Trust. It presents the results of research into scientific literacy aspects of school science and focuses, in particular, on biomedical issues (as the work was funded by the Wellcome Trust, which is a medical research charity). The research was carried out by the Institute for Education and looks at how bioscience issues are tackled in schools and colleges. Questionnaires were sent to head teachers, biology, and science teachers, and humanities and social science teachers in England and Wales; and follow-up work was carried out in 20 schools. The research highlighted the importance of exploring science issues in schoolwork as it helps to build self-confidence, critical thinking and how to deal with issues in a balanced way. Yet teachers felt that science teaching was about teaching facts rather than exploring social and ethical issues. Teachers felt they lacked the confidence and the time to deal with these issues in the classroom, and that the current assessment system also acted as a barrier to debate. The authors feel there is a need to support teachers, and they look to the experience of teachers in other subjects (*eg* Humanities) as providing good examples of developing opinion and moral reasoning. They recommend more cross-curricular collaboration in schools, a more flexible curriculum enabling exploration of science within an ethical framework, and a clear guide (*eg* philosophy) about what science education should be.

Lord Sainsbury (2003), 'Overview of UK Science Education and New Initiatives', Speech at the Weizmann Institute Foundation, April 29th 2003

Starts by praising the UK science base, noting that the UK produces 16 research papers per one million US dollars funding, compared with nine in the US and fewer than four in Japan. England has consistently performed well in science at school age compared with other countries, and we still produce more science, engineering and technology graduates than any other G7 country, apart from France. But despite this there has been a decline in some subjects like materials science, electrical engineering, chemistry, physics and biochemistry. There is a '*need to foster a spirit of enquiry and excitement in the curriculum*.' In response to the fall off in interest in science by 11 year-olds, the DfES is piloting a new science GCSE called 'Science in the 21st Century'. In response to the Roberts' Review, the Government is establishing a national science learning centre and nine regional centres funded by the Wellcome Foundation and the DfES. They will '*provide up-to-date, professional, accessible CPD with high quality facilities*.' More money is being put into updating school laboratories. Significant changes have also been made to the teaching of science in Higher Education (HE) as well as to the methods of funding HE. Emphasised Science Enterprise Centres (SECs), are designed to enhance HE's enterprise and business relevance.

MacKay D (2003), 'Forthcoming changes to the 14-19 science curriculum', *School Science Review*, Vol. 85, Issue 310, pp. 65-68

An outline of the Government's vision for the future of science education between the ages of 14 and 19. The starting points for changes to the system are many, but include:

- only 51 per cent of pupils achieve 5 GCSEs at grades A*-C by age 16
- five per cent of pupils get no GCSEs by age 16
- in a league table of educational participation rates for 17 year olds, the UK is equal 25th out of 29 OECD countries, ahead of Greece, Mexico and Turkey
- one-quarter of 16-18 year olds dropped out of education and training at the end of 2000, significantly more than in our international competitors
- fewer 25-34 year olds in the UK hold level 2 qualifications than in France or Germany
- socio-economic background remains a barrier to educational success.

There are conflicting problems of some pupils failing while others are not stretched by the current curriculum. Therefore, it is intended to add more flexibility to the curriculum especially by adding a vocational component. This will mean that the existing double-award GCSE in applied science will continue with minimal change, and possibly the double award GCSE in science will continue with minor amendment. However, the intention is that it will also be possible to build the core content into a wider range of qualifications than at present, thereby helping to meet the needs of individual students and so raising achievement. An example is the range of qualifications developed as part of the 21st Century Science project, which is being piloted in about 80 schools from September 2003. There are also plans for 'A' levels, with mainstreaming of many vocational qualifications; for instance the Advanced VCE in Science will become the Advanced GCE in applied science. There is to be entitlement for all those up to 19 to continue learning until they achieve at least an 'A' level literacy, numeracy or ICT qualification.

Millar R, Osborne J (1998), *Beyond 2000: Science education for the future*, King's College London, School of Education

This report was based on a series of Nuffield Foundation funded seminars in 1997 and 1998, which addressed four principle questions:

- What are the successes and failures of science education to date?
- What science education is needed by young people today?
- What might be the content and structure of a suitable model for a science curriculum for all young people?
- What problems and issues would be raised by the implementation of such a curriculum, and how might these be addressed?

As such, this is an important review of the way current science education works and how it can be improved.

The report argues for a review of science education in schools to ensure that: a) the gap between school science and science in society is minimised; b) that the tension between scientific literacy and scientist training is reduced; and c) that science is not detached from technology. The authors recommend a range of short, but particularly long-term measures for teaching science to ensure that the wonder and curiosity of science is maintained, that it is seen as relevant, and that choices can be made within the science curriculum. They want to move away from science education as the transmission of a body of knowledge to enable people to train as scientists, and towards a model that fosters scientific literacy and inquiry. This will enable all people to make decisions, hold views, and engage in debate about the world around them.

The tension between science education for all or for future scientists is particularly interesting, and raises questions about who science education is really for? Is it for individuals, for organisations (to supply them with scientists), or society as a whole?

Monk M, Osborne J (Eds) (2000), *Good Practice in Science Teaching: What research has to say*, Open University Press, Buckingham and Philadelphia

Produced partially in response to the Hillage report, which criticised the quality and applicability of much UK educational research. This collection of papers is designed to show how researchers at King's College London produce material relevant to science teachers.

Includes a chapter on attitudes to science, which highlights the importance of effective teaching in developing positive attitudes to science and further science study. Other factors identified are: the perceived difficulty of sciences as an inhibitory factor and gender, with girls preferring 'female' subjects which excludes the physical sciences but includes the biological sciences.

National Foundation for Educational Research (2002*), Pupil's Experiences and Perspectives of the National Curriculum: Summary Outputs for Science*, QCA (www.qca.org.uk/ca/5-14/pp_science.pdf)

The paper presents summaries of 30 articles that have looked at pupil's experiences, and perceptions of, school science. This is a good reference document as it reviews the articles against a standard format, setting out: the purpose of the research, the focus, the sample size and make-up, the duration of the work, and the methodology involved. The main findings of each article are also presented along with implications of these, where relevant, and other key references. Most of the articles are concerned with research in areas within the UK (including Northern Ireland, Wales and Scotland). The articles are arranged in date order and run from 1994 to 1999, and are taken from a range of journals. Journals include: *School Science Review, Forum, Physics Education, The Curriculum Journal, Teaching Mathematics and its Applications, Educational Studies, British Journal of Curriculum and Assessment, Research in Education, Research in Science and Technological Education, Primary Science Review, Gender and Education, International Journal of Science Education,* and *Education Today.*

National Research Council (1996), *National Science Education Standards*, National Academy Press, Washington DC

Documents the US national science education standards developed with the goal that all students should achieve scientific literacy. Argues that: '*in a world filled with the products of scientific inquiry, scientific literacy has become a necessity for everyone*.' This literacy is required to use the products of science and engage in debates about scientific developments and increasingly as a requirement for employment. The standards were intended to apply to all students '*regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest, and motivation in* *science*.' Argues for 'minds-on' science in addition to 'hands-on' science. Provides standards for:

- science teaching
- professional development of science teachers
- assessment in science education
- science content
- science education programmes
- science education systems.

As such, this represents more than a national curriculum, and given that, in the US, education is a local and State responsibility, a national curriculum on the lines of England's would be impossible. However, the national standards represent a series of benchmarks or good-practices against which all of those engaged in the process of science education should judge their inputs.

Nicolson P, Holman J (2003), 'The National Curriculum for science: looking back and forward', *School Science Review*, Vol. 85, Issue 311, pp. 21-27

An article commissioned by the Science Enhancement Programme, an initiative of the Gatsby Technical Education Project. It is intended to provide an analysis of the impact of the National Curriculum on science in schools and issues relating to standards, assessment, delivery, and teacher supply. Examines the history and initial rationale for the national curriculum with special reference to science. The last fifteen years suggests that the national curriculum has been a success with over 90 per cent of pupils now continuing a balanced science course until they are 16. Key Stage 2 and Key Stage 3 results and international surveys confirm a continuous improvement in scientific abilities. This has reflected an increase in the proportion of teaching time allocated to science. One declared aim of the National Curriculum was to reduce the variability of what was taught in each subject. There has been a 95 per cent reduction in the number of syllabuses at GCSE level and a greater coherence between the remaining syllabuses. As such, overall the National Curriculum for science should be considered a success, although there are problems with fitting the content of at least three 'A' level subjects into a double GCSE award. There is also an increasing realisation that science needs to be seen in a social context rather than as an isolated body of knowledge.

In terms of the future, the science curriculum needs to provide an underpinning for future A–level study and provide scientific literacy for all. The 21st Century Science project is intended to address this dual agenda for GCSE science teaching.

OFSTED (2002a), *ICT in Schools: Effect of government initiatives – Secondary Science*, Report No. HMI 715

The report looks specifically at the impact of ICT on science teaching in English secondary schools. It found that increased funding for ICT had improved its use within science teaching. However, large differences remain between schools. ICT use is reported to have improved the quality of teacher presentations and access to visual illustrations and revision material.

OFSTED (2002b), *Primary Subject Reports 2000/01: Science*, Report No. HMI 357

A review of science teaching in English primary schools. The report concludes that science teaching had improved between 1999/2000 and 2000/2001. Science teaching is rated as good in six out of ten schools. In part, this was due to more schools following the DfES/QCA scheme of work. However, some problems were reported to remain due to the lack of longer sessions, which enable practical teaching.

OFSTED (2002c), *Secondary Subject Reports 2000/01: Science*, Report No. HMI 371

A review of science teaching in English secondary schools. The report indicates a slow overall rise in standards, but that a substantial improvement in attainment at Key Stage 3 has been achieved. There is a shortage of physical science teachers and this is reported to be having a negative effect on both the quality of teaching and management in a substantial number of departments.

Osborne J, Driver R, Simon S (1998), 'Attitudes to science: issues and concerns', *School Science Review*, Vol. 79, No. 288, pp. 27–33

This article reviews a number of recent studies into attitudes to science amongst school pupils, students and the general public.

- An Institute of Electrical Engineers (IEE) study (1994) found that whereas students viewed science in a more current and practical sense, as involving new technologies *etc.*, teachers framed science more theoretically, in terms of scientific milestones, such as the discovery of DNA. This was felt to represent 'a major gulf' between the aims and expectations of students and what they experience in the classroom.
- The IEE study also found that positive attitudes to science peaked around the age of 11, and declined thereafter, particularly for girls.
- The perceived difficulty of science-based subjects was found in other research studies to be a powerfully inhibiting factor in school pupils' subject choice.

- Ineffective teaching and an over-prescriptive curriculum were also felt to deter young people from pursuing science.
- Student background is also discussed, with reference particularly to ethnicity. The greater proportion of Asian young people opting for science-based subjects over and above the proportion of their white peers is noted.
- The importance of a more generalised public understanding of science is emphasised.

Osborne J, Collins S (2000), *Pupils' and Parents' Views of the School Science Curriculum*, King's College London DEPSTA

The full report of a study that investigated what turns pupils on to and off science. The study used qualitative techniques to research UK pupils (aged 16), their parents and their teachers. The researchers followed 288 pupils in three areas of the UK. The research concludes that science teaching needs to: be more relevant and to cover contemporary/real world issues; have greater emphasis on technology; more choice and flexibility (reduce the need to cover all subjects); be less repetitious, making the stages seem much more distinct from each other); have good quality teachers that can enthuse pupils; and finally a greater element of interaction and practical work (*ie* less copying). The authors note that it is important not to turn pupils off science because attitudes can be very hard to change.

Osborne J, Collins S (2001), 'Pupils' Views of the Role and Value of the Science Curriculum: A Focus Group Study', *International Journal of Science Education* 23:5 pp. 441–467

UK qualitative research using focus groups and grounded theory techniques to explore pupils' views about the school science curriculum. The authors worked with 144 16 year olds (male and female, those continuing to study science subjects and those not). They found that science is seen as important, and that it is considered important to learn scientific knowledge as it is useful for science careers and is a prestigious subject to follow. However, science skills were not seen as relevant for a broad range of occupations. Chemistry was found to elicit the most negative responses from students whereas biology and astronomy elicited the most positive responses. Aspects that turned students off science were its perceived lack of relevance (*ie* abstract and theoretical), difficulty, and repetitious nature. Students also felt that school science was too rushed, involved too much copying, that there was not enough practical work or autonomy, not enough choice, and was just about learning facts with no time for discussion. The authors assert that the content and assessment-driven national curriculum has squeezed out the aspects of teaching science that are valued by pupils: undertaking practical work, relevance, discussion, choice/flexibility, and coverage of contemporary issues.

Parvin J (1999), *Children Challenging Industry: the research report*, Chemistry Industry Education Centre

An evaluation of a method of teaching industry-based science activities and its impact on the views of children and teachers. The model involved 38 primary schools in Country Durham, with 44 teachers and over 1,300 children. The model consisted of three half-day sessions of science activities, in a three-week period. Over half the children then followed-up the sessions with a visit to an industrial site.

A series of interviews and questionnaires were used before, after, and one year after the intervention:

> *'The main findings are that the profile of the chemical industry was raised in both the children's and teacher's minds during the project. Children had a greater awareness of what happened in the industry, who worked there, and how science fitted into the industrial workplace.'*

Reid A, Martin S, Denley P, Cloke C, Bishop K, Dodsworth J (2003), *Tomorrow's World, Today's Reality – STM teachers: perceptions, views and approaches*, a report for the Engineering Technology Board

This work has been undertaken by researchers at the University of Bath, in order to examine the perceptions, views and approaches of teachers towards STM in the curriculum, and the role of STM as a preparation for careers in science, engineering and technology. The work compares the views and approaches of STM teachers and non-STM teachers in primary and secondary schools and in FE colleges; and involves qualitative and quantitative data collection.

The researchers identify five key 'blockers' to high-quality students pursuing SET careers: image, curriculum and assessment, assessment and accountability, qualifications, and gender. With regard to image, it was found that STM teachers may hold inconsistent, inaccurate and unexpected views about what constitutes engineering and engineering work, and what generic and specific skills engineers should possess. It was also found that teachers hold different views as to the purpose of SET in schools, whether it is vocational or academic in orientation, as an end in itself or as a means to an end. The work looks at initiatives to promote SET in schools, and to encourage students to pursue SET careers, but notes that these can be counter-productive if there is no proper consideration of the image that could be portrayed to pupils. Activities cited include: practical work, planning scientific enquiries and investigations, studying applied mathematics, competitions, visits, links, discussions, and equal opportunities work. However, activities seen as discouraging considerations of SET by students include: coursework, examination demands, the difficulty of maths and physics, staff and student images/ misconceptions, lack of equipment/machinery/computers, and lack of flexibility in teaching activities.

The researchers however note that not all 'blockers' are impenetrable as some present challenges to be overcome. Also, the situation within schools is dynamic so blockers may not remain indefinitely. They point to potential areas for change as being: greater and stronger links between schools and industry, innovative teaching and learning approaches, good-quality teaching materials, updating teachers about the field of engineering, and of approaches to teaching SET. It would appear that teachers want to know about the range of schemes, projects and initiatives available, and to receive support to be able to pursue these — so another area for change/improvement would be, as they suggest, a newsletter for STM teachers. The work also notes the importance of teachers' perceptions of the SET community — whether they feel part of it or remote from it.

Royal Society (2003), *Developing the role of school support staff,: response to the Department for Education and Skills*, the Royal Society

A response to a consultation document launched by the Government, partly in response to a Select Committee report and a joint Royal Society and Association of Science Education report on the number, roles and status of science technicians. The response argues that the Government has not fully understood the distinctive contribution that science technicians make to pupils' achievement. The response calls for: a fourth progression route specifically for technicians; the Government to provide guidance to schools to ensure that any additional funding for support staff does not all go to non-technical support; recognition that some technical staff might want to become teaching assistants or indeed train to be science teachers; ensure that any support staff working in a teaching laboratory has the appropriate health and safety training; and ensure that the status and pay of science technicians reflects their professional role.

RSC (2002a), *Health and Safety Legislation and Practical Chemistry Teaching in Schools*, Environment, Health and Safety Committee, Royal Society of Chemistry

Responds to a popular misconception that Health and Safety legislation meant that exciting practical chemistry teaching in schools is no longer possible. The decline in the quantity and quality of chemical practical teaching should not be blamed on heath and safety legislation. The risk assessments that need to be applied to chemistry also apply to other subjects and the risks that children are exposed to do not justify the cutbacks.

RSC Education Department (1997), Standards in Public Examinations 1975-1995, *Education Issues*, No. 19

A issues paper based on work undertaken by the School Curriculum and Assessment Authority (SCAA) and the Office for

Standards in Education (OFSTED) entitled Standards in Public Examinations 1975-1995. The issues paper focuses on the evidence about chemistry contained in the report. The paper outlines the two approaches to the problem that were used. These were an analysis of the examination results and the analysis of examination papers and what they require of the examinees. Overall, examination results have greatly improved and a number of possible reasons for this are given. In terms of chemistry curriculum content at 16 plus, the following changes are noted:

- 'descriptive content has been reduced, and this is more for double award science than for chemistry in 1995 compared to chemistry in 1975
- assessment of experimental skills has increased
- knowledge of social, economic and technological aspects of chemistry is required
- the range of skills required has broadened, such as select and use information, evaluate data and apply ideas in everyday contexts
- questions became more structured
- questions have been set where answers are embedded in stimulus material in the question
- overall the level of understanding has probably increased but there has been a reduction of demand for higher attaining candidates, *eg* in constructing balanced chemical equations.'

Between 1975 and 1995 the following changes to 18 plus chemistry were observed:

- 'There has been a small reduction in the content of syllabuses, most significantly in inorganic and physical chemistry.
- There is now a greater emphasis on patterns and themes.
- 1995 syllabuses are more explicit thus defining the required depth of treatment.
- Successive syllabuses have been designed to promote a more balanced set of skills including understanding, comprehension, the interpretation and use of data, problem solving and evaluation.
- The assessment of these skills has, in the main, shown an increase in demand over the years.
- The format for coursework assessment of practical skills represents a marked increase in the range of demand.
- The number of opportunities for extended writing has decreased.'

The report makes a series of recommendations that include the establishment of an archive that would make similar exercises easier and more reliable in the future.

Table 3.4: 'A' level entries selected subjects, 1996 to 2003

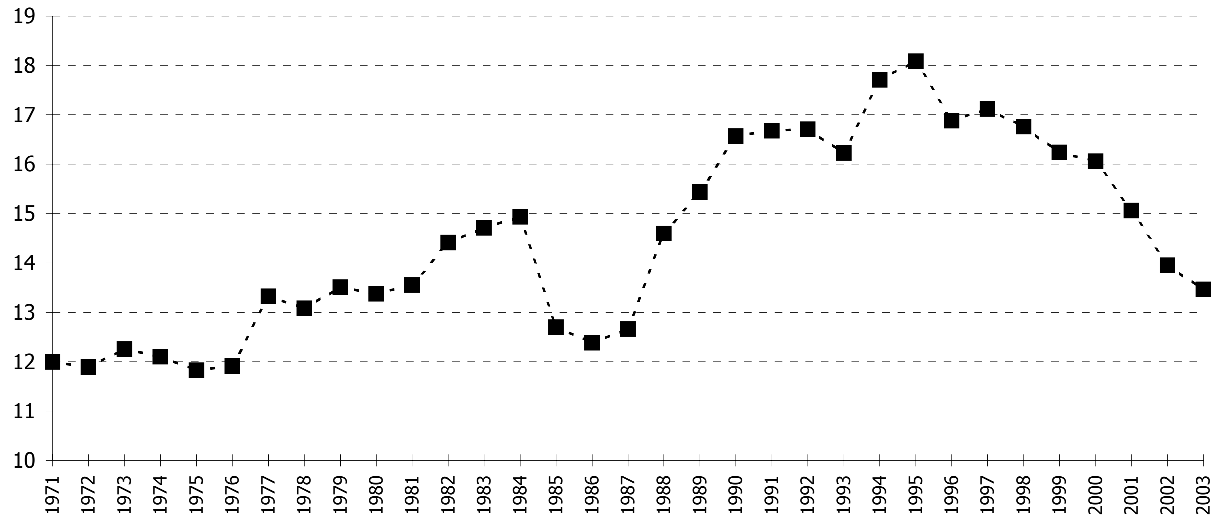
	1996	1997	1998	1999	2000	2001	2002	2003
Chemistry	40,418	42,262	41,893	40,920	40,261	38,602	36,648	36,110
Chemistry as a per cent of total	5.5	5.4	5.3	5.2	5.2	5.2	5.2	4.8
Physics	33,033	33,243	34,209	33,880	31,794	30,701	31,543	30,583
Physics as a per cent of total	4.5	4.3	4.3	4.3	4.1	4.1	4.5	4.1
Biology	52,053	56,706	58,439	56,036	54,650	52,647	52,132	51,716
Biology as a per cent of total	7.0	7.3	7.4	7.2	7.1	7.0	7.4	6.9
Business studies	29,085	33,458	37,644	37,926	36,201	36,834	27,680	33,133
Business studies as a per cent of total	3.9	4.3	4.7	4.8	4.7	4.9	3.9	4.4
All subjects	*740,470*	*777,710*	*794,262*	*783,692*	*774,364*	*748,866*	*701,380*	*750,537*

Source: RSC Education Department, web-based resource

RSC Education Department (2003), *General Certificate of Education – Advanced level, Web resource* http://www.chemsoc.org/pdf/LearnNet/rsc/stats/2.pdf

This PDF file provides time-series data on the number of GCE 'A' level entries in a wide range of subjects. An extract of this data is given in Table 3.4 and shown graphically in Figure 3.1. This shows that entries to chemistry, physics and biology peaked in 1998 in line with all 'A' level entries. However, there is a pattern whereby Chemistry 'A' level entries represent a shrinking percentage of all 'A' level entries.

Figure 3.1: Number of chemistry 'A' level entrants per 1,000 16 to 19 year olds in England and Wales, 1971 to 2003



Source: RSC Education Department: Web based resource for 'A' level entries, Population Trends No. 114 and Government Actuary Department for England and Wales population figures

In 1996 chemistry 'A' level entries represented 5.5 per cent of all 'A' level entries in England and Wales. By 2003 chemistry had dropped to 4.8 per cent of all entries.

Another way of examining the number of chemistry 'A' level entrants is to examine the numbers as a proportion of the cohort that could be expected to be taking 'A' levels. As the number of 16 to 19 year olds has been rising slowly since 1995, the slight decline in the number of chemistry 'A' level entries is more serious as simply on the basis of the size of the cohort an increase would be expected.

Science and Technology Committee (2002a), *Science Education from 14 to 19* (Third Report of Session 2001–2002), House of Commons, Stationery Office, London

The Science and Technology Committee's report presents the results of an inquiry into science education in schools, which involved individuals and organisations in the scientific and engineering learning communities, government bodies and agencies, employers, and young people. The report harshly criticises the curriculum for being inflexible, irrelevant, and repetitive; for stifling debate; for uninteresting and de-motivating practical work; and for having a limited range of courses. The report presents research evidence and commentary, and then goes on to make 66 recommendations and conclusions about science education for 14 year olds to 19 year olds -- encompassing both the compulsory school curriculum and post-16 academic and vocational study. Key areas of interest are presented below.

- The committee report that the curriculum aims to build scientific literacy (a life skill) and inspire further scientific study but does neither very well. Science is seen as *'essential for progression and for personal development'* and should therefore remain compulsory for 14–16 year olds (and possibly beyond) providing a minimum core of science including key ideas and a range of skills associated with scientific literacy. However, there is a need to balance both requirements (scientific literacy and scientific foundation knowledge). Foundation skills are essential when moving onto further science study. However, the committees feel that entry level support courses and e-learning programmes may help with the transition from 'A' level to university study.

  ' … courses should prepare students to feel confident with the science they are likely to encounter in everyday life and provide a route to science post-16, either through traditional 'A' levels or through vocational qualifications'.

  'What is important is not that citizens should be able to remember and recall solely a large body of scientific facts but that they should understand how science works and how it is based on the analysis and interpretation of evidence. Crucially, citizens should be able to use their understanding of science, so that science can help rather than scare them.'

- There are major problems at Key Stage 4. Here pupils lose enthusiasm for science and develop negative and lasting images of science, so the curriculum needs to be changed. Currently the science curriculum is overly prescriptive, putting students off science, and it involves too much repetition, which pupils find boring. The committee suggests that the curriculum should include recent scientific developments to increase the perceived relevance of science study, and that this is particularly effective at attracting girls to study science. They acknowledge that students appreciate the opportunity to discuss/debate issues around science (*eg* ethics), and appreciate practical work (*eg* fieldwork, experiments). Indeed, practical work is seen as a vital part of science education, and the committee is concerned by unfounded beliefs that practical work is constrained by health and safety regulations. The committee support the balanced science approach but feel that a range of different science courses should also be available to allow students the choice/flexibility to explore areas of interest and to reflect their diverse motivations.
- Assessment methods should be revisited, with scientific literacy requiring greater attention. Awarding bodies should be involved in developing new methods, including testing a wider range of skills than recall of facts, and changing coursework to encourage practical and project work.
- The role of ICT in science teaching needs to be spelled out more clearly; and teachers will need greater support (*eg* time, resources, training) to deliver any new curriculum. The committee hopes that teachers will be able to make use of local employers to support their teaching. They also note the importance of good laboratory facilities, and feel that the poor quality of such resources is affecting the quality of teaching. However, government financial support to upgrade facilities is welcomed.
- There are concerns over the lack of a significant increase in the numbers studying science post-16. Students are dissuaded from post-16 science study if it is perceived to be harder work and more harshly assessed. They are also put off by the perceived mathematical requirements of 'A' level study. Vocational science study options are also not attracting students.
- They are concerned over the unpopularity of physics with girls and falling number of boys choosing biology and chemistry and feel further research is needed. The curriculum fails to provide for differing interests of boys and girls. The committee also calls for further research into race equality in STM, and recommends teaching materials to be reviewed to ensure they are anti-racist and multi-cultural.
- Students have limited awareness of scientific careers and limited awareness of the value of scientific skills to other careers (*ie* transferability of science skills). Here, the importance

of careers advice is recognised. The committee tasks the government with ensuring that careers services improve the quality of advice offered to school students about scientific careers and about the breadth of opportunities to those with science qualifications.

The report also presents information on science education in other countries around the world.

Science and Technology Committee (2002b), *Science Education from 14–19: Government Response to the Committee's*, Third Report, HC 1204, Stationery Office: London

This report presents responses from the government (along with response from the Qualifications and Curriculum Authority (QCA), and the Joint Council for General Qualifications), to the committee's recommendations for the science curriculum for 14–19 year olds. Here the government acknowledges the importance of science education for both building technological literacy and building a foundation for further science study. They acknowledge the need to make the curriculum more exciting and relevant to inspire a greater number and a broader range of pupils, especially girls and young people from ethnic minorities, to continue with science study.

The government points to the various initiatives which it feels will help to achieve the committee's recommendations:

- growth in science spending (via the 2002 Spending Review), and increased capital investment in schools including school laboratories (£60 million)
- the Qualification and Curriculum Authority's 'Science for the 21st Century' programme to review science, and the pilot of the new applied science GCSE
- the national strategy for Key Stage 3 (the middle years, age 11–14) and associated targets
- the Science Year initiative (extended to July 2003) including the Faces of Modern Science poster campaign portraying role models from different backgrounds in science-related careers
- the Growing Schools Initiative
- Curriculum Online and the National Opportunities Fund programme to train teachers in the use of ICT
- the Science and Engineering Ambassadors scheme (SETNET)
- establishing a National Centre for Excellence for Science Teaching
- the Specialist Schools Programme (including Science, and Maths and Computing)

- the OST 'Promoting Science, Engineering and Technology for Women' Unit
- the Equal Opportunities Commission campaign: *What's Stopping You?* (challenging stereotypes over science careers)
- extended Schools and Study Support Programme from the DfES (encouraging out-of-school hours activities)
- the broader range of mathematics qualifications available including the new AS-level in Use of Mathematics
- and the Connexions Service offering advice and guidance on learning and career options to all young people in England aged 13–19; supported via the Connexions Support National Unit which produces careers publications.

Smith P S (2002), *Status of High School Chemistry Teaching: 2000 National Survey of Science and Mathematics Education*, Horizon Research Inc.

A US study based on a sample of science and mathematics teachers in 50 states and the District of Columbia that was designed to allow national estimates. The survey examined: science and mathematics course offerings and enrolment; teacher background preparation; textbook usage; instructional techniques; and availability and use of science and mathematics facilities and equipment. This analysis of chemistry is based on the responses of 506 chemistry teachers, who are compared with 814 teachers of other scientific subjects. This showed that slightly more than half of the chemistry teachers were female, predominantly white, about one-half with a masters qualification, and as many as one-third approaching retirement in the next ten years. Overall, 'the chemistry teacher workforce seems to be a fairly well prepared one; most chemistry students receive instruction from teachers who have had substantial course work in chemistry and who are confident in their current knowledge and in their ability to teach the content.' They wanted more training in using instructional technology, and help with accommodating students with special needs. However, they spend very little time undertaking professional development. They use a pattern of instruction that is highly dependent on lectures and discussion, students working problems, and an occasional lab. This pattern is similar to their own college chemistry courses, which might explain this pattern.

4. Chemistry and Careers Advice

4.1 Scope and range of literature

4.1.1 Headings used

The literature in this chapter has been divided into two main sections:

- **nature and impact of careers advice literature** — examines the pattern of careers advice and the research on its impact on the decision making processes
- **interaction of advice and gender literature** — this section covers the extensive literature on the interaction between gender and careers advice processes and impacts.

4.1.2 Amount and type of literature

This chapter is largely based on academic papers and evaluations of career advice provision.

4.2 Key messages

4.2.1 Nature and impact of careers advice

Mixed evidence on the impact of careers services and debate over the measurement of impact

The majority of research reports the relatively low impact of careers advice, guidance and education on young people's choices (Boreham, Arthur, 1993; DfES/Careers Service, 1998; Howieson, Croxford, 1996; Kidd, Wardman, 1999; Morgan, 1999). The low impact could, however, be attributed to receptivity of clients (rather than quality of services), in that services tend to be targeted towards older pupils whose perceptions have already been developed and set. Generally, other factors are acknowledged as having a greater influence on choices and decisions. Factors such as: background characteristics, attainment or perceived ability (which is influenced by experience at school and interaction with teachers), parents and friends, local culture (which is influenced by local industrial structure and labour demand), and what is seen as available, normal and accessible (see also in Section 4.3 Morgan, 1999 and Payne, 2002). Young people's decision making is recognised to be complex and constrained and not necessarily rational (Morgan, 1999).

However, other literature argues that careers services do have an impact. Here the literature indicates that the impact is significant though long term, can be felt in elements of school life as well as by individuals, and that guidance can lead to a greater vocational focus in individuals (Morris *et al.*, 1999; Howieson, Croxford, 1996). Also, impact is felt to be greater, and role of careers services more pronounced, in areas of deprivation and in circumstances where individuals are undecided (see Semple *et al.*, 2002 in Section 3.4).

Careers services are recognised as having multiple roles and, therefore, multiple activities that can make an impact at different levels — at organisational and at an individual level (Morris, 2000). These roles include: changing and making curricula more relevant; helping students with their self-esteem; and promoting learning (Morris *et al.*, 2000). They can provide information and can also provide the context in which occupational information is most likely to be used and used effectively (Boreham, Arthur, 1993). Studies indicate the importance of the 'education' role of careers guidance services, where young people are helped to develop decision-making skills, exploration skills, and self-awareness so that they can impact on their own career development (Boreham, Arthur, 1993). It is about equipping individuals for the future (Morgan, 1999). Indeed, this is where services would appear to have the greatest impact (Morris *et al.*, 1999). Advisers themselves feel they have greatest impact through dedicated careers events and careers education activities (Rolfe, 1999).

However, some work refers to the difficulty in measuring the impact of guidance, and researchers argue that the real impact is hidden, often due to inappropriate measurements. There is a need to be realistic about what careers services can really achieve, and to develop a framework to evaluate services using appropriate measures of outcome in relation to their roles (Bysshe *et al.*, 2002; Kidd, Killeen, 1992; OFSTED, 2001; QCA, 1999).

Need for ongoing student centred support delivered at appropriate times for the individual and by an appropriate person

Recommendations are given in the literature for effective careers support (Kidd, Killeen (1992); Morgan, 1999; Payne, Edwards, 1997; Stoney *et al.*, 1998). It should be: student-centred, personal, customised (in that it meets the needs and abilities of the individual), ongoing, and timely. Careers support should be delivered at a time when students need it rather than when it is convenient to institutions. One report notes how contact with careers support came after key decisions had to be made (Munro, Elsom, 2000). There were concerns expressed over the option system which was felt to be forcing students to make their minds up quickly, and thus potentially cutting off an individual's future options without proper consideration (Kidd, Wardman, 1999).

Need to understand and manage expectations of both advisers (including teachers) and pupils in the careers support relationship

The reports highlight the importance of clear communication, and of establishing rapport, and an unambiguous relationship in providing careers support, especially in the process of careers interviews. There were concerns expressed over the possible role conflict when involving teachers in the provision of careers advice, and concerns over the quality of 'within school' careers provision (DfES/Careers Service, 1998; Morgan, 1999). There were also concerns over the potential mismatch in expectations between careers advisers and young people (clients). It would seem that young people value 'direction', and associate satisfaction (with careers services) with direction (Kidd, Wardman, 1999). The literature indicates that it is the informal networks, rather than the formal networks, which may offer the direction they seek. These informal networks also offer the personal relationship and rapport that they appreciate (see Semple *et al.*, 2002 in Section 3.4). It would seem that for young people decision making is often dependent on someone else and many people can influence the decisions (Boreham, Arthur, 1993). Careers services do not tend to see their role as one of direction, and careers advisers associate satisfaction with establishing communication and rapport (Kidd *et al.*, 1997; Millar, Brotherton, 2001).

Need to challenge individual's assumptions and challenge notions of impartiality in careers advice

The literature highlights the importance of impartiality in the delivery of careers support. It is widely accepted that advice should be impartial, but some commentators argue that in some instances advice should be partial in order to best meet the needs of the client. It is argued that partiality does not mean lack of quality, but means challenging stereotypes rather than responding to clients, targeting services to specific groups, *ie* the socially excluded (as in Connexions approach), and recognising that choices are limited by external factors (Kidd, Wardman, 1999; Kidd *et al.*, 1997; Payne, Edwards, 1997). However, it is acknowledged that services should remain impartial in that they are not to be used as recruitment services for specific institutions or occupations (Morgan, 1999; Payne and Edwards, 1997.

Greater 'joined up' working is needed within the guidance community to ensure minimum levels of service

The literature highlights the need for (and the difficulties with) all agencies in the guidance community to work together to support young people (Rolfe, 1999). The reports point to little evidence of this joined-up working, and little interaction between teachers and careers advisers (Morris, 2000; Munro, Elsom, 2000). Issues also arose in relation to service levels that were reported to vary as was the use of services across schools (Rolfe, 1999).

Possible stigma of careers support

There may be a deliberate avoidance of careers support by individuals. These individuals may want to 'go it alone', making decisions by themselves (probably relying on their informal networks), or may feel that there is some stigma associated with getting help (Morgan, 1999).

Work experience works

The importance of work--experience is highlighted, in that it provides a context in which occupational information is gathered and used (Boreham, Arthur, 1993). It also provides new members for an individual's informal network who can influence choices (see Semple *et al.*, 2002 in Section 3.4). Careers services can help with this process. However, the range of SET work experiences is limited and this is causing concern (Munro, Elsom, 2000; Rolfe, 1999).

Individuals filter the profusion of careers materials according to their preferences

Young people are generally happy with the careers materials that they receive, finding them appropriate and easy to use. However, the materials are used selectively (Kidd, Wardman, 1999; Russell, Wardman, 1998). Information is filtered in or out depending on decisions already made –- so only information that is considered relevant to individuals' existing ideas is used. Thus, careers material has little influence on decisions except that it tends to reinforce decisions already made. Also reports indicate that material tends to be reviewed with parents rather than with careers advisers — so individuals themselves, and their parents, act as filters to occupational and careers information (Munro, Elsom, 2000; Russell, Wardman, 1998).

4.2.2 Gender and careers advice

Factors enhancing women's careers

A supportive family background, strong educational qualifications, later marriage and/or single status, few or no children, and the rejection of traditional attitudes towards women's roles. Personality characteristics that are enhancing: centrality of career self-efficacy beliefs, high self-esteem, instrumentality, multiple role planning, strong locus of control, importance of emotional separation from parents. Other factors are: career goals and strategies, exhibiting positive traits, taking opportunities, acquiring specific skills, positive and predictive interactions with others.

Factors inhibiting career success for women:

- Poor self-concept, low expectations of success, gender role and occupational stereotypes, educational systems, lack of role models, gender-biased career counselling.
- Structural factors operating within organisations: stereotypes and assumptions, organisational cultures and human relations practice, lack of career opportunities, skills abilities and interests, discrimination, and sexual harassment.

Based on the existing evidence, it is reasonable to suppose that the career guidance needs of girls and women are different from boys and men. Conventional career theories do not provide professionals with realistic frameworks for effective practice with girls and women. Consequently, a number of theories that focus particularly on the vocational behaviour and career development needs of women have been developed: the theory of the conscription and compromise, career self-efficacy theory and feminist career counselling. Each of these theories has implications for good careers guidance practices.

4.3 Nature and impact of careers advice literature

Boreham N C, Arthur T A A (1993), *Information Requirements in Occupational Decision Making,* Research Series 8, Employment Department

The report presents UK research with 144 individuals at various stages in their education, training or job search in either Manchester or Bristol into the use of information in choosing an occupation. More specifically the research focused on what occupations individuals were considering, what knowledge they had about these occupations and where they had obtained it, and the usefulness and influence of these sources of information on their occupational decisions. It explored 44 sources of occupational information across five domains of information sources: school, family and friends, the world of work, the media, and life experiences (autonomous).

An initial review of relevant literature indicated that to make occupational decisions individuals need information about occupations (*eg* rewards, requirements, and entry routes), information about themselves (*eg* values, preferred activities, and abilities), and a knowledge base (about the world of work) to make sense of these. It also indicated that there are several barriers (cognitive and affective) to effective use of occupational information including limited ability to process and understand information, poor career exploration strategies, limited range of occupations considered suitable, lack of vocational self-concept, and indecision.

It concluded that occupational information is most likely to be used if it is provided in a context: which offers counselling (*ie* a personal conversation), offers direct or indirect (via the experience of another) work experience, offers practical help/encouragement, and offers a broad range of opportunities. Sources of information considered most important were for:

- young people (*ie* school pupils, Year 10) — teachers, careers teachers and careers officers
- older school pupils (Year 11) and beyond — individuals in the world of work (*eg* speaking to someone in the job, feedback from work colleagues, work experience), and media (*eg* careers directories, and situations vacant column).

The authors found that a wide range of sources were accessed by all individuals except those who were unemployed. Much of the information gathered was about individuals themselves and was gathered by self-directed enquiry and self-evaluation, which highlights the importance of careers guidance in developing appropriate self-concepts. Finally, much of the decision making was dependent on others with individuals having views like 'its their job to get you a job'.

Bysshe S, Hughes D, Bowes L (2002), *The Economic Benefits of Career Guidance: A Review of Current Evidence*, CeGS Occasional Paper

Provides a brief summary of research evidence on the economic benefits of guidance. Identifies four types of outcome: immediate outcomes; intermediate outcomes; individual longer-term outcomes: and longer-term outcomes for the economy. Concludes that evaluating the overall impact of career guidance is complicated by a range of factors:

- career guidance is but one of many factors that influence career choice

- career guidance is often not a discrete component and is embedded into other activities and contexts
- there is no agreed set of outcome measures or measures of intensity of careers guidance input.

DfES/Careers Service (1998), *The Influence of Careers Education and Guidance upon Pupils in Year 11,* (RD17)

A quantitative study into the impact of Year 11 careers education guidance (CEG) (both within-school services and external) on pupils (n = 603) across 20 schools in the East Midlands. Data was collected both by interview and by questionnaire. Self-awareness, opportunity awareness, decision-making skills and transition confidence are analysed. Findings include:

- external CEG 'inputs' tended to be of a consistently higher quality than within-school services
- background factors, such as parental occupation, gender and school status, were found to be more influential over decision making than CEG. Greater scope for CEG impact tended to be associated with more deprived areas or schools with lower staying-on rates.

Background factors were also found to be strongly associated with the level of end-of-year outcomes, especially attainment.

Howieson C, Croxford L (1996), *Using the YCS to analyse the outcomes of Careers Education and Guidance*, DfES RS40

A study that aimed to examine the economic effect at age 18/19 of CEG received at age 15/16, using the Youth Cohort Survey (YCS). Uses the sixth YCS and found that CEG at Year 11 has little impact on the probability of staying in full-time education at 16/17. Personal and social characteristics were much more important determinants. Attainment at 18/19 was more determined by attainment at 11 rather than pattern of CEG. However, those who had had an interview at age 11 were less likely to have attained a NVQ Level 2 qualification. For those in full-time education at 18/19, careers guidance classes and careers officer interviews were both associated with increased participation in vocational courses.

Kidd J M, Killeen J (1992), 'Are the effects of careers guidance worth having? Changes in practice and outcomes', *Journal of Occupational and Organizational Psychology* 65, pp. 219–234

The evaluation of careers guidance for young people (prior to their entry to the world of work) has progressed through two phases. Each evaluation phase is associated with changes in guidance practice and changes in the nature of the underlying theories of occupational choice and career development. In the first phase, the aim of guidance was to make recommendations to young people. Therefore, evaluators of guidance used career outcomes as criterion by which to assess effectiveness.

In the second phase, with developmental guidance interventions, learning outcomes were more appropriate for evaluation. Most reviewers judge the effectiveness of these interventions to be only modest, but the authors suggest that when the realism of goals for the intervention, the appropriateness of criterion measures and clients/treatment interactions are taken into account, the magnitude of the effects may be greater than this.

It is argued that evaluation needs to enter the third phase, in line with changes in labour market institutions, career patterns and consequent changes in the aims of guidance and a shift towards a more dynamic, interactionist explanation of career development. The range of learning outcomes should, therefore, be elaborated to include process skills necessary for active career management. Individuals are capable of impacting their own career development by influencing the system in which they are embedded. Individuals should be treated as involved in the continuous process of selecting and shaping their context.

Kidd J, Wardman M (1999), 'Post-16 course choice: a challenge for guidance', *British Journal of Guidance & Counselling*, Vol. 27, No 2, pp. 259–273

The report presents the results of a DfEE sponsored UK study to investigate the factors associated with switching courses in post-compulsory education (*ie* further education) and the role of careers education and guidance in reducing the need to switch. The study involved work with over 200 16 and 17 year olds in four locations in the UK who had switched courses at least once (single switchers and multi-switchers). It found that many young people made course decisions by themselves or were influenced by parents, teachers or friends. They were less influenced by careers advisers. This was especially true of those who changed courses multiple times, which may suggest that reliance on informal advice leads to inappropriate decisions. Many students felt prepared for their transition to post-compulsory education and this was mainly attributed to the amount of information they had been given. Many had made their choices by Year 11 (age 16) and some were quite closed-minded about their choices. However, others had not yet decided by Year 11 and had to choose quickly. Many reported that making course decisions was easy but those who switched courses more than once were more likely to have found making course decisions hard. Multi-switchers were also less likely to have spoken with a careers adviser. The authors found a relationship between amount of careers education and perceived preparation for further education and decision making, so this suggests that talking to a careers adviser helps prepare students for decision making. Young people tended to criticise sessions with careers advisers for not being directive enough (a theme also highlighted in other research). The authors recommend that institutions help with young people's decision making by offering realistic course previews and that careers guidance should perhaps be about challenging inaccurate beliefs. They also note that course switching is not necessarily bad as many students reported that they had learned from the experience.

Kidd J, Killeen J, Jarvis J, Offer M (1997), 'Competing schools or stylistic variation in careers guidance interviewing', *British Journal of Guidance and Counselling*, Vol. 25, No. 1, pp. 47–65

A good UK quantitative and qualitative research study with a small number of careers officers to examine interview approach and style used in guidance interviews. The research finds that careers officers use a range of models or approaches in interviews, adapting their style to meet the individual needs of the client. Indeed, flexibility of style is valued by the officers. It finds that careers officer training does influence style but this influence diminishes over time as officers work with an increasing range of clients and as their experience and confidence grows. A successful interview is seen as one where the individual has 'moved on', *ie* broadened their job ideas, achieved greater realism (and sometimes narrowed their job ideas). Aspects associated with a successful interview from the careers officer's perspective include: rapport, establishing a purpose, structure, and challenge. Challenging is associated with making a distinction between client wants and client needs, and is seen as a difficult thing to do but an important aspect of a successful interview. Challenging involves helping clients to reality test ideas about themselves and opportunities and may involve challenging unformed ideas or challenging gender stereotypes.

Manufacturing Foundation (2003), *Manufacturing Our Future: A research report on young people's attitudes to manufacturing industry*, Manufacturing Foundation

Based on questionnaires completed by 1,770 pupils aged from 11 to 15 and by 686 of their parents, with additional focus groups and interviews. The key message to emerge from the study was that pupils see manufacturing as '*hard work, sometimes dirty and dangerous, and typically boring*.'

Other beliefs about manufacturing included:

- a poor understanding by pupils of the breath of jobs on offer, equating manufacturing with production line jobs
- an impression that employees manufacturing more glamorous products earn more

- many parents (47 per cent) encourage children to seek work in manufacturing with parents believing interesting work to be the most important reason they would give the children for choosing where to work
- only one in ten pupils had undertaken work experience in the manufacturing industry. Of those who were in a factory 67 per cent gave a favourable response as did 59 per cent of those in a manufacturing office

Contains a series of recommendations:

- we need to demonstrate to children that manufacturing is not hard work, dirty and boring
- although much effort is under way this needs to be better co-ordinated
- we need to improve business education links
- more research needs to be undertaken at the primary level looking at how attitudes develop
- improved teaching resources need to be developed and made easier for teachers to find
- more teacher placements in industry — this means ensuring teachers have the time and that suitable placements are available
- more and better work experience — there should be a trebling of the amount of work experience opportunities available and more effort should go into making the experience worthwhile
- more children and teachers should visit manufacturing establishments, but this should not just be a junior version of industrial tourism
- more visits to smaller manufacturers — often smaller manufacturers are able to offer a more rounded view of manufacturing with the various functions being carried out at one compact site
- improved career guidance — the changing 14-19 curriculum offers opportunities for manufacturers and support organisations to help train careers advisers
- more role models should get involved in schools — role models from manufacturing could inspire pupils and help dispel many of the misconceptions.

Millar R, Brotherton C (2001), 'Expectations, recall and evaluation of careers guidance interviews by pupils and careers advisers: a preliminary study', *British Journal of Guidance and Counselling*, Vol. 29, No. 1, pp. 95–110

This is a general paper about careers guidance for young people in compulsory education. It concerns a small but rigorous study of the expectations, experiences and satisfactions with careers interviews by pupils and careers advisers. The study involved an in-depth study of 51 interviews with 15 and 16 year olds in one area of the UK. The research found considerable differences in the expectations for the interview between pupils and careers advisers. Pupils expected and felt they had experienced direction but advisers felt that the interviews were more about interpersonal rapport and communication. Pupils' satisfaction with careers advice was found to be linked to interpersonal aspects. There are implications here for effective preparation for careers interviews to ensure that expectations on both sides are clear. It is also important to ensure that pupils feel involved in the process.

Morgan B (1999), *Post-16 choice and the impact of careers education and guidance*, Sussex University DPhil thesis

A PhD thesis based on a case study of 14–16 year olds in a school in the South East. Looked at choices made about post-compulsory education. Found that decision making was not necessary rational but very complex and often somewhat constrained (often through academic ability). Many chose to stay on at the school out of risk avoidance and convenience (*ie* pragmatism) but this may result in people staying on and studying courses that do not meet their interests and abilities. Parents were found to be a greater source of influence on choices/decisions than formal advisers as parents were perceived to be more personally concerned with an individual's welfare than school-based advisers would be. The author raised concerns over the possible role conflict of teachers acting as careers advisers and the lack of relationship with those acting solely as careers advisers (who were often regarded as strangers). The study also found that some pupils deliberately chose not to use the careers services on offer at the school. The author suggests that for careers education and guidance services to be effective they need to be student-centred, personal, customised and ongoing (*ie* not one-off). Services should also be impartial and not a marketing exercise — it should be about giving the best advice to meet the needs and abilities of the individual. Careers advice and guidance should also be about equipping individuals for the future (*ie* making further decisions) and needs to be delivered at a time when students need it, rather than at a time that is convenient to the institution.

Morris M, Rickinson M, Davies D (2001), *The Delivery of Careers Education and Guidance in Schools*, RR296, National Foundation for Educational Research/DfES

The report found that the impact of the move in 1998 to focus the schools careers education and guidance agenda on delivery was perceived to be more significant than the impact of earlier legislative change. Positive outcomes of focusing the agenda were said to be:

- greater flexibility and more innovative ways of working than had been possible when careers services needed to meet contractual targets for action plans
- better and clearer identification of young people's guidance needs
- fewer students lost to the system, and better support for at risk or disengaged students moving them onto further education or training.

However, negative outcomes included:

- The polarisation of provision in schools, with a widening of the gap between schools with good careers education and guidance programmes and those where provision was poor; the deficiencies were primarily the result of a lack of capacity, rather than inadequate facilities or insufficient internal resources.
- A significant deterioration in careers service inputs to clients in education, particularly to those who might be seen as average ability or most able; and reduction in the status of careers education guidance in schools and amongst young people.
- A great deal of career advice time spent tracking down young people who are hard to reach, with success levels that are not in line with the effort involved.
- A reported increase in dropouts from post-16 academic courses, said to be partly the result of insufficient preparation of Year 11 students outside the target group (*ie* at risk or disengaged) and consequent poor decision making.

Morris M, Golden S, Lines A (1999), *The Impact of Careers Education and Guidance on Transition at 16* (DfES/NFER RD21)

A study into the impact of careers education and guidance on young people’s post-16 transitions, building on previous research into Year 9 career aspirations. Longitudinal data (n = 938 for the second wave in 1998) based on a postal questionnaire filled in by the cohort of young people were used, along with data derived from interviews with school and careers staff. Changes between Year 9 and Year 11 are discussed, along with the relationship between the development of careers-related skills and satisfactory transitions. The authors find that pre-16 CEG can have significant medium- and possibly longer-term outcomes for young people. Where participants had been enabled to build up a range of careers skills including exploration and self-awareness, they appeared more likely to make satisfactory post-16 transitions. Implications for CEG are discussed.

Morris M (2000), *School Improvement: The Contribution of Careers Education and Guidance* (an ECER conference paper), NFER

A background briefing paper to accompany a lecture given at the European Conference on Educational Research (ECER). An overview of recent policy developments is given, as well as findings from various NFER research projects designed to explore the impact of careers guidance on school effectiveness. During the first phase of this research (1994–5), over 1,000 interviews were carried out with school pupils (aged 15–17), staff, parents, employers and training providers. Subsequently, around 2,000 young people (aged 15–16) completed a detailed questionnaire relating again to the impact of careers guidance. Further phases of research were carried out during 1995–8 which built upon original methods and findings, and which incorporated the views of some 15,000 students and 300 teaching and careers staff. As a result of the research, the term 'guidance community' was coined to describe the importance of a joined-up network of services — both within the school and without — to support young people through post-16 transitions. The schools under study used careers services in different ways. None, however, combined all the elements identified by researchers to be necessary for 'effectiveness' at every level, that is, in terms of student attainment as well as softer outcomes. The researchers found it difficult to make the link between careers guidance and overall school effectiveness, but found that quality guidance services may positively impact on certain elements of school life, *eg* the enrichment of the wider curriculum and the promotion of effective student transitions.

Morris M, Rudd P, Nelson J, Davies D (2000), *The Contribution of Careers Education and Guidance to School Effectiveness in 'Partnership' Schools*, DfES, RR198

The study was driven by the identification in the government's white paper Excellence in Schools that CEG was an important part of the strategy for promoting higher educational standards. The report is based on a study of 30 selected schools across England; and identifies four driving forces leading to the distinctive positive role played by careers education and guidance. Services for careers education and guidance were acting as:

- an agent of change for school curriculum or organisational strategy
- a means of enhancing student self-esteem
- a means of promoting life-long learning, or
- a means of creating curriculum relevance.

Each (or combinations) of these strategies had led to good integrated careers education and guidance. However, this multiplicity of strategies made it harder to evaluate the impact of CEG.

OFSTED (2001), *Inspecting Careers Education and Guidance: pre- & post-16 with guidance on self evaluation*, OFSTED

This paper is designed to help inspectors and staff in schools, colleges and training organisations to evaluate CEG. It focuses on CEG for those in Years 9–11 when it is a compulsory element in the curriculum; and on educational provision for the 16–19 age range. It covers: what to look for in pupils' and students' work; the questions to ask pupils about CEG; the subject-specific points to observe in lessons; what to investigate; and how to draw a coherent evaluative view of CEG. It notes that there is no prescribed programme of study but that the Qualifications and Curriculum Authority (QCA) has published helpful guidance on the recommended learning outcomes pre- and post-16 (QCA, 1999). The report also contains examples of good, average and below average CEG, but makes no specific reference to SET.

Payne J, Edwards R (1997), 'Impartiality in pre-entry guidance for adults in further education colleges', *British Journal of Guidance and Counselling*, Vol. 25, No. 3, pp. 361–375

An interesting article that raises questions about what impartiality is in the practice of careers advice given in institutions, by institutions. It also asks whether careers advice should be impartial or, perhaps, in some circumstances should be partial.

The authors note that guidance given in institutions by institutions suffers from role conflict — systematic efficiency versus equality of opportunities. Yet good practice guidance suggests that careers guidance should be: client centred, confidential, open and accessible to all, independent, widely publicised, should contribute to the development of learning opportunities — and should be impartial. Impartiality is seen as central and has been incorporated into notions of quality assurance. The authors wanted to explore perceptions of impartiality amongst the guidance community, so in 1995 carried out interviews with 16 careers advisers in three different colleges. They found that impartiality was seen as a broad and complex concept that involved issues around: fair and unprejudiced access to guidance, impartiality between opportunities available, and impartiality demonstrated in the destinations of individuals. Impartiality in access implied positive efforts to reach the excluded, *ie* outreach, and could be affected by costs (charging for services) and negative associations with guidance, *ie* that seeking guidance is a signal of inadequacy. Questions were raised about the potential for guidance to be used for institutional recruitment and retention purposes, and whether clients were made aware of *all* the possible choices open to them (*ie* beyond the college). Impartiality was also explored in relation to challenging clients — is impartiality about challenging the clients or responding to their position? The authors posit that partial guidance may therefore be necessary to move people beyond stereotypes (*eg* gender and occupational stereotypes) and to be more ambitious which is a more reactive rather than passive or responsive stance. Lastly impartiality was explored in relation to enabling individuals to make choices. Again the authors posit that partial advice may be needed to acknowledge the fact that individuals' choices are constrained by factors (*eg* cost, location, format, personal responsibilities). They conclude that impartiality is complex and is unclear in practice, and that in some circumstances partiality is legitimate. See also the discussion of Connexions in Chapter 2.

Payne J (2001*), Patterns of Participation in Full-time Education after 16: An Analysis of the England and Wales Youth Cohort Study*, DfES Research Report 307

The study is part of a programme of in-depth analysis of the Youth Cohort Study (a regular study to tack young people between the ages of 16 and 19) undertaken by the Policy Studies Institute. This study focuses on participation in full-time education beyond compulsory school age, and attempts to identify where (*ie* amongst which groups of young people) educational participation could be increased. In doing so the work examines the choices that young people make about which courses to take and where to study, and how these relate to attainment (*eg* at GCSE level) and to background factors such as gender, ethnicity and home background.

Payne J (2002), *Attitudes to Education and choices at 16: A Brief Research Review*, Policy Studies Institute/DfES

The brief for the study was to undertake a review of research on the attitudes of parents and of young people towards their experience of education, and the influence this had on their choices after compulsory education.

Generally positive attitudes but some negativity associated with a perceived lack of value of education.

The literature suggests that, in general terms, most young people are reasonably happy at school. However, there is a sizeable minority who dislike school and whose feelings cause problems for both themselves and for teachers. Negative attitudes towards school have a multiplicity of causes but common problem areas included: the perceived lack of value of education and qualifications, boredom, poor relationships with teachers, and general anti-school culture. Evidence suggests that attitudes towards school tend to become more negative as young people progress through secondary education.

Similarly, the literature points to positive attitudes towards education amongst parents. However, it is argued that the positive picture presented is founded upon a fairly weak evidence base. It is noted that social class differences amongst parents in their views about the importance of education are comparatively small but ethnographic studies suggest that middle-class parents may take a more interventionist approach to their children's education.

QCA (1999), *Learning Outcomes from Careers Education and Guidance*, Qualifications and Curriculum Authority

The report contains guidance aimed at governors, senior managers, careers co-ordinators, careers advisers and others supporting the provision of careers education and guidance in secondary and special schools and Further Education colleges. It presents the case for developing learning outcomes for careers education and guidance and offers examples of outcomes at Key Stage 3, Key Stage 4 and post-16, which are supported by case studies.

Stoney S, Ashby P, Golden S, Lines A (1998), *Talking about 'Careers': Young People's Views of Careers Education and Guidance at School* (DfES/NFER RD18)

A very useful and interesting qualitative study exploring the views held by young people (n = 226; focus groups; NE/SE/NW England) of the impact of careers guidance services on their post-16 choices. The views of careers advisers and training providers were also gathered by face-to-face interview. Young people's perceptions of teachers and careers advisers, careers programmes, and guidance interviews are explored. The ways in which participants would find careers services more helpful and useful are also explored, and elements of good practice as suggested by the findings are clearly listed. Developments and innovations in the field are discussed, including new technologies and mentoring. Finally, recommendations are made for future practice.

Stuart N, Tyers C, Crowder M (2000), *Outcomes from Careers Education and Guidance (Phase II) – a Tracking Study*, DfEE

The report provides findings from a study carried out between 1997 and 1999 into the outcomes from CEG. The study aimed to inform understanding of how CEG in Year 11 and careers-related skill development can influence the transition to post-compulsory education and to early outcomes. The researchers tracked the progress of 603 students (via postal survey) in the East Midlands over two years, many of whom were high achievers.

The study found that 'high quality' Year 11 CEG (and early engagement with CEG) can positively influence certain outcomes post-16 such as perceptions of CEG and of the transition to post-compulsory education, and increased take-up of CEG post-16. However, CEG at Year 11 did not seem to have any significant influence on career decisions of those who follow 'A' level study, nor have an influence on successful completion of post-16 activities. Also, whilst CEG is linked to the development of careers-related skills (such as decision making, opportunity awareness and information seeking, and self-awareness), these skills were found to have no significant influence on early post-16 outcomes. Instead, success or the achievement of qualifications is related to academic ability, the type of activity followed (*eg* full-time or part-time education, government sponsored training, or employment) and the number of changes in activity made. Nevertheless, the authors' stress the importance of continuing to provide accessible and high-quality CEG especially for those who are less decided about their career options.

4.4 Interaction of advice and gender literature

Bimrose J (2001), 'Girls and women: challenges for careers guidance practice', *British Journal of Guidance and Counselling*, Vol. 29, No. 1, pp. 79–94

This article reviews the position of women in the UK labour market and the increasing complexity of their employment patterns. It criticises current career theories for girls and women and examines enhancements and inhibitors of women's career development.

Firstly, women are still more restricted then men in their occupational choice: that is, they are under-represented in a variety of fields and professions. Secondly, women tend to under-use their abilities and talents, being less likely to advance to a higher level in their occupational fields. Women continue to bear primary responsibility for childcare, and continue to earn less than men, and work fewer hours in paid employment.

Blattel-Mink B (2002), 'Gender and subject decision at university: Gender specificity in subject perception and decision with main emphasis on science and technology', *Equal Opportunities International*, Vol. 21, No. 1, pp. 43–64

The unequal distribution of men and women in the German academic and scientific arena is discussed in this article. Two hundred and twenty four university students were interviewed and, in addition, surveys conducted in Germany were drawn upon for evidence. The fact that the higher the status of university positions the lower the proportion of women, is felt to be crucially important. The author explores the 'masculine terms and characteristics' within which scientific disciplines are currently framed, and explores the problems associated with the re-shaping of the discipline in respect of this. Gender is explored in the context of various frames of influence, including family, school, HEIs and the labour market itself. Women are less likely than men to choose science and engineering subjects, and the kinds of social cognitive characteristics of women who opt for a 'male' subject is explored. Parental occupation is felt to be very important, with girls who pursue non-traditional subjects tending to be strongly influenced by their fathers.

Breakwell GM, Robertson T (2001), 'The gender gap in science attitudes, parental and peer influences: changes between 1987–88 and 1997–98', *Public Understanding of Science*, Vol. 10, pp. 71–82.

The study looks at changes during the 1990s in the gender differences in attitudes to science by replicating a study in 1997 that was conducted originally in 1987. Comparison of the data gathered indicated that females still: liked science less than males, had a perceived lower performance in science than males, participated in fewer science-related activities outside of the classroom, and had more negative attitudes towards science in general. Also the results showed that overall (for both males and females) liking of, and performance in, science had declined over the period, although attitudes towards science in general remained constant.

The report indicated that parental influence, particularly mothers' perceived support for science, was important in the liking of, and attitudes towards, science. It also found that mothers' support for science increased over the ten-year period. The authors argue that parents and peers do influence individuals and that the largely negative results in the research were due to external factors: *'positive changes in parental factors were swamped by changes in other areas not measured by this study.'*

The authors conclude that over the ten years from 1987 to 1997 there has been no narrowing of the gender gap in attitudes towards science.

Brownlow S, Smith T J, Ellis B R (2002), 'How Interest in Science Negatively Influences Perceptions of Women', *Journal of Science Education and Technology*, Vol. 11, No. 2, pp. 135–144

A study of 114 American university students was carried out to find out whether women who pursue scientific training are viewed negatively by other students. If the female student was described as expressing strong commitment to her subject, she was perceived by others as having a high level of academic achievement, intellectual competence and assertiveness. However, the perception of a female chemistry student was negative, with male participants, *eg* saying they would be unlikely to want to go out with her, and female participants saying she would have a less fulfilling career.

Munro M, Elsom D (2000), *Choosing Science at 16: The influences of science teachers and careers advisers on students' decisions about science subjects and science and technology careers*, NICEC/CRAC

This is a key report. It presents findings of a study that examined the influence of science teachers and careers advisers on pupils' decisions in Year 11 (aged 16) about whether to continue with science subjects or to work towards science and technology careers. It looked at the extent to which school science departments and careers departments work together to help students with their decision making. The work involved questionnaires to careers advisers working with Year 11 pupils and a series of six case studies in schools.

The work with teachers found that school science teachers influenced choices about further science study through the experience of studying science, through extra-curricular activities and through providing information about further science courses. However, teachers did not see themselves as influential and indeed did not wish to be involved in career choice. There were concerns that pupils were not aware of the links between science topics and careers or real-life applications — it was felt that awareness needed to be raised early as by Year 11 it would be too late to involve individuals in discussing careers related to science subjects if they had already lost interest. There were also concerns that because science was a core subject there was little need to promote it, and that pupils seemed to lose interest during or after Year 10 (aged 15) reporting it hard or dull. Again, physics was seen as hard (and severely graded), chemistry was seen as dull whereas biology was seen as fun, and maths as useful but difficult. However, the authors suggested that these perceptions could be over-ridden with good teaching. Teachers felt that the national curriculum had placed time pressures on teaching and this had squeezed out extra 'fun' activities; and that stringent health and safety requirements had decreased opportunities for practical work. The authors found there to be very little interaction between careers advisers and science subject teachers — this was attributed to time constraints.

The work with deliverers and recipients of careers education and guidance found that the core nature of science meant that there tended to be no real discussion about science (and its importance to later choices) in Year 9 when pupils were choosing between options. Advisers reported that by the Year 11 careers interview, many were already switched off science and were not receptive to discussing science-related careers. Work experience in science areas were found to be limited due to health and safety and insurance restrictions/regulations — which was a missed opportunity. Careers advisers' workload was found to be greatly influenced by administration demands and the option choice system which tended to dictate their scheduling. This also tended to force pupils to make up their minds early. This meant that in some cases the careers interview came after the pupil had already made up his or her mind (*ie* not to continue with science) so the influence of careers advisers would be limited. This suggests that perhaps advice should be targeted earlier in the process. Formal and informal (from parents, *etc.*) advice seemed to be based upon what pupils were interested in or enjoyed. Very few careers advisers had a SET background and therefore tended to rely on their own personal networks for information and confidence in the subject, and therefore perhaps need training or updating in occupational information.

The report concluded that:

> *'… pupils have to make subject choices which can crucially affect their future options at a time when their motivation in science subjects is reducing and their perceptions of what for many are largely invisible careers are very hazy.'*

It suggests that interest in science can be kept open with good teaching, extra-curricular activities and by careers education and guidance. The authors recommend that: careers departments and the science department work more closely together to develop approaches to increase pupil motivation in science; careers advisers undertake more work with younger pupils, with science teachers, parents and local employers to increase awareness of the width of opportunities available before attitudes harden; and careers advisers receive training and updating in relation to occupational information (which changes rapidly).

Rolfe H (1999), *Gender Equality and the Careers Service*, Equal Opportunities Commission

A study addressing gender equality amongst UK Careers Services, encompassing an initial overview of Careers Service policies and practices, an in-depth best practice case study of Sheffield Careers Guidance Services, plus additional case-focused research at various other services. Findings include:

- Only one-third of Careers Services were found to have most of the policy features recommended by the Equal Opportunities Commission.
- Effective partnerships and networking were felt to be key in improving careers service delivery, enabling the sharing of expertise and other resources.
- The standard of careers education in schools was found to be variable.
- The careers services themselves felt the greatest impact on school pupils could be gained from dedicated careers events and careers education activities.

- Gender stereotyping influences decisions concerning work experience placements, and this was felt to represent a lost opportunity to interest young people in following non-traditional careers.
- Although many careers services were keen to target primary age pupils, this work is not funded as part of the core contract. Services which have focused at this level have found younger pupils very receptive to ideas about social change and equality.
- Careers services were keen to involve parents in gender equality and career-decision work, but gender was felt to be relatively difficult to address through community meetings or other such events designed to involve parents.
- Difficulties in pursuing Equal Opportunities Commission guidelines included widespread traditional views on gender roles in the local culture and the large size of some careers service catchment areas.

It was felt that careers advisers would be more confident to explore non-traditional routes with young people if there were better systems in place to support these young people once they had made these brave choices.

Russell M, Wardman M (1998), *The value of Information Types and Sources for Year 11 Decision Making*, MORI/DfEE

A qualitative study designed to assess the quality of careers material currently available to young people, those planning to remain in full-time education, as well as those planning to enter the labour market. Some 462 interviews were carried out at four sites around the UK with pupils who had just completed Year 11. The researchers note that the study was based on an unrepresentative sample, and that findings should be read with this in mind.

Key findings include:

- The majority of participants found the careers material they had seen easy to follow, felt the type and amount of material was on the whole appropriate, and felt that the material was fairly well-designed.
- A majority were unfamiliar with some of the key careers materials (*eg* Labour Market Information and Post-16 School/College Performance Tables).
- Few of the participants had previously read the careers materials in any great detail. With the exception of the Post-16 Options document, only a minority had read most or all of any publication they had come across. The most common reasons given for this were that the young people had already decided what their next step was going to be and that the documents

were (as a result, perhaps) not thought to be relevant to their needs. Most said they had already made future plans before they even became aware of the publications.

- Few of the participants felt the materials they had come across had influenced their post-16 decision, rather, any information gleaned from the material had been used to guide decisions already made.
- On the whole, the participants were more likely to have discussed careers materials with their parents than with a careers adviser.

Various policy-related issues are discussed, including the need both to distribute careers materials at an earlier age and to heighten parents' understanding of Year 11 decision-making.

5. Post-Compulsory Chemistry

5.1 Scope and range of literature

5.1.1 Headings used

Two main sub-divisions of the literature covering chemistry in Higher Education were used, these were:

- **undergraduate entry and study** — this section covers the choice of chemistry as a subject of undergraduate study and the type of training received by undergraduates. The section also covers what is known about the career choices of chemistry undergraduates.
- **postgraduate and academic entry and careers** — this section covers postgraduate and post-doctoral training of chemists and their career choices. The section also covers what is known about the careers of chemistry academics.

5.1.2 Amount and type of literature

There is a large amount of literature available on post-compulsory chemical education, but this mainly focuses on how to teach certain chemical concepts or common chemical misconceptions by chemistry undergraduates. This means that the literature on why they choose chemistry and their subsequent choices tends to be sparse and limited to a few journals. Similarly, the literature on chemistry postgraduates and academics tend to be sparse and confined to a few academic journals and publications of chemical professional bodies.

5.2 Key messages

5.2.1 Undergraduate entry and study

UK undergraduate chemistry under pressure as entrant numbers drop

There has been a significant drop in the number of home entrants to UK undergraduate chemistry courses (UCAS, various years). This is part of an international pattern and this has led to a lot of heart searching amongst chemists in the UK (Breuer, 2002) and overseas (Hill, Cross, 2003). This has led to calls for a revision of the way chemistry is taught at universities (Wallace, 2000) and examination of the factors that cause students to choose these subjects (Woolnough, 1994).

The growth of medicine may explain the decline in chemistry student numbers

Since 1997 there has been a dramatic and continuing decline in the numbers choosing to study chemistry at UK universities (Breuer, 2002). Although the parallel increase of medical students, as a result of Government policies, may explain the decline in chemistry students as 'A' level chemistry is also compulsory for medical students (UCAS, various years).

Despite growing efforts the secondary/tertiary interface for chemistry is poorly understood

The reasons why those with chemistry 'A' levels or Scottish Highers choose to, or not to, study chemistry at university are poorly understood. However, it is clear that a declining proportion, from a declining pool of those with chemistry 'A' levels, are opting for chemistry at universities (RSC Education Department, 2002).

Gender imbalance at university entry

An important aspect of the secondary/tertiary interface is the disparity between the proportion of females gaining chemistry 'A' level (51 per cent) and the proportion of home entrants to first degree university chemistry (42 per cent).

Practical work and industrial exposure still important

Practical work is still important for both the development of technical and manipulative skills as well as an aide to learning, although the purpose of each practical needs to be thought out (Bennet, O'Neale, 1998). As with school students, exposure to industrial work-experience makes for better graduates and those more likely to enter the chemical industry (Wallace, 2000).

Interventions aimed at increasing university science take-up have ambiguous results

A longitudinal controlled evaluation of a series of interventions designed to increase the uptake of science subjects at a Canadian university (Madill *et al.*, 1999). This showed that while the experiences were valued they did very little to change attitudes which had been set years before. When the influences are examined they tend to involve positive school experiences with the subject and, where it occurred, industrial experience (Robertson, 2000). However, role models have little reported impact and in Australia, New Zealand and North America careers advisers had no impact (Shallcross, 2002).

5.2.2 Postgraduate and academic entry and careers

Women are progressively under-represented in the higher levels of academic science

Even in sciences where women are the majority of undergraduates, and sometimes the majority of postgraduates, women are still poorly represented in the higher echelons (Bebbington, 2002). The situation is chemistry is little different (Ea, 2000), with women being more put off by the negative aspects of an academic career, such as long-hours and low pay. Another report suggests that chemistry departments need to put in place a series of good practices to ensure more female recruitment and retention (Evaluation UK, 2002).

5.3 Undergraduate entry and study literature

Bennet S W, O'Neale K (1998), 'Skills Development and Practical Work in Chemistry', *University Chemistry Education*, Vol. 2, No. 2, pp. 58-62

A paper questioning the importance of practical work in university chemistry teaching, in an environment where a lesser number of chemistry graduates will enter occupations where their practical skills are required. Argues that the role of practical work needs to be clarified and if it is skill development this should be made more explicit. Students should not simply be blindly following recipes.

Breuer S (2002), 'Does Chemistry Have a Future', *University Chemistry Education*, Vol. 6, No. 1, pp. 13-16

A paper highlighting the steep absolute, and steeper relative decline, in the numbers of students that are choosing to study chemistry at UK universities post-1997. Reviews evidence on the attitudes towards chemistry and actual career options for chemistry graduates. Puts forward two response strategies, the first involves reducing the number of chemistry departments to concentrate on the few who want to study chemistry. The second strategy would involve actively marketing chemistry as a subject that prepares graduates for a wide range of occupations and growing the subject.

Cotton S (2001), *The secondary/tertiary interface in chemistry: a teacher's perspective*, a report for the RSC

Reports research undertaken during a sabbatical by a school chemistry teacher examining the skill requirements of undergraduate chemistry students. Argues that, if 'A' level chemistry teachers want a greater proportion of their students to progress to studying chemistry at university, they need to encourage a wider view of the subject than encouraged by the examination system. *'To do this they need to keep in touch with the world of chemistry beyond the door of their laboratory and university chemistry departments can certainly help.'* 'A' level students need to be aware that universities recognise the range of previous experience that entrants now have and plan accordingly. At the same time university chemistry departments need to track the changes to the 'A' level curriculum and plan accordingly.

Gadd K (2000), *The secondary/tertiary interface*, a report for the RSC

Reports on a survey of current practice at UK universities designed to ease the transition from secondary chemistry to tertiary chemistry. The report also identifies effective measures and suggests further actions that could be taken to ease the transition. The survey found that most university chemistry departments were aware of the changes under way within secondary education and were taking steps to reflect these changes. The report makes a number of recommendations to make it easier for universities to take on board the many said changes to secondary education. The suggestions include the creation of a web page by the RSC that provides details of specifications for the new GCE and GNVQ curricula. Encourages schoolteachers and university lecturers to interact more so both groups understand the concerns of the others.

Hill J O, Cross R T (2003), 'Shaping the future of chemical education to meet the challenges of the new millennium', *Chemical Education Journal*, Vol. 6, No. 2, online chem.sci.utsunomiya-u.ac.jp/v6n2/hill/hill_abs.html

Argues that the major challenge for chemical education in the new millennium is the restoration of chemistry 'to its former pre-eminent position as the 'central-science' and, simultaneously, as one of the four 'enabling sciences'. Starts from the position that Australia is not producing sufficient numbers of trained research scientists and does not have enough science school teachers to generate more in the future. There is recognition that much of the solution will depend on reforming the secondary and tertiary curriculum in chemistry. Indeed, the authors are engaged in developing a new first year degree course for Australian chemistry. However, the solution 'also involves the Australian chemistry profession continuously making our governments aware of the significance and achievements of our scientists and of our chemists in particular, since it is the science fraternity which forms the core of the 'knowledge nation' philosophy.'

Madill H M, Fitzsimmons G W, Montgomerie T C, Ciccocioppo A L, Stewin L L, Armour M A, Tovell D R (1999), *A Longitudinal Approach to Studying Young Women's Career Decision Making in Science,* A paper presented at the International Association for Education and Vocational Guidance and the Institute of Careers Guidance, University of Warwick UK, August 4-7, 1999

A report covering a six-year series of follow-ups of two types of intervention designed to encourage young women into science-based study and careers. All the qualified applicants to the pre-college WISEST summer research program were randomly assigned into three groups:

- the Summer Research Program of six weeks
- a one day Discovery Science Career Workshop
- a control group with no intervention.

The study concluded that:

> *'The special initiative program that we evaluated … does not attract young women to science careers. That had already occurred before they applied to the WISEST Summer Research Program. However, participants in the study group who attended the Summer Research Program highly valued that experience and they used the six week experience to confirm their field choice.'*

Robertson I J (2000), 'Influences on choice of course made by university Year 1 bioscience students — a case study', *International Journal of Science Education*, Vol. 22, No. 11, pp. 1201–1218

A study of 157 bioscience students at the University of Strathclyde that:

> *'… clarified factors influencing course choice, particularly those relating to the role of schools. In-school experiences provided the earliest source of interest in science for the majority, with males developing interests earlier and ages 10–14 important for both genders. Interest and success in previous studies were the most popular reasons given as the main influence on course choice. Work experience, was very influential for some. The practical nature of schools science, intellectual satisfaction of studying science and quality of senior school teaching and examination results in biology and chemistry, were identified by almost all as encouraging influence. Significant gender differences were found for influences of early perception of science as difficult, study of physics at 14–16 and quality of physics teaching in the senior school. Advice from the university and attendance at an open day were influential, particularly for female students.'*

In addition to these details from the abstract, the article looked briefly at the influence of careers services, which was assessed in comparison to a specified range of other influences on degree subject choice — it came bottom. Also, first year undergraduates' perceptions of working in industry — they agree with: value of interpersonal skills; that salaries in SET are good; and that status is high.

RSC Education Department (2002), *University Degree Course Entrants 1995-2000*, RSC

This paper provides information on the first degree subjects entered by those with chemistry 'A' levels. This shows that in 2000 only 6.9 per cent of those with a chemistry 'A' level chose to study chemistry. Nearly one-quarter of those with chemistry 'A' levels chose another science, while nearly one-third chose medicine, veterinary science and related subjects. However, some of the largest recent changes have been the increase in chemistry 'A' level holders entering arts and social science courses with 46 per cent more entrants in 2000 than 1995. This in turn suggests that the main task for university chemistry departments lies in persuading the large number of potential chemists that they want to study chemistry.

Shallcross D C (2002), *Factors Influencing the Selection of Chemical Engineering as a Career — Results of an International Survey*, Proceedings of the 9th APCChE Congress and CHEMECA 2002, 29 September — 3 October 2002, Christchurch NZ

> *'During 2000 and 2001 more than 2500 undergraduate chemical engineering students in fifteen universities in Australia, Canada, New Zealand, Thailand, the United Kingdom, the USA and Vietnam were surveyed on the reasons behind their selection of chemical engineering as a career.'*

Table 3.5: University entrants with chemistry 'A' level, 1995 and 2000

University subject	1995		2000		% change
	entrants	% of total	entrants	% of total	
Chemistry	2,779	8.7	2,527	6.9	–9
Other science	8,731	27.5	8,877	24.2	+2
Medicine/Veterinary and related	9,066	28.5	11,700	32.0	+29
Engineering/ Technology/ IT	4,742	14.9	5,424	14.8	+14
Law/ Finance/ Business	1,317	4.1	1,769	4.8	+25
Arts/ Social Sciences	1,866	5.9	2,719	7.4	+46
1st Degree Teaching Qualification	580	1.8	326	0.9	–44
Other Combined Degrees	2,702	8.5	3,392	9.3	+26
Total All Subjects	*31,779*	*100.0*	*36,609*	*100.0*	*+15*

Source: RSC Education Department and UCAS, 2002

The survey found that students had been drawn to chemical engineering because:

- they liked chemistry at school
- they saw the profession as being involved in a diverse range of industries
- they wanted to study engineering, but did not like the other engineering disciplines
- in Australia, New Zealand and North America career teachers played almost no part in influencing students
- few students studied chemical engineering because their parents told them to
- tertiary information events, such as engineering camps and open days played a small part in positively influencing students to study chemical engineering
- very few students were influenced by role models.

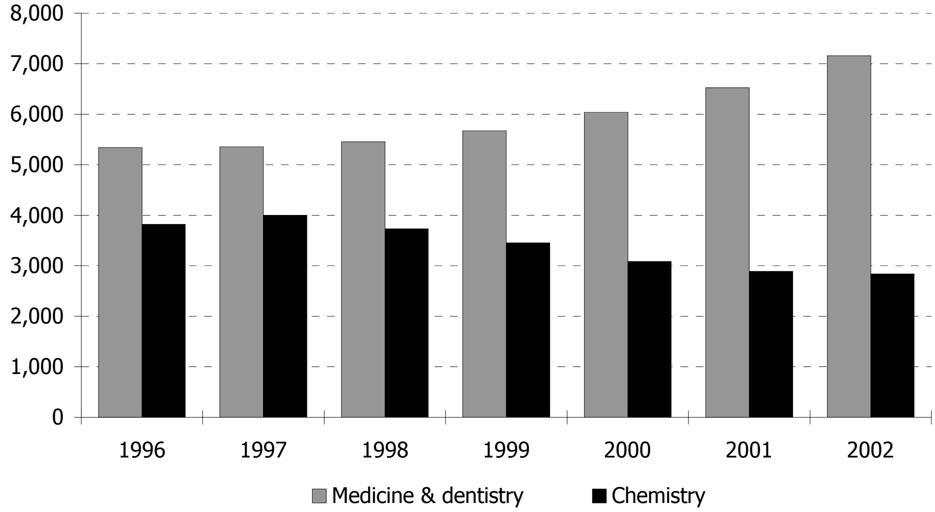
Siann G, Callaghan M (2001), 'Choices and Barriers: factors influencing women's choice of higher education in science, engineering and technology', *Journal of Further and Higher Education*, Vol. 25, No. 1, pp. 85–95

This article is concerned with the under-representation of women in science and engineering and technical courses in Higher Education in Britain and the underlying reasons for this. The first section critically examines a barrier model, which focuses on factors which may impede and/or discourage women from entering the field, reviewing potential barriers such as: SET education in schools; the nature of scientific inquiry; the masculine occupational culture of SET; the image of scientists and lack of role models and networks. The second section briefly presents an alternative model that focuses on the extent to which such an under-representation reflects a tendency for women to make positive choices of alternative occupational fields. It is concluded that rather than focusing on a barrier model image, where women are seen in a relatively passive role, more consideration should be given to the extent to which career decisions arise out of positive choices.

UCAS (various years), *UCAS annual reports and data downloads*, Universities and Colleges Admissions Service

UCAS provides a series of useful data on entrants to university study in various subjects broken down in a variety of ways. It is from the UCAS data that the dramatic decline of UK domiciled entrants to chemistry degrees since 1997 can be derived. This shows a 29 per cent decline in entrant numbers between 1997 and 2002 (4,003 entrants to 2,836 entrants). However, the data also provides a partial rationale for the decline. Over the same period UK entrants to medicine and dentistry rose from 5,356 to 7,159 as a result of a major Government initiative. Since medicine and

Figure 5.1: Home domiciled first degree entrants Medicine & Dentistry and Chemistry

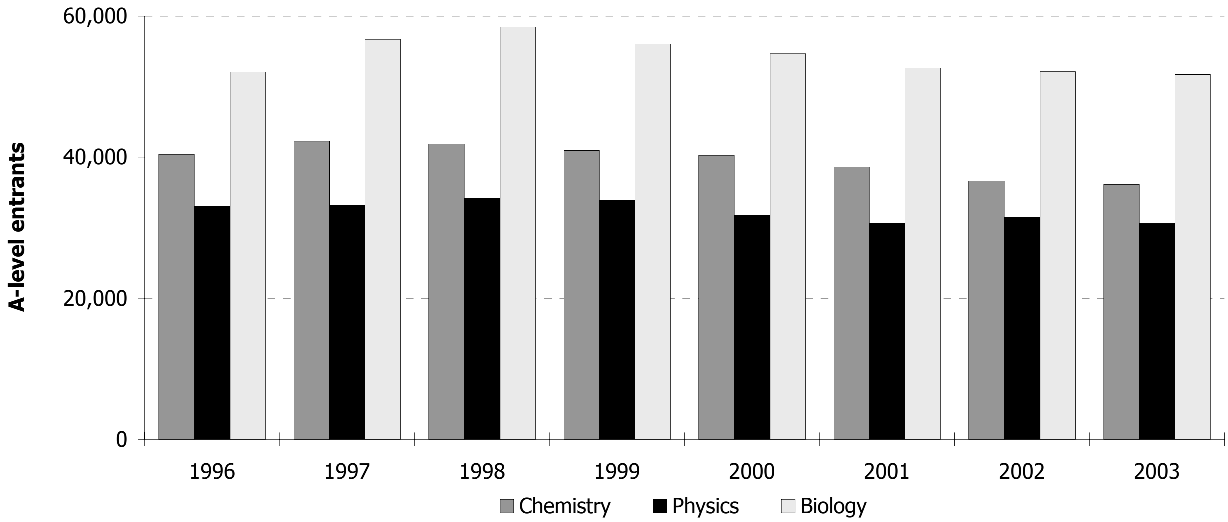


Source: UCAS statistics, various years

dentistry represent the only other discipline for which a chemistry 'A' level is a pre-requisite, it would seem that the growth in medicine and dentistry numbers has been directly at the expense of chemistry (Figure 5.1).

Another way of examining the UCAS data on home first degree entrants is by gender. Figure 5.2 shows the percentage of home entrants to chemistry, physics and biology that were female. The data for chemistry shows the proportion of females has steadily grown, with 42 per cent of the home entrants female in 2002, although the proportion had peaked in 2000 at 43 per cent. This compares with physics where the proportion of female home entrants has remained pretty constant at about 19 per cent. On the other hand, 61 per cent of biology home first degree entrants were female, up from 56 per cent in 1996.

Figure 5.2: Home chemistry, physics and biology entrants by gender 1996 to 2002



Source: UCAS statistics, various years

Wallace R G (2000), 'The chemistry graduate destined for employment but with no experience in it. Does it make sense?', *Chemistry Education*, Vol. 1, No. 1, pp. 169-174

Describes a four-year MChem degree programme that includes a year in industry. This is compared with another four year MChem at the same institution without the year in industry. The industrial placement and the way it is used to develop skills derives from earlier sandwich degrees. Modules before and after the placement are used to reinforce skills, and a project as well as distance learning occurs while on the placement.

Wallace R G (2003), 'Rethinking the education of chemists — The odyssey is over, time for action', *Chemistry Education*, Vol. 4, No. 1, pp. 83-96

Argues that chemistry is a mature discipline but that there is a need to reappraise what constitutes chemistry in the light of declining student numbers. Suggests some ways to move forward that include: consolidation; metamorphosis; diversification; re-badging; and radical thinking.

Woolnough BE (1994), *Factors Affecting Students Choice of Science and Engineering*, International Journal of Science Education, 16, No. 6, pp. 659–676

The abstract reports on a study of over 1,000 18 year olds, looking at the relationships between preferred science learning activities, encouraging and discouraging factors and personality traits on the decision to choose physical science, engineering or other subjects in HE. The author found differences between science and non-science students, but also between engineers and physical scientists, in terms of the timing, and reasons for their course choices and preferred science learning activities. Influences were: home background; personality type; and preferred teaching styles.

5.4 Postgraduate and academic entry and careers literature

Bebbington D (2002), 'Women in Science, Engineering and Technology: A Review of the Issues', *Higher Education Quarterly*, Vol. 56, No. 4, pp. 360–375

Concern continues to be expressed over women's difficulties in advancing their careers as academic scientists. Though some sciences may be numerically feminised, few women reached the upper echelons of science. Women are under-represented in academic employment, they are disadvantaged compared to men in terms of pay, are more likely to be employed on short-term contracts and are less likely to apply for research grants. Women are best represented in language-based studies at almost every grade and worst represented in engineering and technology. There is an European trend of a generally high representation of women in the social and biological sciences and a lower presence in the natural sciences and engineering.

Scant attention has been paid to issues of the progressing of women from non-traditional backgrounds, such as those from ethnic minorities, and who may be particularly disadvantaged. What research there is indicates a variation between the sciences in terms of women's careers, and patterns that are replicated globally. Explanations are now focusing on how the scientific culture itself acts as the barrier to women, rather than on the notion that women themselves lack the requisite skills. The Athena project is a policy response to this issue. Future research and policy needs to look more closely at the differences between sciences, how women from diverse backgrounds experience the academic labour market, and epistemological connections between employment and engagement with the scientific agenda.

Also published by Athena, this paper provides a short overview of the available research, literature and statistics in the UK, and selectively overseas. It highlights some of the, then, current policy concerns and initiatives. It concludes that women are not equally represented in science in higher education and that their representation is even lower at higher levels. It highlights the limited scale of recent policy initiatives to improve women's representation and concludes that more in-depth research is needed to understand their low representation. All literature reviewed is well referenced. Looks specifically at higher education only, draws comparisons with women in other disciplines, considers doctoral students, career progression, representation of women in positions of status, explains disadvantages faced by women, policy developments in UK, and European policy.

Ea (2000), *Study of the Factors Affecting the Career Choices of Chemistry Graduates*, A report for the Royal Society of Chemistry

Provides a quantitative analysis largely based on HESA data of the position of women in academic research. This found that women were more likely to be in junior, temporary and part-time positions. The next section examines the status of women in academic chemistry cost centres. This found women were less well represented as students and staff in chemistry than most other subjects. The third section contains the results of six discussion groups aimed at establishing the factors affecting the career choices of typical chemistry graduates. This found that women were more likely to have been originally motivated into chemistry by emotional reasons and good teachers while men had been motivated by chemistry's linkages with the real world and good teachers. Academic chemistry careers were seen as requiring a great passion and interest in the subject, that became allconsuming. An important barrier to female academic careers was their higher probability of moving to follow a spouse's career which limited their career options. Chemistry was liked by all groups because it enabled you to get results and solve problems in a creative way, although, both men and women were concerned at the poor image of chemistry. The men felt that this also impacted on their career prospects with other disciplines seen as more employable. Women conversely felt that chemistry was an employable discipline. Both men and women saw academic freedom as the main appeal of an academic career. Men saw the public recognition of publication as an appealing aspect of an academic career. The negative aspects of an academic career included: the long hours culture; pay, and; the career structure. Women had additional concerns around poor and unsafe working conditions, an emphasis on results rather than process and isolation.

Evaluation UK (2002), *Recruitment and Retention of Women in Academic Chemistry*, a report for the Royal Society of Chemistry

A report commissioned by the RSC to explore why some academic departments manage to recruit and retain female academics while others do not. The data suggests a particular problem with chemistry.

> *'Currently chemistry compares well overall with other SET subjects in the proportion of women undergraduate and postgraduate students it attracts (approximately 38 per cent), but the proportion of women post-doctoral fellows falls to around 25 per cent. Only around two per cent of chemistry professors in the UK are women which is one of the lowest proportions of any subject.'*

The report is based on interviews with 35 women across seven chemistry departments, plus the heads of these departments. The departments selected were from a range of RAE ratings and had differing proportions of women staff. Identifies a series of good practices:

- in first appointment
- in induction
- in retention
- in management structure and style
- in promotion
- more broadly.

The report concludes that:

> *' … the best departments do not target measures specifically at women: they create a culture of diversity where all individuals can thrive and be rewarded for their contribution, regardless of gender or family circumstances.'*

6. Chemical Employment

6.1 Scope and range of literature

6.1.1 Headings used

The literature in this chapter was kept in one section, partly due to the scarcity of literature in this area and partly because gender, as the main issue, was spread over all the literature.

6.1.2 Amount and type of literature

As already mentioned, and as with Chapter 5, the literature covering this area is more sparse, and mainly consists of journal articles from a few specialised journals and policy related documents produced by learned societies.

6.2 Key messages

6.2.1 Chemistry careers key messages

There is very little literature that specifically examines chemistry careers and why they were selected. The only literature specifically covering chemistry careers came from the US. This showed that women in US chemistry still faced obstacles to advancement, specifically with moving into management positions, although the situation has improved in recent years (ACS, 2003).

The more general literature covering scientific careers can give some insights for chemistry. Scientific careers depend on the nature and extent (Farmer *et al.*, 1995) of scientific experiences at school as well as the levels of satisfaction with these experiences (O'Driscol, Anderson, 1994). Future predicted income (Gati *et al.*, 1995) and predicted status (Farmer *et al.*, 1999) were important predictors of scientific and technical careers amongst men, while relationships with people were important for women (Gati *et al.*, 1995). These gender differences are important as fewer scientifically qualified women than similarly qualified men pursue scientific careers. There is a suggestion that the gender differences are not so much due to differences in perceived desirability of scientific jobs, but more due to underlying psychological differences about what careers can offer (Miller *et al.*, 2002). These differences mean that men perceive scientific careers as more interesting than women do (Morgan *et al.*, 2001), this in turn makes them more likely to pursue scientific careers. There are specific problems with the culture surrounding academic research for women and they were less willing to undertake research in military areas or involving animal experimentation (O'Driscol, Anderson, 1994). However, women did not perceive scientists working hours to be excessive or attach importance to role models (*ibid*). As with US chemists, there was concern about the advancement of women within scientific careers (Bebbington, 2002). Women were also more likely to be on short-term contracts and more likely to be poorly paid (*ibid*). An international review found that although many of the barriers to women's progression in scientific careers they were still widespread in many countries (Etzkowitz, Kemelgor, 2001). Practical guidance to overcoming some of these barriers is given in Warrior, 1997.

The available information suggests that chemists are relatively well paid, although there is some evidence that chemists' salaries may be falling back relative to other professionals (ONS, various years). The RSC's remuneration survey (RSC, 2002b) also shows that their members, especially those in managerial positions and those working in the pharmaceutical sectors, are well rewarded.

6.3 Chemistry careers literature

ACS (2003), *American Chemical Society Women in the Chemical Professions Study – Executive Summary*, American Chemical Society

Based on an in-depth telephone survey of 109 chemists (100 women and nine men) and building on the ACS 1990 salary survey. The report concludes that women in US chemistry still face obstacles to advancement, despite an improved professional climate in recent years. Another key finding was that while women were being recruited into chemistry in larger numbers they were failing to move into management positions or into higher academic ranks in proportional numbers.

Bebbington D (2002), 'Women in Science, Engineering and Technology: A Review of the Issues', *Higher Education Quarterly*, Vol. 56, No. 4, pp. 360–375

Concern continues to be expressed over women's difficulties in advancing their careers as academic scientists. Though some sciences may be numerically feminised, few women reached the upper echelons of science. Women are under-represented in academic employment, they are disadvantaged compared to men in terms of pay, are more likely to be employed on short-term contracts and are less likely to apply for research grants. Women are best represented in language-based studies at almost every grade and worst represented in engineering and technology. There is an European trend of a generally high representation of women in the social and biological sciences and a lower presence in the natural sciences and engineering.

Scant attention has been paid to issues of progressing of women from non-traditional backgrounds, such as those from ethnic minorities, and who may be particularly disadvantaged. What research there is indicates a variation between the sciences in terms of women's careers and patterns that are replicated globally. Explanations are now focusing on how the scientific culture itself acts as the barrier to women rather than on the notion that women themselves lack the requisite skills. The Athena project is a policy response to this issue. Future research and policy needs to look more closely at the differences between sciences, how women from diverse backgrounds experience the academic labour market, and epistemological connections between employment and engagement with the scientific agenda.

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Etzkowitz H, Kemelgor C (2001), 'Gender inequality in Science: A Universal Condition', *Minerva*, Vol. 39, pp. 153–174

This article reviews international literature on women in science and finds that barriers to entry into the scientific professions are falling. Nevertheless, despite significant increases in the number of women in science, women scientists face a cluster of impediments to their ascent in science, irrespective of nation or social system. Conclusion: there is a universal gender inequality. When science is of low cultural status, numbers of women increase. When doing science has the potential for not only improving social status but also increasing prestige, money and other kinds of power, women tend to be excluded. Women have made the greatest gains in technical fields where science occupies a relatively low status in comparison with other professions.

Farmer H, Wardrop J, Anderson M, Risinger R (1995), 'Women's Career Choices: Focus on Science, Math, and Technology Careers', *Journal of Counselling Psychology*, Vol. 42, No. 2, pp. 155–170

This US study tracked the career outcomes of a sample (n = 173) of young men and women who, during secondary school in the 1980s, had aspired to enter science, maths, or technology-related careers. By 1990, 36 per cent of the women and 46 per cent of the men had pursued these early aspirations. Different factors were found to have influenced the men and women respectively. For example, persistence in young women was found to be related to the number of science and maths related options they had taken at school. The authors suggest that guidance counsellors should note these kinds of factors, *eg* encouraging female pupils to opt for more science courses where possible.

Farmer H, Wardrop J, Rotella S (1999), 'Antecedent Factors Differentiating Women and Men in Science/Nonscience Careers', *Psychology of Women Quarterly*, Vol. 23, pp. 763–780

Factors that differentiate women and men who choose a science career from those who do not were investigated using longitudinal data from 1980 and 1990. The participants were ninth or twelfth graders at six mid-western high schools in 1980. Women in science, compared to women in other careers, were significantly more likely to value maths and science for their future career goals, whereas men in science, compared to men in other careers, had significantly higher high school grade point averages in natural science and high career aspirations.

The findings indicated that environmental variables, such as the influence of parents, teachers, and counsellors, did not contribute to the fitted models. One of the strongest predictors for young adult women who were participating in science careers was current motivational feelings and commitments, namely, valuing mathematics and science for their career relevance.

Not unexpectedly, both women and men in science careers, compared to those in non-science careers, took more high school science courses because they wanted to, aspired to higher prestige careers as young adults, and attributed their maths successes more to their ability. The male model accounted for more than twice the variance accounted for by the female model, and context variables were not predicted for either model. Suggestions for revising the model and improving the assessment of context influences are made. Implications for research and practice include designing and evaluating programmes to increase the number of intellectually able girls valuing maths and science as these relate to their future goals.

Gati I, Osipow S, Givon M (1995), 'Gender Differences in Career Decision Making: The Content and Structure of Preferences', *Journal of Counselling Psychology*, Vol. 42, No. 2, pp. 204–216

This Israeli study is based on an analysis of monitored dialogues of 1,252 women and 751 men with a computer-assisted career decision-making system. The research was set against gender stereotyping in the workplace and was intended to establish whether gender differences exist in the career decision-making process. Participants were asked to rate the importance of various aspects in their decision making, including prestige factor, income, flexibility in working hours, and amount of travel. On the whole, few differences were found between the sexes, but notably, income was found to be more important to men, and relationships with people more important to women. Importantly, it was found that men and women sometimes associated the *same* aspect, *eg* flexibility in working hours, with *different* contexts. Men perceived flexibility in working hours to be related to status at work, while women related it to working conditions. Therefore, there is not necessarily a universally agreed-upon meaning for the factors which may be included in such computer-assisted systems, and this has implications for careers counselling practice.

Miller L, Lietz P, Kotte D (2002), 'On decreasing gender differences and attitudinal changes', *Psychology, Evolution & Gender*, Vol. 4, No. 1, pp. 69–92

Encouraging the entry of women into scientific data careers remains problematic in the UK and Australia. Although recent initiatives have resulted in increased participation of girls in science-related subjects in schools, there remains a significant gender divide in entry to scientific programmes of study at post-compulsory and university levels. In this study, datasets for 13-year-old pupils in Australia and England, taken from the third international maths and science survey, were used to derive path models that identify factors influencing the extent to which science-related careers are viewed as desirable by Australian and English pupils. Results indicate that, in both countries, attitudes to science form the strongest factor influencing desire for jobs in science. The other factor that has a direct impact on the desirability of jobs in science is the pupils' achievement level. While gender was not found to impact on attitudes, the teaching approach adopted influenced the development of pupils' attitudes towards science.

On the issue of attributions for performance, mothers are key in determining the child's belief that effort can lead to higher performance in maths and science. The greater importance mothers are perceived as assigning to high performance, the more likely their children are to believe that performance can be influenced by effort. However, perceptions of the importance assigned by the mother impact most strongly on the development of the child's own view of the importance of maths and science.

Encouragement of positive attitudes towards science appears to be of key importance. In other words, if the school/home environment fails to foster positive attitudes towards, and perceptions of, science within pupils, then it is perhaps of little surprise that children do not aspire towards science-related careers at later stages in life. Also socio-economic status continues to have a direct impact on achievement level in both Australia and England. But gender was found to exert no direct effect on the perceived desirability of jobs in science, though gender was found to impact on psychological processes indirectly influencing development of an interest in science-related careers. These indirect effects of gender were found to be stronger in England than in Australia. One of the most encouraging findings points to the influence that teachers can have in this process. The approach to learning utilised within the classroom was identified as the factor influencing the development of attitudes towards both maths and science. Teachers' use of practical problems, demonstrations and active learning techniques led not just to the development of more favourable attitudes towards maths and science, but also to pupils being more likely to believe that their performance can be improved through their own effort.

Morgan C, Isaac J, Sansone C (2001), 'The Roles of Interest in Understanding the Career Choices of Female and Male College Students', *Sex Roles*, Vol. 44, Nos. 5/6, pp. 295–320

Women are under-represented in maths and science careers. This study tries to explain gender differences by looking at students' work goals, interest and career choices. Men and women are similar in their number of work goals but differ on two goals: to have a career that involves others and to have a career that provides high pay and status. Overall, both men and women may find careers that satisfy interpersonal goals more interesting than careers that only satisfy extrinsic reward goals, because both men and women are more likely to prioritise interpersonal goals than extrinsic reward goals. Students perceived careers in physical mathematical science to provide less opportunity to meet interpersonal goals than education and social services careers and medicine. In addition, students perceived careers in education and social services to provide less opportunity to meet high pay and status goals, relative to physical and mathematical sciences and medicine. Men rated careers in physical and mathematical sciences as more interesting than women did. Conversely, women rated careers in education and social services as more interesting than men did. Students' perceptions of how different careers offered interpersonal opportunities significantly predicted the level of interest in careers in physical and mathematical sciences, education and social services, and medicine. By contrast, students' perceptions of careers offering high-paying status goals

Table 3.6.6: Average gross annual survey for chemists and all professionals 1999 to 2003

	1999	2000	2001	2002	2003
Chemists	£28,950	£29,062	£30,205	£31,665	£32,254
All Professionals	£27,521	£29,608	£30,874	£32,657	£33,741

Source: New Earnings Survey: Streamlined and Summary Analysis

significantly predicted perceived interestingness for physical and mathematical science careers only.

ONS (Various years), *New Earnings Survey: Streamlined and Summary Analysis*, Office of National Statistics

The New Earnings Survey is an annual survey based on a sample of PAYE tax returns and contains salary as well as occupation and sector of employment details. Importantly, as the survey is based on PAYE returns the sample does not include the self-employed.

However, this survey provides the most reliable information on average and median salaries as well as their distribution. Table 3.6.6 presents average salary data for chemists and all professionals from 1999 to 2003. This shows that chemists in 1999 were earning on average £28,950, more than the average professional on £27,521. However, by 2003 chemists had fallen behind the other professionals, but were still earning £32,254 on average. It should be noted that in 2003 the survey was reported on the basis of the SOC2000 Occupational Classification rather than the SOC90 classification of the previous surveys, although this classification change should have had no impact.

O'Driscol M, Anderson J (1994), *Women in Science: Attitudes of university students towards a career in research: a pilot study,* PRISM Report No. 4, Wellcome Trust

Starts from the position that women are under-represented in senior scientific research positions. Argues that despite this position very little systematic research has been aimed at the reasons for this. Reports a short scoping study based on two universities (Leeds and Cambridge) and two disciplines within them (physics and biochemistry). Used 47 semi-structured face-to-face interviews of undergraduates and postgraduates. This was supplemented by a questionnaire survey completed by 130 students half of whom were women. Key findings:

- women were less likely to consider scientists' working hours to be excessive
- stimulating first degree courses were important for encouraging female research careers
- the culture surrounding academic research was perceived by women to be unattractive

- women were more likely than men to want to work in areas that involved contact with people
- women were less likely than men to undertake research that was defence funded or involved animal experimentation
- contrary to belief, women did not attach importance to female role models.

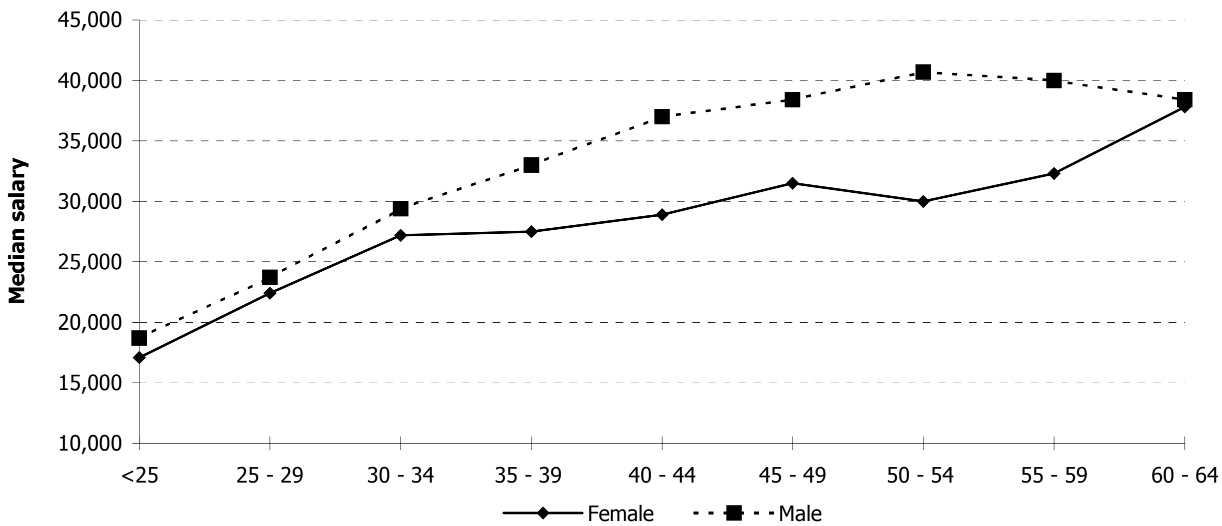
RSC (2002b), *Trends in Remuneration UK Survey Report 2002*, Royal Society of Chemistry Members Only Report

This report, which is based on a survey of RSC members, is only available to members and not otherwise publicised. The 2002 survey is based on an analysis of 12,000 responses to a survey sent out to 33,100 members in December 2001. This shows that two thirds of those with CChem status are employed in industrial or commercial companies, with a further nine per cent employed in Higher Education. As might be expected, 23.4 per cent work in the Pharmaceutical sector and another 8.5 per cent in the other chemicals sector. Chemists who enter general management earn the most followed by R&D managers. These higher salaries often reflecting the stage in their career with those aged between 50 and 54 earning the most. There remain some differences due to gender (as shown in Figure 6.1), with female RSC members starting their careers earning slightly less than their male counterparts. However, by age 35 females are dropping significantly behind males, which can at least partially be explained by career breaks disrupting their progression.

Warrior J (1997), *Cracking it! Helping women to succeed in Science, Engineering and Technology*, Training Publications Ltd

Women are still in the minority in SET occupations. They might face obstacles in trying to combine a career and family, and hit a

Figure 6.1: Median salaries for all RSC members by age group and gender



Source: RSC (2002b), Trends in Remuneration UK Survey Report, 2002 glass ceiling. This handbook looks at the experiences of women who have survived and succeeded in SET, and provides positive guidance to those embarking on their careers. This book provides an introduction to the career path faced in SET and describes how one can create a successful SET career and how to overcome barriers to success. It summarises the various skills, qualifications, causes and funding sources that might be needed. It gives helpful insights to finding the right job and how effective mentoring and successful networking can make a difference in one's career path. Attention is paid to balancing career and family responsibilities: how do you manage your work, your career development and your family responsibilities, what good strategies there are to managing a career break successfully and how to get back into SET after several years away. Lastly, it gives examples of the many ways in which SET expertise can be used in areas other than straightforward scientific, engineering and technological careers. This book is a very practical handbook in helping girls and women to finding their way into a SET career.

7. Conclusions and Recommendations

7.1 Conclusions

7.1.1 Public perception of chemistry

The public are generally appreciative of the products of chemists and the chemical industry, and the current Government is very supportive of science and thus of chemistry. However, there remains some negative associations with chemistry, especially those which are a result of the perceived risks associated with the discipline.

7.1.2 Chemistry in schools

Chemistry is liked as a subject up until 16 years old, with perceptions of the subject as hard and abstract appearing to deter more chemistry study between 16 and 19 years old. Despite historic problems, chemistry is no longer perceived as a 'male' subject, with slightly more girls than boys studying chemistry at 'A' level and more girls than boys obtaining good grades. The Government review of 14 to 19 year old provisions in England provides an opportunity for the revision of the curricula to make chemistry at GCSE and 'A' level more attractive.

7.1.3 Chemistry in universities

The main current concern amongst UK university chemistry departments is the dramatic fall in the number of first degree entrants from 4,003 in 1997 to 2,836 in 2002. In many ways this can be explained by a parallel increase in the number of entrants to medicine, the other subject for which chemistry 'A' level is a pre-requirement. However, the proportion of those with chemistry 'A' levels entering chemistry first degree courses is low and always has been low. Rather than trying to increase the numbers studying chemistry at 'A' level, probably a more effective strategy would be to increase the proportion entering chemistry first degree courses. However, very little is known about the career and study aspirations of chemistry 'A' level students. At the same time very little is also known about why those with chemistry 'A' levels do not choose chemistry at university and what universities can do to make chemistry more attractive to them. One area of concern is that 51 per cent of chemistry ‘A’ levels are obtained by females, while only 42 per cent of home entrants to chemistry first degree courses are female.

7.1.4 Chemistry careers

Very little is known about chemistry careers. The only available evidence suggests that the area, especially in academia, is very male dominated. The New Earning Survey by the Office of National Statistics (ONS) suggests that chemists have comparable incomes to other professionals although they may be falling back in comparison. The RSC’s own remuneration survey shows chemists are concentrated in the pharmaceutical industry, other chemicals and higher education. Members who have become managers and those working in the pharmaceutical industry are the best rewarded.

7.2 Recommendations

Public perception of chemistry

Given some of the problems surrounding the public perceptions of chemistry it is recommended that the RSC:

Build on the positive attitudes to the products of chemistry to develop positive attitudes to chemistry

The benefits of the products of chemistry, such as pharmaceuticals, are widely accepted and acknowledged. There is a need to translate this into more positive attitudes towards chemistry and its study. This means linking chemistry and chemists to positively viewed products such as pharmaceuticals. There remain issues surrounding the perception of risk and pollution which the RSC is well placed to address through the media.

Reincorporate nano-technology into chemistry as nano-chemistry

Chemistry appears to spin off a sequence of new disciplines which are no longer identified with chemistry, such as nano-technology. This means that the public and potential students rarely understand the full scope of chemistry and its new developments. The RSC is well placed to urge the re-incorporation of nano-technology into the chemistry domain, perhaps under the name of nano-chemistry.

Pre-empt public misunderstanding of nano-technology

Actively engage in a debate about safety and ethics associated with nano-technology, perhaps by trying to refocus the debate around chemical nano-technology or 'nano-chemistry' to emphasise the chemical rather than technological nature of the debate. Technology also tends to be an instrumental term with negative connotations. By changing the terms of the debate it is to be hoped that many of the problems associated with biotechnology will not come to surround nano-technology.

7.2.1 Chemistry in schools

There is a wide range of issues impacting on chemistry in schools and again the RSC are well-placed to address these issues. This has led to the following suggestions for action by the RSC.

Encourage science and chemistry teachers to take-up and use appropriate chemistry careers materials

The changes in the Careers Service and the increasing need for science teachers of pre-16 year olds and chemistry teachers of 16-19 pupils to provide careers advice causes problems. Unfortunately these teachers often do not have up-to-date careers knowledge or use available materials. This suggests that there is a need for teachers to be encouraged to use appropriate material promoting chemistry careers. The RSC is well placed to both mobilise corporate sponsorships and develop and distribute any careers material, as well as arrange training in their use at the Science Learning Centres.

Understand the career and study aspirations of chemistry 16 to 19 year old students

It is surprising that it appears that the only study of the career and study aspirations of 'A' level students covered only Northern Ireland. If effective careers material and advice is going to be developed we need to know what resonates with 16 to 19 year olds. Therefore, an understanding of post-16 chemistry students, based on a sufficiently large UK wide study, could underpin the development of policy, careers materials, attractive curricula and university recruitment material.

Engage in the development of new chemistry curriculum specifications

It is known that chemistry taught using up-to-date and everyday examples engage students better, and thus encourages take-up. Therefore the RSC should encourage the introduction of modern and interesting contexts into the new specifications being developed for first teaching in 2006.

Encourage a dialogue between the chemical industry and chemistry teachers as to the best approach to industrial visits and placements

It is known that industrial visits and industrial placements, if organised successfully, are very effective. However, work experience is often difficult to organise because of perceived health and safety problems. The RSC could, through its members in industry, promote increased dialogue with teachers ensuring effective industrial visits and placements.

7.2.2 Chemistry in universities

Chemistry departments are under pressure due to the recent drop in entrants. Apart from the growth in the number of medical studentships available, very little is known about the underlying factors or consequences of this decline. Therefore, the following suggestions for action by the RSC attempt to address these issues.

Lobby for transitional support for chemistry departments suffering from the expansion of medical studentships

Recognise that the recent decline in first degree chemistry numbers is more to do with the massive increase in the number of places available to study medicine than a decline in interest in chemistry. The solution will remain in increasing the numbers of students with 'A' level chemistry choosing chemistry at university, rather than competitively bidding for the current declining number opting for chemistry. The expansion of medical places is the result of deliberate and highly-funded Government policy. Therefore, there may be a case for lobbying for Government funds to temporarily sustain the chemistry departments that are suffering as a result of an unintended consequence of the expansion of medical places.

Understand why chemistry undergraduates choose chemistry

There is a need to understand why chemistry undergraduates choose to study chemistry and why those who are otherwise qualified choose not to study chemistry. An important part of this process would be understanding why females with chemistry 'A' levels do not choose chemistry at university as much as their male counterparts. The results of such a study could inform the development of policy and the development of university prospectus material. Any such study would require the active support and involvement of university chemistry departments and the RSC is well placed to mobilise this support.

Urge universities to co-operatively respond to university funding changes and avoid cannibalising chemistry courses

A climate of rapid and relatively dramatic decline in the number of entrants attempts by some universities to significantly grow their entry through bursaries and other measures can only lead to a more rapid decline of entrants at the other universities. This in turn could lead to the closure of more chemistry departments to the long-term detriment of the discipline. The RSC, by bringing chemists from competing universities together, could urge a co-operative response to the issue rather than a cannibalistic response.

University chemistry lecturers to be aware of and engage in the debate surrounding 14-19 education changes

The review of 14 to 19 year old education currently underway in England is an opportunity to make the chemistry curricula more attractive and more relevant. These changes will undoubtedly have implications for the knowledge, skills and attitudes of entrants to chemistry courses in the future. Therefore, it is critical those involved with university chemistry engage with those developing any new curricula in a two-way dialogue. The RSC, as a body covering those involved in both areas, appears to be an ideal body to initiate and support this dialogue.

7.2.3 Chemistry careers

Given the lack of information there is a need to obtain better data about the careers of chemists, both for the development of policy and for the provision of advice to potential chemistry students. Therefore it is recommended that the RSC:

Release selected highlights of the RSC members remuneration survey to provide inputs to policy debates and careers advice

Currently the only information available in the public domain covering the salaries and careers of chemists is the Government's New Earnings Survey. The RSC undertake a regular survey of their members which provides details of salaries, broken down by age, RSC membership status, sector of employment, type of employment and gender. The report is intended as an internal document as a service to members. However, information about the sorts of salaries received by chemists and where they work and the sort of work they do is of wider interest. Selected highlights of the survey could be used for careers materials or by policy makers. Without detracting from the current exclusive service to members, some information could usefully be released to the public domain.

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