

SET for success

The supply of people with science,
technology, engineering and
mathematics skills

The report of Sir Gareth Roberts' Review

April 2002

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The Rt. Hon. Gordon Brown, MP
Chancellor of the Exchequer
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April 2002

Dear Chancellor

Scientists, mathematicians and engineers contribute greatly to the economic health and wealth of a nation. The UK has a long tradition of producing brilliant people in these areas, from Isaac Newton and Isambard Kingdom Brunel, to Dorothy Hodgkin and Neville Mott last century, and most recently to Andrew Wiles who proved Fermat's Last Theorem. The challenge we face is to continue to attract the brightest and most creative minds to become scientists and engineers.

The Government, in partnership with the Wellcome Trust, has done much in recent years to increase investment in scientific research in UK universities. There are already signs that this and the measures taken to stimulate the commercialisation of research are yielding fruit. Much has also been done to stimulate UK industry to invest more in research and development through the introduction of tax breaks and special partnership schemes linking universities and industry. The purpose of this Review has been to establish whether we have sufficient people to exploit these new facilities and technologies.

The Review has identified a number of serious problems in the supply of people with the requisite high quality skills. They are not equally spread across science and engineering; indeed, the aggregate numbers of students with broadly scientific and technical degrees has risen in the last decade. However, there have been significant falls in the numbers taking physics, mathematics, chemistry and engineering qualifications. These downward trends, combined with deficiencies in transferable skills among graduates, could undermine the Government's attempts to improve the UK's productivity and competitiveness. Furthermore, these discipline-related problems will have negative implications for research in key areas such as the biological and medical sciences, which are increasingly reliant on people who are highly numerate and who have a background in physical sciences. It should also be acknowledged that there are other shortage areas, such as modern languages, outside the scope of this Review.

EXECUTIVE SUMMARY

Purpose of the Review

- 0.1 This Review was commissioned at the time of Budget 2001 as part of the Government's strategy for improving the UK's productivity and innovation performance. It stemmed from the Government's concern that the supply of high quality scientists and engineers should not constrain the UK's future research and development (R&D) and innovation performance.
- 0.2 Continuous innovation is key to the future survival and growth of businesses operating in what are increasingly competitive global markets. Although not all innovation is based on scientific R&D, the need for human ingenuity in making discoveries and creating new products, services or processes means that the success of R&D is critically dependent upon the availability and talent of scientists and engineers.
- 0.3 The Review considered the supply of science and engineering skills in the UK and the difficulties employers face in recruiting highly skilled scientists and engineers. A number of problems were identified in the development of science and engineering skills in school, further and higher education, and the Review makes a number of specific recommendations to the Government and the education sector to address these problems.
- 0.4 The Review also identified the need for further action by businesses and others seeking to employ scientists and engineers to work in R&D. Scientists and engineers are in increasing demand right across the economy and employers cannot expect to attract the best scientists and engineers without offering competitive conditions of employment. The challenge for R&D employers, therefore, is to improve the attractiveness of the jobs they offer, improve the coherence of their skills planning, and increase dialogue and research collaboration with the education sector, all of which are crucial in ensuring an adequate supply of scientists and engineers to work in R&D.

Scope of the Review

- 0.5 The report focuses on biological sciences, physical sciences, engineering, mathematics and computer science. Graduates and postgraduates in these subjects are referred to as 'scientists and engineers'.¹ The Review recognises, however, the powerful influence of multidisciplinary and interdisciplinary activities in innovation, where related subjects (for example, medicine and information studies) are increasingly important, and that consumer-led demand is a powerful motivator in the production and development of novel products and services.²

¹ In order to concentrate on the labour market for scientists and engineers in R&D, the Review notes but does not examine explicitly, the supply of graduates and postgraduates from areas such as medicine, agriculture, social sciences, and psychology. The labour markets for most researchers in these areas are significantly different to those for science and engineering graduates.

² The Review recognises that subjects in other areas - for example, arts and humanities - are important in the supply of innovative and creative employees. The Review also acknowledges that a limited number of these subjects, which lie outside the scope of this Review, may face one or more of the same problems as science and engineering.

- 0.6 This Review was commissioned by the UK Government and it therefore focuses its recommendations on the Government's areas of responsibility. It is hoped, however, that elements of the report will be of use to the Devolved Administrations and add to their understanding of differences in the supply of, and demand for, science and engineering skills in different parts of the UK. Most of the data used by the Review therefore refer to the UK as a whole (although England-only data have been used for school qualifications and English regional comparisons).

Overview of the Review's findings

- 0.7 Compared to other countries, the UK has a relatively large, and growing, number of students studying for scientific and technical qualifications. However, this growth is primarily due to increases in the numbers studying IT and the biological sciences, with the overall increase masking downward trends in the numbers studying mathematics, engineering and the physical sciences. For example, the number of entrants to chemistry degrees dropped by 16 per cent between 1995 and 2000.
- 0.8 However, graduates and postgraduates in these strongly numerical subjects are in increasing demand in the economy – to work in R&D, but also to work in other sectors (such as financial services or ICT) where there is strong demand for their skills. Many areas of biological science research also increasingly rely on the supply of these skills. Furthermore, there are mismatches between the skills of graduates and postgraduates and the skills required by employers (for example, many have difficulty in applying their technical knowledge in a practical environment and are seen to lack strong transferable skills).
- 0.9 The 'disconnect' between this strengthening demand for graduates (particularly in highly numerate subjects) on the one hand, and the declining numbers of mathematics, engineering and physical science graduates on the other, is starting to result in skills shortages. This is evident in higher employment rates and salaries for graduates and postgraduates in these disciplines, and in surveys of employers' recruitment difficulties. The Review identifies a number of issues that lie behind this 'disconnect':
- a shortage of women choosing to study these subjects at A-level and in higher education;
 - poor experiences of science and engineering education among students generally, coupled with a negative image of, and inadequate information about, careers arising from the study of science and engineering;
 - insufficiently attractive career opportunities in research for highly qualified scientists and engineers, particularly in the context of increasingly strong demand from other sectors for their skills; and
 - science and engineering graduates' and postgraduates' education does not lead them to develop the transferable skills and knowledge required by R&D employers.

- 0.10 Addressing these issues requires action in school, further and higher education. However, improving the supply of scientists and engineers to R&D cannot be tackled through the education system alone. Ultimately, those wishing to employ scientists and engineers to work in R&D must offer attractive career packages that are competitive with the full range of other opportunities open to scientists and engineers. The action taken by employers in responding to this challenge will be crucial in securing a strong supply of highly skilled scientists and engineers who want to work in R&D.
- 0.11 This report follows the development of science and engineering skills through school, further and higher education, before considering the issues surrounding careers for scientists and engineers in academia and in the labour market more generally. The main issues and the thrust of the key recommendations in each area are set out below. A full list of all recommendations is provided at Annex A.

School and further education

- 0.12 The experiences of pupils in school and further education are crucial to their subsequent education, training and careers. Although standards in schools and colleges are rising overall, it is concerning that significantly fewer pupils are choosing to study mathematics and the physical sciences at A-levels in a period when total A-level entries have risen by more than 6 per cent. The decline has been most marked in physics, where between 1991 and 1999 numbers taking A-level physics in England fell by 21 per cent. During the same period, the numbers taking A-level mathematics in England fell by 9 per cent, and those taking A-level chemistry by 3 per cent.
- 0.13 There are a number of deep-seated issues particular to these subjects that need to be addressed in order to improve the UK's future supply of high level science and engineering skills. These issues, which are common to both school and further education, include:
- shortages in the supply of physical science and mathematics teachers / lecturers;
 - poor environments in which science, and design and technology practicals are taught;
 - the ability of these subjects' courses to inspire and interest pupils, particularly girls; and
 - other factors such as careers advice which affect pupils' desire to study science, technology, engineering or mathematics at higher levels.

Teachers

- 0.14 Secondary schools and further education colleges find it increasingly difficult to recruit science, mathematics ICT and design & technology (D&T) teachers and lecturers, since graduates in these subjects often have other more attractive and better paid opportunities open to them. This is evident in the consistent failure to recruit sufficient numbers specialising in these subjects onto Initial Teacher Training courses and in the higher teacher vacancy rates in these subjects.
- 0.15 This is in part due to the increasing demand for science, mathematics and engineering graduates from other sectors combined with static or falling numbers of graduates in a number of science and engineering disciplines.³ Linked to this, a significant stumbling block to recruiting more science and mathematics teachers is their relative remuneration. The Government has taken steps to target financial rewards to teachers of subjects in which there are teacher shortages – for example, through the introduction of golden hellos and the flexibility for schools to target additional allowances on particular recruitment and retention problems. These have had an effect, although serious shortages and recruitment difficulties remain and are damaging pupils’ attainment. For example, the most recent OFSTED⁴ subject teaching reports revealed that:
- “[In mathematics] there are insufficient teachers to match the demands of the curriculum in one school in eight, a situation that has deteriorated from the previous year.”*
- 0.16 **The Review concludes that the Government should tackle such recruitment and retention problems through increasing the remuneration offered to teachers of these shortage subjects – and also that head teachers and governing bodies use all the pay flexibility at their disposal.⁵**
- 0.17 Particularly in science there are also concerns over the level of initial training that teachers receive. This is important both in primary schools, where very few teachers have a strong scientific background, and in secondary schools and further education colleges, where science teachers are often required to teach areas of science that they did not study at degree level (nor, in many cases, at A-level).
- 0.18 **To address these issues, the Review makes recommendations that trainee teachers receive significantly more training aimed at improving their teaching of areas of science in which they have not specialised.** This is particularly important in addressing the declining numbers of pupils choosing to study the physical sciences, since primary school teachers and many secondary school science teachers (who often come from a biological science background) are in general least confident in teaching the physical science elements of the National Curriculum.⁶

³ The Review’s recommendations aimed at increasing the number of graduates in these subjects will therefore be of help.

⁴ Office for Standards in Education.

⁵ The Review acknowledges that similar measures may be necessary for a limited number of other subjects outside the scope of this review - for example, modern foreign languages.

⁶ *Science Teachers: a report on supporting and developing the profession of science teaching in primary and secondary schools*, CST, February 2000.

0.19 In a similar vein, the Review also concludes that the Government must act to improve the take up of science-related continuing professional development (CPD) by science teachers. CPD is vital in improving science teachers' understanding of, and ability to teach, all areas of science – particularly those related to contemporary issues discussed in society and the media that are most likely to capture pupils' interest. CPD also allows science teachers to stay in touch with the latest developments in their specialist subjects, which can be an important retention mechanism. Yet only around 15 per cent of science teachers at secondary school take up subject-related CPD a year.⁵ **The Review therefore, makes recommendations aimed at improving science teachers' take up of science-related CPD – in particular, supporting the Government's commitment to a National Centre for Excellence in Science Teaching and urging the Government to work closely with others (notably the Wellcome Trust) with an interest in delivering this.**

The teaching environment

0.20 The environment in which science and D&T are taught is also an important influence on the achievements of pupils, and on their desire to pursue further study and careers in science and engineering. At their best, science and D&T laboratories and equipment can inspire pupils. However, only just over a third of school science and D&T laboratories in secondary schools are estimated to be of a good standard or better; in general they are in a worse condition than the overall school estate. **The Review therefore, recommends that the Government and Local Education Authorities prioritise school science and D&T laboratories, and ensure that investment is made available to bring all such laboratories up to a good or excellent standard, as measured by OFSTED.**

0.21 A further factor that influences the environment in which science and D&T are taught is the pupil-to-staff ratio in practical classes, which is higher in England than in Scotland and many other countries. The Review believes that skilled teaching assistants can be important in lowering pupil-to-staff ratios, thereby improving the learning experience for the pupils, as well as assisting the teacher and the other support staff (e.g. technicians). **The Review therefore, recommends that the Government establish a major new programme to pay undergraduates and postgraduates to support the teaching of science and D&T in schools.** The Review believes that mathematics and IT (and possibly other subjects outside the scope of this review such as modern foreign languages) would also benefit from such a programme, and recommends that the Government should set an ambitious target for the number of science and engineering university students who should be participating in such a scheme by 2005. This initiative would also bring benefits to the university students, through developing their transferable skills.

Subject curricula

0.22 The content and difficulty of the subject curricula, as well as pupils' access to initiatives that can enhance their learning (for example, trips to science centres), significantly affect the desire of pupils to study particular subjects. However, pupils' views of the physical science elements of the science curriculum are poor and pupils can be put off studying the physical sciences and mathematics due to the perceived difficulty of these courses. **The Review makes a number of recommendations, across the spectrum of academic and vocational courses, aimed at:**

- **improving the relevance of the science curriculum to pupils in order to capture the interest of pupils (especially girls) and to better enthuse and equip them to study science (particularly the physical sciences) at higher levels;**
- **ensuring that pupils stand a broadly equal chance of achieving high grades in all subjects (in particular, ensuring that it is not more difficult to achieve high marks in science and mathematics, as currently appears to be the case);**
- **ensuring that pupils are able to make the transition smoothly from GCSE to AS- and A-level and in turn to further and higher education in science and mathematics; and**
- **providing easier access for teachers, schools and colleges to the many independently organised initiatives (for example, the Crest Awards and the Industrial Trust) to enhance the science, D&T, mathematics and ICT curricula.**

Other factors influencing students' choices to study science and engineering

0.23 The views of parents, teachers, careers advisors and society in general towards study and careers in science and engineering can play a significant role in shaping pupils' choices as to whether to study these subjects at higher levels. Regrettably, and incorrectly, pupils often view the study of science, mathematics and engineering as narrowing their options, rather than broadening them. A contributing factor is that careers advisers often have little or no background in the sciences, and that science teachers are often unwilling to advise pupils on future career options. **The Review recommends that the Government establish a small central team of advisers – possibly within the new Connexions service – to support existing advisers, teachers and parents in making pupils aware of the full range of opportunities and rewards opened up by studying science, mathematics and engineering subjects.**

- 0.24 Improving the public perception of SET more generally is also important. The Review noted extensive activity and interest in this area and therefore does not make an explicit recommendation on this issue. Instead, the Review focuses its recommendations on improving the reality of science and engineering study and careers, which it believes will in turn have a positive effect on the public perception of SET.
- 0.25 The Review also calls for improving participation from groups currently under-represented in science and engineering, particularly women and those from certain ethnic minority groups. Although this is important at all levels of education, it is particularly vital in schools. The Review welcomes initiatives such as Baroness Greenfield's study on improving the participation of women in science and engineering and urges the Government to take forward the actions that will in due course be identified.
- 0.26 Through the recommendations relating to school and further education, the Review also sets out a vision for science, technology and mathematics education that it believes will lead to exciting, challenging and rewarding learning experiences for all pupils, and thereby strengthen the UK's supply of science and engineering skills.

Undergraduate education

- 0.27 Undergraduate education is the springboard from which science and engineering graduates either enter employment or continue their studies through postgraduate courses. Compared to its competitors, the UK has a relatively high proportion of graduates in scientific and technical disciplines. However, the trends seen in students' subject choices at A-level (with fewer choosing to study engineering and the physical sciences) are repeated in their choice of undergraduate course. Between 1995 and 2000, although overall graduate numbers rose by 12 per cent, the number of entrants to chemistry degrees fell by 16 per cent and the number of entrants to physics and engineering degrees by 7 per cent.
- 0.28 These declines are partly due to pupils' subject choices at A-level. However, the Review identified a number of issues specific to higher education that reduce the attractiveness of undergraduate education in mathematics, engineering and the physical sciences:
- students can experience difficulty in making the transition from studying at A-level to degree level in these subjects;
 - the teaching environment for these courses often gives rise to poor learning experiences;
 - the course content can be out-dated and not as relevant as it could be to either the student or to future employers; and
 - issues arising from the student funding system may cause added difficulty in studying science and engineering subjects.

The transition to degree level study

- 0.29 Students can sometimes struggle to make the transition from A-level to degree level study in science, engineering and mathematics, since undergraduate courses often do not pick up where students' A-level courses end. Furthermore, the increasing modularisation of A-level courses has led to students entering higher education with wider varieties of subject knowledge; differences in students' mathematical knowledge are perceived to cause particular problems for mathematics, engineering and physical science degree courses. **The Review makes recommendations to address this issue, including the promotion of special 'entry support courses' to bridge gaps between A-levels and degree courses, and encouraging higher education institutions and A-level awarding bodies to manage this transition better.**

Undergraduate course content

- 0.30 Improving the relevance and excitement of science and engineering courses to students is linked closely to improving the relevance of these courses – in terms of skills and knowledge taught – to employers. Updating the nature and content of the course to reflect the latest developments in science and engineering can be achieved both through having lecturers who can draw on recent experience of work environments other than Higher Education Institutions (HEIs), and through explicit changes in course content. The Review believes that both are important in improving the attractiveness of science and engineering study.
- 0.31 **Accordingly, the Review makes recommendations to both employers and HEIs aimed at increasing the interchange of staff between academia and business, and encouraging universities to be more innovative in course design in science and engineering – thereby improving the attractiveness of courses to both students and employers.** These actions by HEIs and employers must be supported by those professional bodies that accredit science and engineering courses – for example, members of the Science Council and the Engineering and Technology Board – who must work with HEIs to drive forward innovation in course design and not allow the accrediting processes to inhibit this.
- 0.32 The Review's recommendation that undergraduate and postgraduate students should be paid to support the teaching of science, mathematics, IT and D&T in schools will also help students develop good communication and other highly sought-after transferable skills.

Undergraduate teaching environment

- 0.33 Outdated science and engineering laboratories and equipment inhibits a potentially vital way of enthusing students about science and engineering, as well as reducing their knowledge and expertise in areas of cutting-edge research. Although the Government – in partnership with the Wellcome Trust – has invested heavily in research laboratories, outdated science and

engineering teaching laboratories are a major problem. The Higher Education Funding Council for England (HEFCE) estimates that about half of all teaching laboratories are in urgent need of refurbishment.

- 0.34 **The Review, therefore, recommends that the Government should introduce a major new stream of additional capital expenditure to tackle the backlog in the equipping and refurbishment of university teaching laboratories. In particular, the priority should be to ensure the availability of up to date equipment and that then, by 2010, all science and engineering laboratories should be classed as at a good standard or better, as measured by HEFCE.⁷**
- 0.35 **Furthermore, in order to ensure that in future higher education institutions can and do invest properly in science and engineering teaching laboratories, the Review recommends that HEFCE should formally review, and revise appropriately, its subject teaching premia for science and engineering subjects.** The revisions should ensure that the funding of undergraduate study accurately reflects the costs – including the market rate for staff, as well as the capital costs – involved in teaching science and engineering subjects.

Student funding and debt

- 0.36 The Review considered whether the length of engineering and physical science degrees (most are now four years, compared to three years for many other courses) is a further factor behind the declining number of students taking these courses (since students would be aware that they would be likely to build up more student debt during four years than three). Little firm evidence exists to prove that this is having an impact, although the Review believes that the Government should monitor the situation closely.
- 0.37 However, there are more widespread concerns that students' longer scheduled hours of study on science and engineering courses – in the laboratory, as well as in lectures – inhibits their ability to take part-time work to support themselves through university. Given the growing reliance of students on part-time work, and bearing in mind the Government's agenda to widen access, the Review believes that access and hardship funds are particularly important for those students who cannot take up part-time work due to these long hours of scheduled study. **The Review makes recommendations to ensure that such students are able to access these funds effectively.**

⁷ In delivering this recommendation, the Review believes it is important that the teaching infrastructure capital stream complements research infrastructure funding to facilitate the building or refurbishment of joint research and teaching facilities, where appropriate.

Postgraduate education

- 0.38 Postgraduate study is fundamental to the development of the highest level of science and engineering skills. It develops specialist knowledge and, particularly at the PhD level, trains students in the techniques and methods of scientific research. However, the number of doctorates awarded to UK-domiciled students in the physical sciences, for example, fell by 9 per cent between 1995/96 and 1999/00.
- 0.39 The declining attractiveness of PhD study has given rise to concern about the quality of postgraduate students – illustrated by declining proportions of PhD students with 2:1 or first class degrees in some subjects.
- 0.40 There are a range of factors that act to reduce the attractiveness of a PhD, including:
- low stipends, when seen against the option of entering employment and reducing the substantial debt that many students will have built up during their first degree;
 - concern from students that they are likely to take more than three years to complete their PhD, while generally, funding is only available for three years; and
 - inadequate training – particularly in the more transferable skills – available during the PhD programme. As a consequence, many employers do not initially pay those with PhDs any more than they would a new graduate, viewing the training (particularly in transferable skills) that PhD students receive as inadequate preparation for careers in business R&D.

PhD Stipends

- 0.41 To improve the attractiveness of studying for a PhD it is vital that PhD stipends keep pace with graduate salary expectations, particularly given the increasing importance of student debt on graduates' career choices. It is also important that stipends better reflect the market demand for graduates in different disciplines. **The Review therefore recommends that the Government and the Research Councils raise the average stipend over time to the tax-free equivalent of the average graduate starting salary (currently equivalent to just over £12,000), with variations in PhD stipends to encourage recruitment in subjects where this is a problem.**

Length of funding

- 0.42 Although students have traditionally been funded for three years by the Research Councils, the average PhD takes considerably longer – nearer to 3½ years. This can deter students from taking a PhD, and the time pressure can also lead to the students being given ‘safe’, rather than innovative, projects to complete. **To address these issues, and to allow time for the greater training referred to below, the Review recommends that the Government and the Research Councils should fund their present numbers of PhD students on the basis that full-time students need funding for an average of 3½ years.** The Review makes further recommendations to enable this principle to be applied in flexible ways.

PhD training

- 0.43 Current moves to improve the quality of PhD training are welcome but institutions are not adapting quickly enough to the needs of industry or the expectations of potential students. The Review therefore believes that the training elements of a PhD, particularly training in transferable skills, need to be improved considerably.
- 0.44 **In particular, the Review recommends that HEFCE and the Research Councils, as major funders of PhD students, should make all funding related to PhD students conditional upon students’ training meeting stringent minimum standards. These minimum standards should include the provision of at least two weeks of dedicated training a year, principally in transferable skills, for which additional funding should be provided and over which the student should be given some control.**
- 0.45 There should be no requirement on the student to choose training at their host institution. The minimum standards should also include the requirement that HEIs – and other organisations in which PhD students work – reward good supervision of PhD students, and ensure that these principles are reflected in their human resources strategies and staff appraisal processes. The Review also believes that institutions should introduce or tighten their procedures for the registration of students to the PhD as part of these standards to ensure, for example, that all PhD projects test and develop the creativity prized by employers.

Employment in higher education

0.46 Upon graduating, over one-third of PhD students become postdoctoral researchers in HEIs,⁸ which for nearly all PhD graduates is a necessary step before becoming a permanent member of the academic staff. Postdoctoral researchers work in the research teams of permanent academic staff, who may have received funding for the project from the Research Councils, businesses, charities or elsewhere (including self-finance by the HEI). Those in receipt of prestigious fellowships have more influence over the nature of their projects.

Postdoctoral Researchers

0.47 Postdoctoral research is a crucial phase in researchers' careers, for it is here that researchers can make a name for themselves through ground-breaking, innovative research. It is also an important phase in which they can develop the skills to lead research projects, which in turn is vital in making the transition to becoming a permanent member of academic staff (or to leading research work elsewhere).

0.48 However, entering the environment of postdoctoral research work is an uncertain and, for many, unattractive prospect. Postdoctoral researchers receive pay that compares unfavourably with that which comparably qualified people could expect to earn outside academe; receive few opportunities to undertake training and development; and are faced with uncertain futures since employment beyond the current project contract – commonly around two years – is not guaranteed. Furthermore, there is little structure to their career, and little advice as to how to make the jump to becoming a permanent member of the academic staff. Although a large proportion remain intent on pursuing academic research careers, it is estimated that fewer than 20 per cent reach a permanent academic job.⁹

0.49 The Research Careers Initiative (RCI) has made considerable progress in analysing the problems surrounding postdoctoral 'contract' research. The Review endorses the work of the RCI and builds on this work through making a number of recommendations to improve the attractiveness of postdoctoral research, and thereby improve the supply of skilled scientists and engineers to both academia and beyond.

⁸ Or similar organisations such as public sector research establishments.

⁹ Source: *Career Paths of Physics Postdoctoral Research Staff*, Institute of Physics, London, 1999.

- 0.50 Foremost, it is important that postdoctoral researchers are able to develop individual career paths, reflecting the different career destinations – industrial, academic and research associate – open to them, and that funding arrangements reflect the development of these career paths. **The Review believes that enabling the individual to establish a clear career path and a development plan to take them along it are critical to improving the attractiveness of postdoctoral research. The Review therefore recommends that HEIs take responsibility for ensuring that all their contract researchers have a clear career development plan and have access to appropriate training opportunities – for example, of at least two weeks per year. The Review further recommends that all relevant funding from HEFCE and the Research Councils be made conditional on HEIs’ implementing these recommendations.** Funders of postdoctoral researchers need to take this requirement fully on board in providing resources for research projects.
- 0.51 **In addition to establishing clearer career progression, the Review recommends that Research Councils should significantly increase salaries – particularly starting salaries – for the science and engineering postdoctoral researchers they fund, and sponsors of research in HEIs and Public Sector Research Establishments should expect to follow suit.** The Review considers that the starting salary for science and engineering postdoctoral researchers should move in the near future to at least £20,000 and that there should be increases above this aimed at encouraging recruitment and retention in disciplines where there are shortages due to high market demand (for example, mathematics).
- 0.52 The Review makes further recommendations to improve the interchange of postdoctoral researchers between academia and industry, in order to assist their accumulation of a broad range of skills and experiences.
- 0.53 As well as recommending an increase in postdoctoral researchers’ salaries and industrial secondment schemes, the Review believes that there should be a clearer path for postdoctoral researchers into academic lectureships. This should be achieved through creating prestigious fellowships which allow those involved to move from principally research-based work towards the role of lecturer, with the added roles of supporting reach-out to schools and widening access to Higher Education. **The Review therefore, recommends that the Government provide funds to establish a significant number (the Review believes 200 a year) of academic fellowships to be administered by the Research Councils.** The fellowships should last for five years and should be designed to prepare people explicitly for an academic career, to be distributed and awarded on the basis of academic (not only research) excellence across the range of subjects considered in this Review.

Academic Staff

- 0.54 Academic staff contribute to the UK's R&D and innovation performance both directly, through innovative research and knowledge transfer activities, and through training the next generation of researchers. There is widespread concern that HEIs are increasingly finding it difficult to recruit and retain their top academic researchers, with universities in other countries and businesses both in the UK and abroad offering better pay and conditions. These problems in recruitment and retention tend to be in particular subjects rather than across the board, and can be seen in the response of universities (namely, earlier promotion of academic staff in these subjects).
- 0.55 There are also concerns over the demographic profile of academic staff in the mathematical and physical sciences, with over 25 per cent of academic staff in these disciplines over the age of 55, compared to an average across all subjects of 16 per cent.
- 0.56 **The Review concludes that in order to attract academic staff, universities must use all the flexibility at their disposal differentially to increase the salaries – particularly starting salaries – of some scientists and engineers, especially those engaged in research of international quality, where market conditions make it necessary for recruitment and retention purposes.¹⁰**
- 0.57 The Government should assist by providing additional funding to permit universities to respond to market pressures. The additional funding, which must be permanent, may initially have to be part of a separate stream to institutions. However, the Review believes that it should be incorporated into core funding for research and also into revised subject teaching premia once more market-based salary systems have been established.

Scientists and engineers in R&D

- 0.58 Ultimately, those wishing to employ scientists and engineers to work in R&D must offer attractive career packages that are competitive with other opportunities open to scientists and engineers. This applies not only to businesses but also to public sector organisations such as the NHS, Public Sector Research Establishments and Government departments.
- 0.59 However, other sectors from which there is strong, and growing, demand for the skills and knowledge of science and engineering graduates (for example, financial services) tend to offer more generous pay and more attractive career structures. For example, salaries offered to science and engineering graduates in these other sectors can often be 20 per cent or more than those offered by many R&D businesses. As a result, they have taken increasing proportions of the best science and engineering students.

¹⁰ The Review notes that these conditions are likely to affect a number of other subjects outside the scope of this review, such as economics.

0.60 Responding to the challenge of improving the attractiveness of jobs in research and development, to match or surpass other opportunities open to the best science and engineering graduates and postgraduates, is crucial to individual businesses' future success, since their R&D underpins their future products, services and, ultimately, their future sales and profits.

Attractiveness of work in R&D

0.61 The Review identifies a number of issues that act to reduce the attractiveness of working in R&D, and makes recommendations to employers for addressing these issues. **In particular, the Review is clear that the continued supply of scientists and engineers to R&D requires more R&D employers to:**

- **compete directly on pay with private sector employers, both through an attractive starting package and through competitive salary progression;**
- **provide time and resources to allow their scientists and engineers to stay in touch with the latest developments in their field (for example, by registering for a part-time PhD programme or having an association with a research intensive university), since those working in research are often motivated by an interest in their subject area; and**
- **more generally, ensure that from entry their scientists and engineers have professional development plans, structured and attractive career paths, and adequate training and development opportunities.**

0.62 The Review is clear that the response of employers to the challenge of improving the opportunities for working on research and development activities will be a deciding factor in the future supply of scientists and engineers to R&D and, therefore, also the UK's innovation and R&D performance.

0.63 **The Review therefore, recommends that the Government should establish a group of R&D employers to support and monitor employers' responses to the challenge of improving the pay, career structures and working experiences for scientists and engineers in R&D.** The group should include representatives from businesses (large, medium and small) and others that employ scientists and engineers in an R&D capacity.

0.64 The Review believes the group must drive the recommendations in this report forward, and thereby ensure that the supply of scientists and engineers acts as a stimulus to innovation and R&D, not a constraint. **Furthermore, the Review believes that the group should publish a report, before the next public spending review, setting out the response of employers to the challenges identified in this report.**

Skills planning and dialogue

- 0.65 It is also clear that there are serious weaknesses in communication between R&D employers and HEIs and students. Although some large businesses have the resources to influence particular university courses directly, the evolving skills needs of most businesses are not known to students or HEIs and therefore, not planned for. The consequent delays in providing the skills required by employers contribute to the emerging skills shortages seen in the economy. Addressing these communication difficulties requires action, in particular, from both employers and universities.
- 0.66 First, it is important that R&D employers identify the skills they need to underpin their R&D activities. It is clear that although many employers plan R&D projects many years in advance, fewer employers consider the people and skills that are needed to underpin this research. Although there are difficulties in detailed skills planning, the Review believes that employers must do more to identify their evolving skills needs.
- 0.67 Secondly, through coherent dialogue with businesses HEIs can learn the extent to which, and how, skills needs are evolving. **The Review believes that the Regional Development Agencies (RDAs) should, through the new FRESAs (Frameworks for Regional Employment and Skills Action), take a leading role in the coordination of communication mechanisms between businesses and HEIs regionally, to ensure that demand for higher-level skills at a regional level can be met.** Other parties – in particular, trade associations, the Learning and Skills Council and Sector Skills Councils – should be involved in this dialogue, to ensure that cross regional and national trends relevant to particular sectors and clusters can be recognised and acted upon.
- 0.68 The Review also identified widespread concern over the level of research and training collaboration between universities and businesses. Although there are excellent examples of innovative and mutually beneficial collaborative research, the Review feels that there is both the scope and need for the levels of research collaboration to be increased significantly. This would both improve the flow of scientists and engineers into business R&D (through helping to bridge the gap between studying science and engineering and then working in R&D) and increase the UK's overall R&D and innovation performance.

0.69 There are a number of Government sponsored and/or funded schemes that exist (for example, Faraday Partnerships) that act to encourage this type of collaboration. However, the Review feels that the collective impact of these schemes is not as high as it should be. **The Review therefore recommends that the Government should develop stronger, more coherent and more substantial innovation partnerships to boost research collaboration between universities and businesses. The Review believes that these should incorporate the following principles:**

- that the research be business led and focussed on commercially-oriented R&D;
- that the partnerships be based on clusters of businesses with particular research interests, either nationally or regionally;
- that the Government invest in each partnership alongside the primary funders (business, higher education and RDAs);
- that each partnership could be virtual or have a physical centre, depending on the nature of the research and the participants; and
- that each partnership should have an explicit aim of prioritising skills training for science and engineering students/graduates, building a critical mass of SET students/graduates with experience in commercial R&D, and encouraging the interchange of people and technology between business and academia.

International migration

0.70 There is widespread concern that some of the best scientists and engineers are leaving the UK to work abroad – a trend that is commonly referred to as a ‘brain-drain’. Some evidence for this is found, although, in fact, more scientists and engineers locate to the UK than leave the UK. However, it is vital that universities and businesses compete with their counterparts abroad through offering attractive and well-paid career structures and working environments. Earlier recommendations are intended to help achieve this.

0.71 It is also important that universities, businesses and other employers in the UK are able to access scientific expertise from abroad. The Review therefore welcomes the Government’s campaign to raise HEIs’ and overseas students’ awareness of the recent improvements to the work permit system. **However, given the lack of knowledge of these changes shown by businesses during the consultation, the Review recommends that this campaign be extended to cover the business community, including smaller and medium-sized businesses engaged in R&D.** Through this, more UK businesses will be able to draw upon worldwide scientific expertise in driving forward their R&D.

Conclusion

- 0.72 The Review has identified a number of issues in school, further and higher education, as well as in the labour market for science and engineering skills, that need to be addressed in order to secure a strong future supply of scientists and engineers in the UK.
- 0.73 The recommendations set out in this report, which represent challenges for the Government, for employers and for the education system, are designed to help secure a strong supply of people with science and engineering skills. The Review believes that implementing these recommendations will be a crucial element in achieving the Government's agenda for raising the R&D and innovation performance of the UK to match the world's best.
- 0.74 The Review is clear that progress towards the goals set out in the report must be reviewed regularly in order to ensure that the UK's R&D and innovation performance can grow as intended. **In particular, the Review recommends that that the Government should review progress on improving the supply of scientists and engineers, encompassing all the areas identified by this Review, in three years' time, and take any further necessary action to continue the process of improvement.**

SCIENTISTS AND ENGINEERS IN THE UK

Summary of issues

The UK's innovation and research and development (R&D) performance is relatively weak, with the UK spending only 1.8 per cent of its Gross Domestic Product (GDP) on R&D, compared to the US and Japan which spend nearer 3 per cent of their GDP on R&D. Furthermore, the proportion of GDP spent on R&D in the UK fell between 1980 and 1997, whereas the proportion in nearly all other major industrialised countries increased.

More recently, however, there have been signs that the UK's R&D performance is improving, with increased public sector investment being accompanied by an apparent upturn in private sector R&D investment. This in turn is leading to a rising demand for scientists and engineers to work in R&D, while at the same time there is strong demand for graduates with highly numerate science and engineering degrees to work in other areas (notably the financial services sector).

Although the overall number of science and engineering students in the UK is relatively high, and growing, the numbers of students choosing to study the highly numerate scientific subjects of mathematics, physics, chemistry and many branches of engineering are falling significantly. For example, the number of students studying A-level physics in England fell by 21 per cent between 1991 and 2000. Unchecked, these trends could result in a serious shortage of scientists and engineers, both for R&D and for other areas of the economy. The first signs of this are starting to appear, with graduates in mathematics, engineering and the physical sciences commanding higher, and faster increasing, salaries than most other graduates (including biological science graduates). These difficulties were borne out in the Review's consultation and are also evident in surveys of employers' recruitment difficulties. Given the increasing importance of interdisciplinary and multidisciplinary research, these trends in engineering and the physical sciences could also affect research in other areas, for example, the biological sciences.

Alongside these subject-related skills shortages, there are also issues around the ability of students emerging from higher education to apply their scientific and technical knowledge in a practical and business environment.

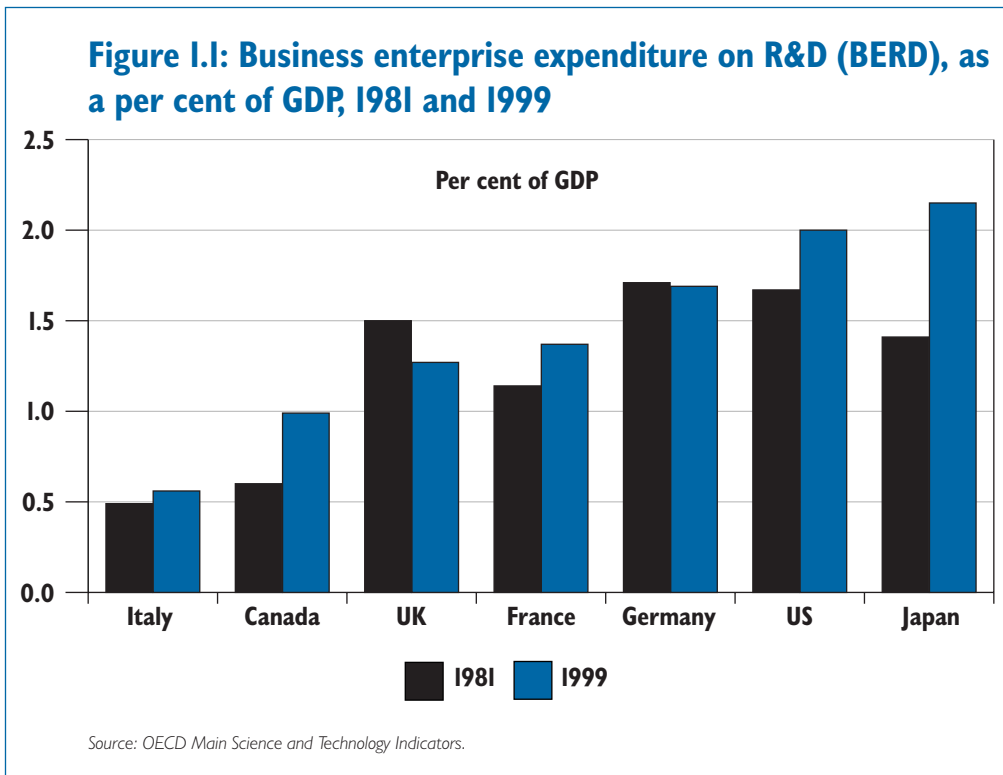
There is, therefore, an emerging 'disconnect' between the demands of businesses and other employers for high-level science and engineering skills and the supply of suitably skilled scientists and engineers.

Innovation and R&D in the UK

- 1.1 Research and development (R&D) is widely recognised to be one of the most important factors in the innovation process. Numerous studies have shown a direct link between investment in R&D and future improvements in productivity.¹¹ The Government is therefore concerned that, for much of the last two decades, UK businesses have invested proportionately less in R&D

¹¹ *The impact of R&D investment on productivity – New evidence using linked R&D – LRD data*, Lichtenberg and Siegel, *Economic Inquiry*, Vol. 29 (2) (1991).

than their counterparts in other countries. This is illustrated in Figure 1.1, which also shows that between 1981 and 1999, investment in R&D as a percentage of GDP fell in the UK, although it rose in nearly all other G7 countries.¹²



1.2 The Government has sought to improve the UK's R&D and innovation performance through a number of measures, including promoting macroeconomic stability, seeking to encourage investment generally and introducing tax credits to stimulate investment in R&D. There are signs that businesses' commitment to innovation and R&D may be increasing, since between 1997 and 1999 expenditure by UK business as a proportion of GDP increased from 1.20 per cent to 1.27 per cent, although it fell back slightly in 2000.

1.3 Although not all innovation is based on scientific research and development, the need for human ingenuity in making discoveries and creating new products, services and processes means that the success of R&D and innovation is critically dependent on the availability and abilities of scientists and engineers. It is therefore vital that the supply of science and engineering graduates with appropriate skills keeps pace with greater investment in R&D and innovation, and with the demand for these skills from other sectors.

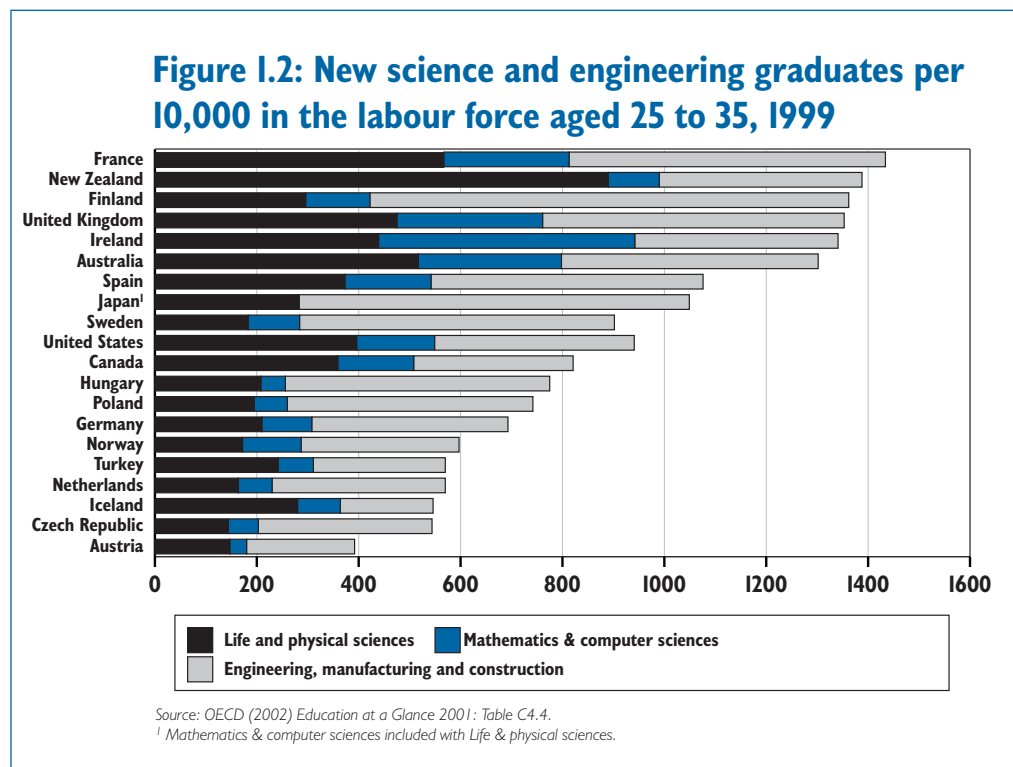
¹² The fall in Germany is due in part to an inconsistency in the time series – 1981 data relate to West Germany only, whereas 1999 data relate to the reunified Germany.

The UK's supply of scientists and engineers

- 1.4 Students learn about science, technology, mathematics and IT in school, from where they can advance, either directly or via further education (FE), into higher education (HE) at a university or HE college. Some university and college graduates go on to postgraduate work, to study for Masters degrees or PhDs, before entering employment – which could be in higher education, in business R&D, in school or further education, or elsewhere in the economy.
- 1.5 This section focuses initially on the supply of graduates (and postgraduates) in scientific and technical disciplines, since they are most likely to be at the forefront of businesses' R&D activities.¹³

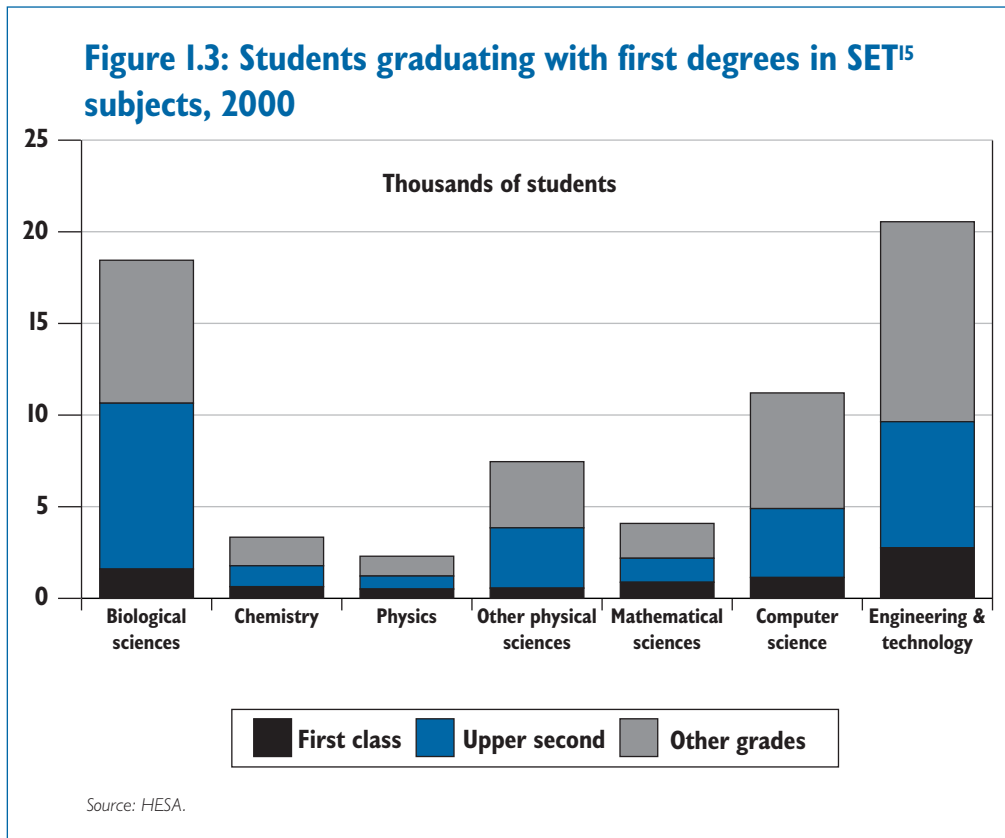
Science and engineering graduates

- 1.6 Overall, the UK's supply of science and engineering graduates is strong compared to that in many other industrialised countries (Figure 1.2), with the UK having more new science and engineering graduates as a percentage of 25-35 year olds than any other G7 country apart from France.



¹³ The Review acknowledges, of course, that progress and growth in the new cultural and creative arts industries will depend on the supply of high-quality and innovative graduates from other disciplines.

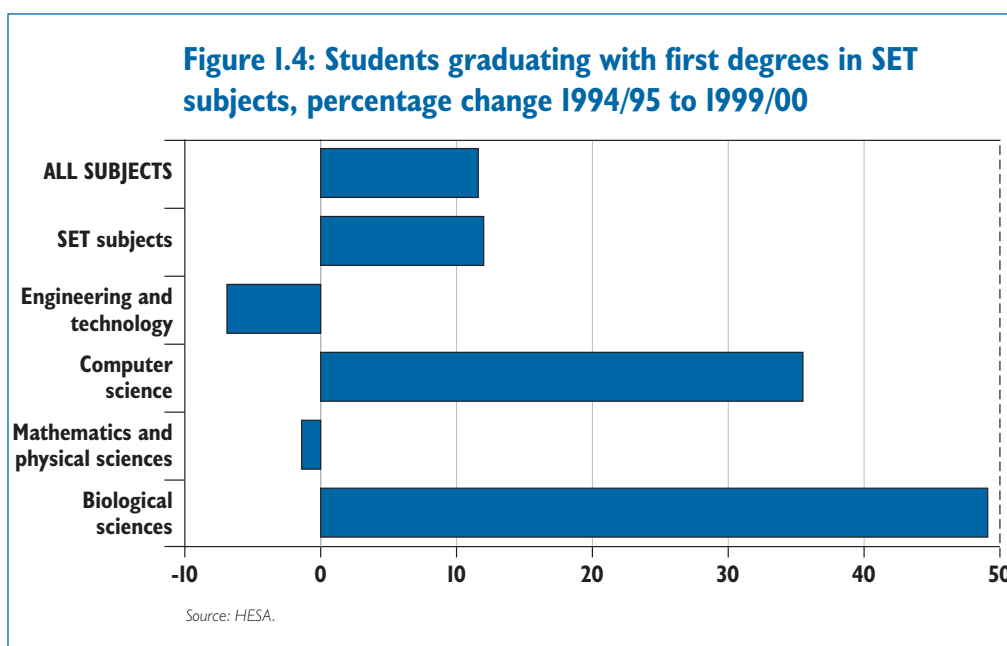
1.7 As Figure 1.3 shows, the majority of these graduates in the UK are in the biological sciences or in engineering & technology and computer science. Relatively few students study the mathematical sciences, or the physical sciences of chemistry and physics.¹⁴ Indeed, more students study computer science than study all of these subjects combined, and the numbers studying the biological sciences, or engineering and technology, are around double the number of graduates in the mathematical sciences and the physical sciences of chemistry and physics combined.



1.8 In recent years the number of science and engineering students in the UK has been increasing, mainly on the strength of growth in biosciences and computer science. However, this growth masks a steady weakening of demand for courses in physical sciences, engineering and mathematics. Figure 1.4 shows that whereas the numbers of students in the UK entering higher education rose by more than 10 per cent between 1995 and 2000, the numbers studying engineering & technology fell by 7 per cent, and those studying mathematics and the physical sciences by 1 per cent.

¹⁴ The physical sciences additionally include earth and material sciences.

¹⁵ Science, Engineering and Technology (including mathematics).



Development of science and engineering skills

1.9 The previous section showed that relatively few students take degrees in the physical and mathematical sciences, and that the number that do has fallen significantly in recent years. Table 1.1 takes this analysis one step further and summarises the proportions of students taking scientific and technical qualifications at different levels. It shows that at the stages when a positive decision to carry on studying mathematics or a physical science subject has to be made, such as from A-level to degree level, the number of individuals choosing SET subjects falls off significantly¹⁶. This is in contrast to business studies – and the biological sciences to a lesser extent – where the proportion taking the subject at degree level is closer to proportion taking the subject at A-level.

Table 1.1: Percentage of ‘year group’¹⁷ taking SET qualifications, 2000

	A-level	First Degree	PhD
Mathematics	7.8	0.6	0.05
Physics	4.1	0.3	0.07
Chemistry	5.1	0.5	0.13
Biology	6.6	2.5	0.25
Engineering & Technology ¹⁸	2.2	2.8	0.24
Computer science	2.8	1.5	0.04
Business studies	4.7	4.4	0.05

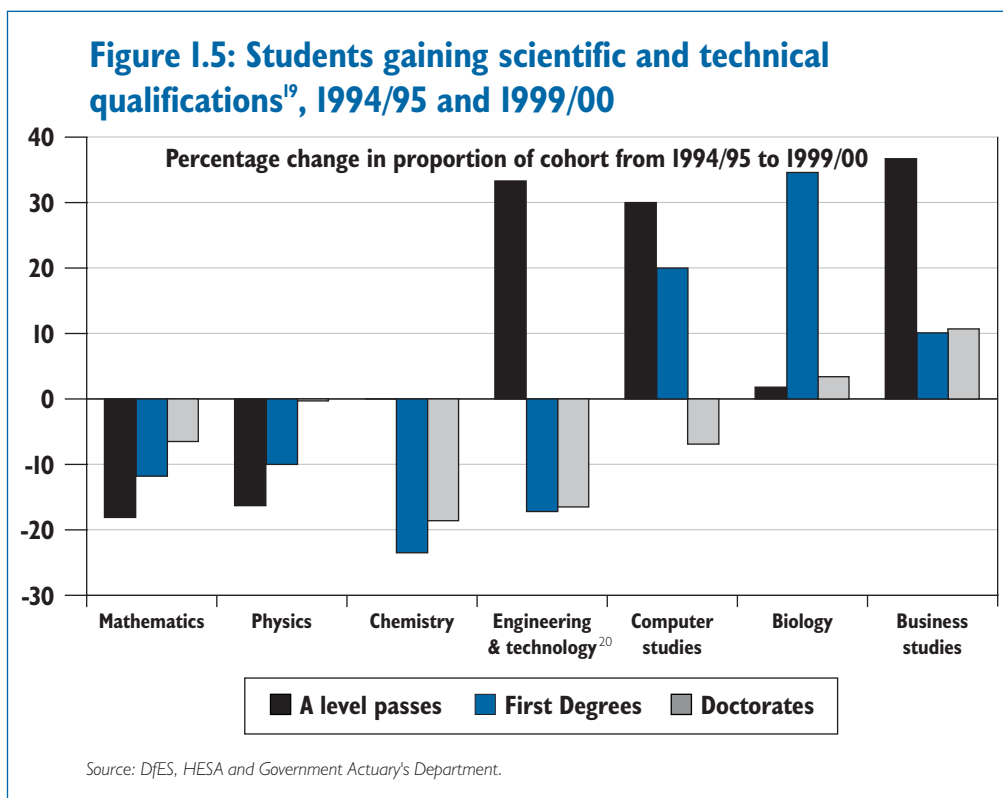
Source: DJES, HESA and Government Actuaries Department.

¹⁶ This will, in part, be due to the fact that some students taking physics, mathematics (in particular) and chemistry at A-level will study engineering, computer science or ‘other physical sciences’ at degree level, rather than continue with these subjects directly.

¹⁷ The base age group: for A-levels is the average of the numbers of 17 to 18 year olds; for first degrees is 21 year olds, and; for PhDs 27 year olds.

¹⁸ A-level figure represents the proportion taking design & technology. It is smaller than the proportion taking engineering and technology degrees since the numbers taking engineering and technology degrees tend to be determined more by the numbers taking A-levels in mathematics and the physical sciences.

1.10 Figure 1.5 examines the change between 1994/95 and 1999/2000 in the proportion of students gaining qualifications in different scientific and technical subjects (and business studies) at A-level, first degree and doctorate level. It shows that the falls in the numbers of mathematics and physics students at A-level are larger than the falls seen for students in these subjects at degree level. This might suggest that issues in school and further education are the main cause of fewer students taking these subjects at degree level. However, there has been little change in the proportion of students taking chemistry at A-level although a significant fall at degree level, which suggests that issues specific to undergraduate education may also be having an effect (at least in this subject).



1.11 Although the proportion taking design and technology at A-level has risen sharply, the numbers taking engineering and technology subjects at degree level and doctorate level have fallen significantly. This seeming disparity arises, in part, because other subjects such as mathematics and physics – which are in decline at A-level – are also very important in preparing students to study engineering in higher education.

1.12 Figure 1.5 also shows that proportion taking computer science and the biological sciences has increased at degree level and at A-level (particularly in computer science). However, a smaller proportion of computer science students go on to take a PhD, which is primarily because a PhD is not viewed as essential a qualification to work in cutting-edge IT development work, as a PhD in chemistry is to work in, for example, cutting-edge pharmaceutical R&D.

¹⁹ Business studies is included as a comparator.

²⁰ Note that the Engineering & technology A-level figures are for Design and Technology.

Summary

- 1.13 The UK has a relatively high and growing overall number of students taking scientific and technical qualifications. However, relatively few study mathematical or physical sciences courses. Furthermore, the growing overall trend masks some significant reductions in the proportion (and numbers) taking mathematics and the physical sciences at A-level as well as engineering at first degree and doctorate level.

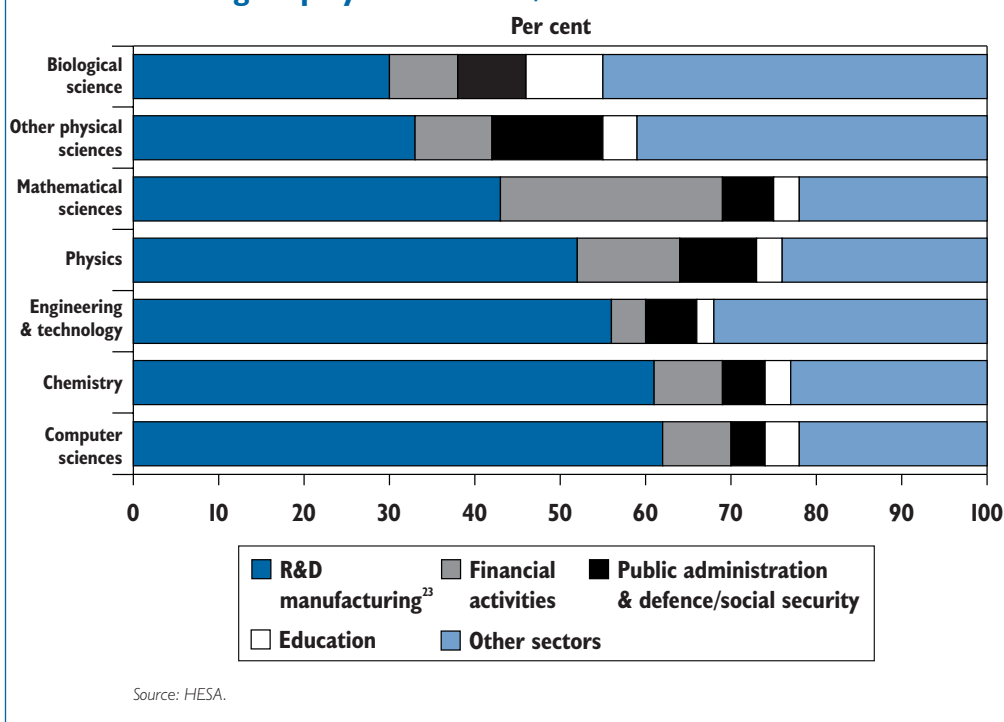
The demand for scientists and engineers

- 1.14 Scientists and engineers in the UK are in demand from a wide range of sectors, not just from higher education or from businesses looking for R&D workers. In particular, recent years have seen an increasing demand from the financial services sector for highly numerate graduates and postgraduates. Increasingly, scientists and engineers are also in demand from businesses and universities in other countries. Other research,²¹ which included a survey of 23,000 employers across the economy, found that over one third of employers need more and higher levels of problem solving, communication and IT skills than they did 5 years ago – in addition to a continuing strong demand for specialist information and communication technology (ICT) skills.
- 1.15 Figure 1.6 illustrates that in many science and engineering subjects over half of all new graduates enter employment working in 'R&D manufacturing'.²² The figure is noticeably lower for graduates in the biological sciences, who tend to work in a greater variety of areas. Two further points to note are:
- mathematics and physics graduates are more likely to enter the financial services sector (which is consistent with the highly numerical and problem solving nature of these degrees); and
 - biological science graduates are more likely to work in education than physics or chemistry graduates (with many working as science teachers/lecturers in schools and further education colleges).

²¹ *Skills for all: Research Report from the National Skills Task Force*, June 2000.

²² This is defined as the Standard Industrial Classification (SIC) group for 'Manufacturing' and the SIC group for 'Real estate, renting and R&D' (which in this case is primarily R&D).

Figure I.6: First destination for first degree graduates entering employment in 1999/00



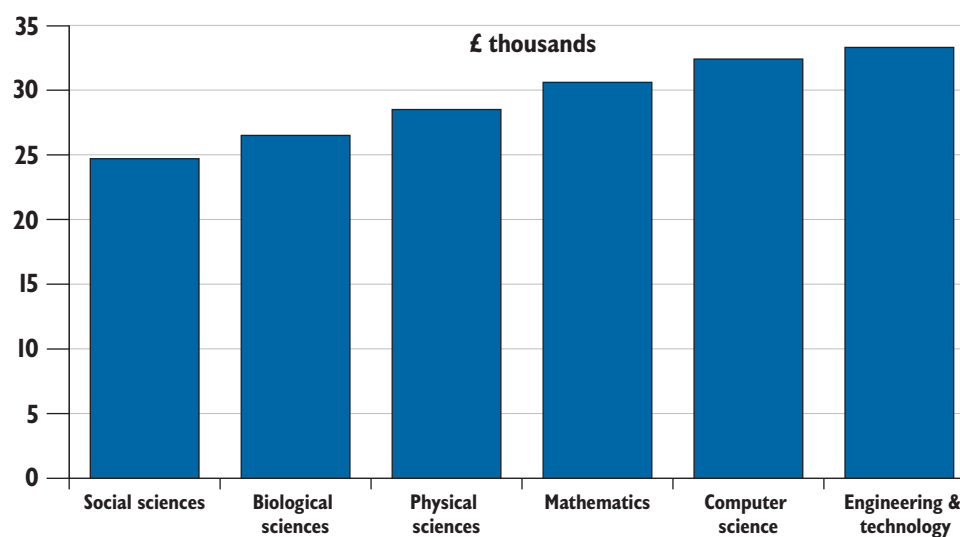
Shortages in the supply of scientists and engineers

1.16 Shortages resulting from the declining numbers of graduates in the mathematical and physical sciences might be expected to show up in increased salaries for these graduates, as employers find they must compete harder to attract the same calibre of employee. Figure 1.7 presents data from the Labour Force Survey, which shows that graduates with degrees in computer science, mathematics, engineering & technology, and the physical sciences do indeed attract higher salaries than graduates in the biological sciences or the social sciences.²⁴

²³ This is defined as the Standard Industrial Classification (SIC) group for 'Manufacturing' and the SIC group for 'Real estate, renting and R&D' (which in this case is primarily R&D).

²⁴ These differentials are in part related to the higher proportions of men taking computer science, mathematics, engineering & technology and the physical sciences; men on average earn more than women. However, these subject-related salary differences still exist even after taking into account these gender issues.

Figure I.7: Graduates' average gross salary in primary job, 2001



Source: Labour Force Survey, March 2001.

1.17 Emerging shortages in the supply of scientists and engineers, caused by strengthening demand for them to work in both R&D and elsewhere, would also be expected to show up in recent increases in scientists' and engineers' salaries. Table 1.2 shows that the annual salary increase in real terms has risen substantially in the last few years compared to the 1980s and early 1990s.

Table I.2: Real-terms increases in median salary for technical and senior R&D specialists

	Annual percentage change (1980/81-1996/97)	Annual percentage change (1996/97-1999/00)
Senior specialist	1.0	3.8
Technical specialist	1.7	2.4

Source: Research & Development Rewards, Reward Group.

1.18 It is not possible directly to disaggregate these data to identify whether these increases have been more pronounced in the subjects in which graduate numbers have been falling (mathematics, engineering and the physical sciences). However, data from other sources appear to confirm that recent wage rises have been focussed more in these subjects (Table 1.3). While the average salary for biological scientists fell by 1.9 per cent in real terms between 1994 and 2000, the average salary for natural scientists overall rose by some 0.4 per cent (which implies that the salary growth for physical scientists rose by considerably more, in order to offset the fall in biological scientists' salaries). Salaries for engineers and technologists also rose in this

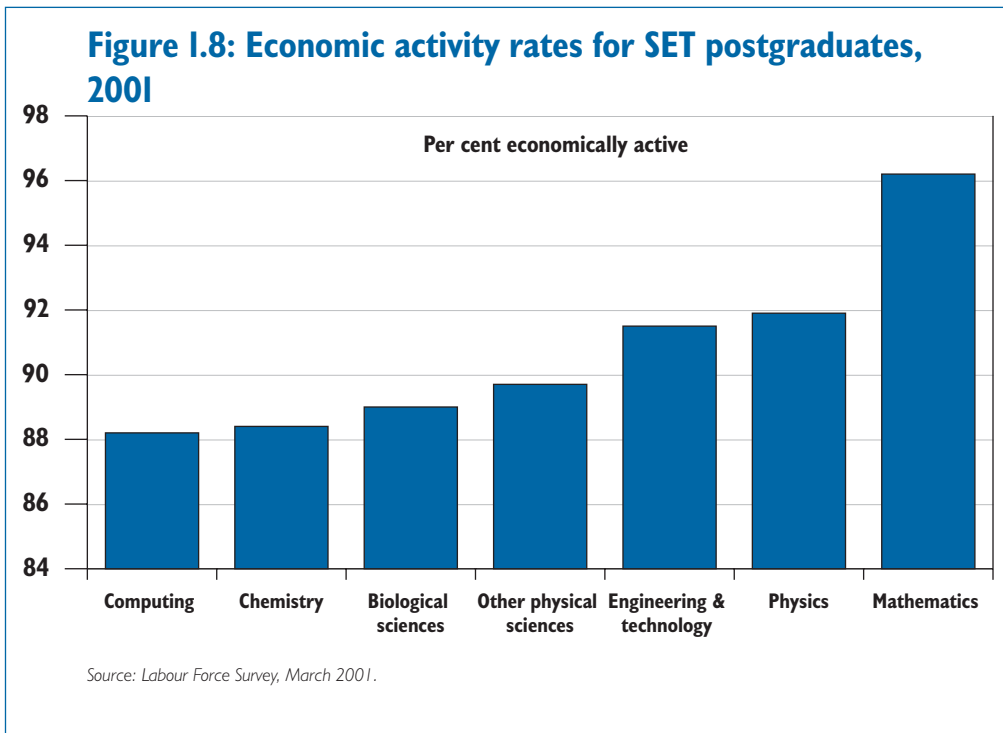
period, by 4.1 per cent in real terms.²⁵ These figures support the views expressed by many employers that there are developing shortages in engineering, mathematics and the physical sciences.

Table 1.3: Increase in average gross weekly pay in real terms, 1994 to 2000

Subject	Percentage change
Natural scientists	0.4
<i>Of which: biological scientists</i>	-1.9
Engineers and technologists	4.1

Source: *New Earnings Survey* (various years).

1.19 An alternative way of identifying emerging shortages is to compare employment rates (or 'economic activity' rates, *i.e.* the proportion of people of working age known to be working or seeking work) amongst science and engineering graduates and postgraduates. Figure 1.8 contrasts the economic activity rates for those with different postgraduate qualifications and presents a picture consistent with the salary data presented above. Engineering, physical science and particularly mathematics postgraduates are more likely to be economically active than those with postgraduate qualifications in the biological sciences, computer science and the social sciences.²⁶



²⁵ These increases are lower than the figures presented in Table 1.2 since these new figures include public sector scientists and engineers as well as private sector scientists and engineers. They are also over a longer period of time, over part of which demand for R&D (and hence, for scientists and engineers) was not particularly strong.

²⁶ These differences are in part related to the higher proportion of women who take biological and social sciences degrees and PhDs, where issues such as career breaks to start a family may affect the figures. However, these differences in economic activity rates exist even after taking account of these greater issues.

Employers' recruitment and retention difficulties

1.20 The emerging shortages suggested by the previous analysis were supported by the Review's consultation. Many employers reported more difficulty in filling positions in or related to the physical sciences and engineering areas as opposed to the biological sciences. Employers often said their problems were with the quality of applicants, which they tended to define as the combination of general transferable skills and the required breadth in a relevant technical or scientific field. This criticism extended to biological scientists too. These views are supported by other studies of recruitment and skills needs.

- A report by Mason²⁷ found that 43 per cent of recent recruiters in R&D services had faced some difficulty in meeting recruitment targets. The report also found that the majority of mismatches between supply and demand for SET graduates ". . . appear to be attributable to quality shortcomings rather than any overall shortfall in quantity".
- Work by The Institute for Employment Studies²⁸ found that technical and generic skills deficits persisted in the ICT sector although this had eased more recently. The report also established that ICT employers' recruitment difficulties increasingly concentrated on the 'quality' of applicants. Interviews with employers suggested that the technical skills gaps were caused by difficulty in keeping pace with the fast changing nature of the ICT sector, as well as a failure by employers to provide adequate training and development for their staff.
- A study of the current and future skill needs of the electronics sector²⁹ found difficulties with both quantity and quality of recruits. Lack of experience was a common problem, particularly for recruitment to higher level posts, and recent graduates were criticised for their inability to apply their academic knowledge in a practical environment and their lack of important generic skills such as problem-solving, communication and commercial awareness.
- A report on skill needs in engineering³⁰ also found that a number of employers faced recruitment difficulties and identified skills gaps in specific technical as well as generic skills. It was estimated that one in six engineering employers had 'hard to fill' vacancies, particularly at the higher end of the skills spectrum and at

²⁷ *The labour market for engineering, science and IT graduates: are there mismatches between supply and demand?*, G Mason, National Institute of Economic and Social Research, March 1999.

²⁸ *An Assessment of Skill Needs in Information and Communication Technology*, Report by The Institute for Employment Studies to the DfES, Helen Connor, Jim Hillage, Jane Millar, Rebecca Willison, 2001.

²⁹ *Skill Needs in Electronics*, A report by The Institute for Employment Studies commissioned by the National Training Organisation for Engineering Manufacture (EMTA), Jim Hillage, John Cummings, David Lane, Nick Jagger, January 2001.

³⁰ *An Assessment of Skill Needs in Engineering*, A report by The Institute for Employment Studies to the DfEE, Helen Connor, Peter Bates, Sally Dench, February 2001.

professional engineer level. These often involved the need for project management, commercial awareness and people management skills, together with up-to-date technical skills.³¹ The national Employers Skills Survey (ESS), cited by the report, showed that the problems were with applicants' general skills, rather than their technical qualifications. Low numbers of applicants and a lack of experience were also factors.

- This shortage of engineers in the UK was mirrored by the findings of a survey carried out for the World Competitiveness Yearbook, 2001. In a survey of executives about the availability of qualified engineers, the UK ranked 45th of the 49 participating countries, significantly behind all other G7 countries.
- The British Chambers of Commerce Skills Survey³² found that engineers and technologists were among the five most commonly cited occupations with hard to fill vacancies.
- In the R&D-intensive aerospace industry, one survey³³ established that the main reasons for recruitment problems were "not enough suitably skilled people, people lacking practical skills and a lack of people interested in the type of work", suggesting that both quality and quantity issues may be at the root of the problem.

1.21 There are also reports of shortages in supply and quality of academic staff, which are discussed in Chapter 5.

The *quality* of scientists and engineers

The definition of *quality* varies depending on the type of employer – for example, whether they are a university or a business, or even whether the business is large or small.

Generally, businesses seek quality applicants who have sound scientific knowledge but who also have the ability to apply their knowledge in a practical environment and have transferable skills – such as communication, business awareness and team working. In addition, R&D businesses stressed the importance of recruits needing to be innovative, and having a 'creative spark'. Skills needs vary according to the different natures and sizes of business; for example, smaller businesses place more emphasis on SET graduates possessing business awareness and other transferable skills and knowledge.

Universities have tended to stress the importance of scientific knowledge and an aptitude for leading scientific and technical research and less emphasis on transferable skills.

³¹ *Employers Skills Survey Case Study - Engineering*, Tony Buckley, Colin Davis, Terence Hogarth, Ruth Shackleton - Institute for Employment Research/Warwick Manufacturing Group.

³² *The British Chambers of Commerce Skills Survey*, January 1998 (last survey).

³³ *People Management in Aerospace, The Competitiveness Challenge*, Report Summary, The Society of British Aerospace Companies (SBAC), London.

- 1.22 On issues of quality and the mix of skills possessed by graduates and postgraduates, a study of postgraduate physicist employers for the Engineering and Physical Sciences Research Council (EPSRC) found that employers were generally content with the technical skills of physics postgraduates. However, they felt that softer skills such as communication, team working and business awareness were often not well-developed among these graduates.³⁴ This survey found that such employers therefore often recruited on the strength of the transferable skills possessed by a suitably qualified applicant.

Summary: Emerging shortages of scientists and engineers

The declining number of graduates in mathematics, engineering and the physical sciences, coupled with increasing demand for these highly numerate, highly skilled graduates, is leading to emerging shortages in the supply of these scientific and technical skills. However, instead of the resulting higher salaries acting to draw more students into these subjects to fill these shortages, the trend is that fewer students are choosing to enter these shortage areas. This suggests that there is a 'disconnect' between the demand for these skills and their supply.

There are also some shortages in the supply of IT skills, although students do appear to be responding to these shortages and pursuing IT-related courses. The trend of increasing student numbers, coupled with the slowing demand for IT skills (following the downturn in the dot.com market) suggest that the same 'disconnect' does not apply to IT skills generally. However, there are concerns that these positive trends mask shortages of graduates with specialist or high-level IT skills such as software engineering.

Skills shortages also appear to arise due to a limited pool of students emerging from higher education with both an excellent scientific and technical background, and an ability to apply these skills in a practical environment (e.g. in problem-solving), at a time when transferable skills are increasingly valued by businesses.

Addressing problems in the supply of science and engineering skills

- 1.23 The Review based its approach to addressing problems in the supply of science and engineering skills on analysis of responses to the Review's consultation carried out during the summer of 2001. A short summary of the issues raised in the consultation is provided in the box below.

³⁴ *Employers' Views of Postgraduate Physicists*, Report by The Institute for Employment Studies to the Engineering and Physical Sciences Research Council, N Jagger, S Davis, D Lain, T Sinclair, February 2001.

Addressing shortages in science and engineering skills – consultation responses

Respondents to the Review's consultation identified issues throughout the education system; from primary and secondary schools through to further education, undergraduate education and postgraduate education. These issues were believed to be contributing to the declining number of students in mathematics, engineering and the physical sciences. Concerns were also expressed that the jobs of scientists and engineers, whether in higher education or in business R&D research, were unattractive to science and engineering graduates and postgraduates.

Science and mathematics education in school and further education was the subject of many responses, with widespread concern about the supply and quality of teachers, particularly in mathematics, physics and chemistry. Further comments were made about the poor standard of school laboratories and the quality of pupils' learning experiences in practical classes. In addition, respondents were concerned that pupils found science and mathematics courses hard, that they were not enthused by the content of the science curriculum nor by the way it was taught, and that they could not relate the issues they studied in science to the world around them. All these issues, coupled with a lack of positive advice about careers arising from the study of science and engineering, were seen to result in declining numbers taking mathematics, physics and chemistry at A-level and beyond.

Concerns raised on issues related to university science and engineering education often focussed on a lack of modern and well resourced university laboratories, as well as the negative effect of student debt on postgraduate study. Respondents also mentioned the importance of employers' involvement to making study at university relevant to the student and employer.

On postgraduate education, many respondents thought that PhD stipends were uncompetitive compared to the employment opportunities available to science and engineering graduates. The amount of training – particularly in transferable skills – available to postgraduates was criticised as inadequate, contributing to many employers not valuing a postgraduate student significantly more than a first degree graduate.

Employment in higher education was believed by many respondents to be unattractive compared to other opportunities for the best science and engineering postgraduates, both in the UK and abroad. Particular issues raised included the uncertain nature of short-term postdoctoral research and the poor pay and limited training given to those in such posts. Low salaries available to junior academic staff were also seen to be causing difficulties for the recruitment and retention of academic staff in subjects such as physical, mathematical and computer sciences as well as engineering, where overall demand for their skills in the economy was particularly strong.

Looking at the role of employers more generally, many respondents felt that jobs in R&D needed to be more attractive (both financially and in terms of job design) so as to compete better with other employment prospects for scientists and engineers. Concern was also expressed that the communication mechanisms between R&D employers and HEIs regarding the skills needed by R&D employers were often incoherent and uncoordinated, and should be improved.

A number of respondents made it clear that action by government (in improving scientific, technical and mathematical education) needs to be matched by employers responding to the challenge of improving the attractiveness of careers in R&D.